UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 997

Joint contribution from the Office of Farm Management and Farm Economics, H. C. TAYLOR, Chief; Bureau of Public Roads, THOS. H. MacDONALD, Chief; and Bureau of Animal Industry, JOHN R. MOHLER, Chief

Washington, D. C. ▼ December 21, 1921

THE COST AND UTILIZATION OF POWER ON FARMS WHERE TRACTORS ARE OWNED

286 FARMS—OHIO, INDIANA, ILLINOIS—1920

By

H. R. TOLLEY, Agricultural Engineer, and
L. A. REYNOLDSON, Junior Farm Economist

CONTENTS

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THIS bulletin presents the results of the first of a series of investigations which have been planned by the Committee on Farm Power, appointed by the Secretary of Agriculture to represent the Bureau of Public Roads, the Office of Farm Management and Farm Economics, and the Bureau of Animal Industry in a cooperative study of all phases of the farm power problem. This committee has been charged with carrying out, for the Department of Agriculture, the plan of research in this field outlined by the Farm Power Conference, at Chicago, on October 6 and 7, 1919.

The committee recognizes the great importance of this field of work and the inadequacy of the present investigation. It is hoped that through more adequate appropriations and more general cooperation with the State agricultural experiment stations, the work may be broadened to make possible a comprehensive study of the problems now calling for solution in the development of farm power, in order that farmers, horse breeders, and manufacturers may have at hand such facts as will guide them toward the greatest ultimate success.

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By H. R. Tolley, *Agricultural Engineer*, and L. A. Reynoldson, *Junior Farm Economist.*

CONTENTS.

INTRODUCTION.

During October and November of 1920 the Bureau of Animal Industry, the Office of Farm Management and Farm Economics, and the Bureau of Public Roads of the United States Department of Agriculture made an investigation of the cost and utilization of power on representative farms where tractors are owned in Ohio, Indiana, and Illinois. Two hundred and eighty-six farmers in these States who had been using tractors for a year or more were inter-

Note.—Special credit is due to W. R. Humphries, Bureau of Public Roads, for valuable assistance in collecting and in supervising the tabulation of the data presented in this bulletin.

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viewed. A complete record of all the farm operations and of the work which was done both with tractors and with horses for the year ending October 31, 1920, was obtained from each farmer. Data from which the cost of operating the tractor and the cost of keeping workstock could be determined, the acreages and yields of different crops, the size of the farm and the number of workstock before the purchase of the tractor, and related information were also collected.

The object of the investigation was to obtain information, in addition to that already available in the Department of Agriculture and the various State colleges of agriculture, which would assist in determining the most profitable forms of power for different farms under different conditions.

SUMMARY.

The average size of the farms visited was 258 acres. This is considerably above the average size of all farms in these States.

Two-plow tractors were owned on 174 of the 286 farms, 3-plow tractors on 104, and 4-plow tractors on 6 farms. One farmer owned a 1-plow machine and one farmer owned a 5-plow machine. Two-plow machines were found on 75 per cent of the farms with less than 160 crop acres, and on 53 per cent of those with 160 or more crop acres.

One hundred and six of the tractors had been in use 1 year, 100 had been in use 1½ or 2 years, 49 had been in use 2½ or 3 years, and 31 had been in use more than 3 years.

On the average each tractor was used for 30.8 full days during the year covered by the investigation. Of this period, 23.5 days were devoted to drawbar work on the home farm, 2.7 days to belt work, and 4.6 days to custom work. Of the 286 tractors, 73 did less than 20 days' work during the year and 26 did 50 or more days' work.

The number of workstock owned at the time of the investigation varied from 2 head on 11 of the farms to more than 15 on 5 of the larger farms. On the average each farm had 6.8 head at the time of the survey, and their value was $144 per head. In all, the 286 farms had 1,878 head of workstock and 111 colts less than 1 year old.

The average number of full days' work per year per horse, for all farms, was 68.6. On 20 of the farms, the workstock did less than 40 full days' work each, and on 27 they did 100 or more days' work per year.

The tractors did 85 per cent of the plowing on these farms, 73 per cent of the disking, 43 per cent of the harrowing, rolling, planking, and packing, 41 per cent of the grain cutting, and 15 per cent of the loading and hauling of hay.

Of 267 farmers who did spring plowing, 142 did it all with tractors, 121 used both tractors and horses, and 4 used horses only.

Of 225 who did fall plowing, 190 did it all with tractors, 27 used both tractors and horses, and 8 used horses only.

Of 284 farmers who did disking, all but 15 used tractors for at least a part of it. Two hunderd and seven used their tractors for harrowing, rolling, planking, or packing, 130 for cutting grain, and 37 for drawing the hay loader. Smaller numbers used their tractors for drawbar operations other than those enumerated.

In all, the power for 30 per cent of the drawbar work on these farms, as measured by days or horse labor required for it, was furnished by tractors and the remainder by horses.

On the average, the 2-plow tractors saved 25 to 30 days of man labor, and the 3-plow tractor 30 to 35 days, required for drawbar work during the year on these farms.

The average cost per head of keeping workstock on these farms for the year ending October 31, 1920, was $159, and the average cost per farm was $1,076.

This cost includes charges for feed at the average price for the year, chores at 25 cents per hour, shoeing, veterinary, harness, interest at 6 per cent, and depreciation. A manure credit of $15 per head was allowed.

Exclusive of grass and stalk pasture, the average ration per horse for the year consisted of 1.3 tons of hay, 1.2 tons of straw, 0.2 acre of stover, 37.8 bushels of corn, and 22.3 bushels of oats. The cost of feed per head was $134. Based on present prices (Sept., 1921), the cost of feed per head would be about $60.

The average cost per day of horse labor for the year of the survey was $2.43. At present prices, the cost on these farms would be not far from $1.30 per day.

The average first cost of the 2-plow tractors was $972; of the 3-plow tractors, $1,354; and of all tractors, $1,140. The average amount spent for equipment, mostly plows and disks, for use with tractors was $343. The average value of the horse-drawn implements disposed of after the purchase of the tractors was $12.

The average life of these tractors, as estimated by their owners, is 6.7 years. The annual depreciation of the 2-plow tractors amounted to $164, and of the 3-plow, $217. The annual cost of repairs, including the value of the owners' time spent in repairing the tractors, was $39 for both the 2-plow and the 3-plow sizes. The tractors were out of commission when needed an average of about 2 days during the year. A little over 50 per cent were not out of commission at all when needed, and about 1 in 7 were out of commission five days or more.

The fuel consumption per day for the 2-plow tractors varied from about 18 gallons for fall plowing to about 11 gallons for drawing the hay loader. For the 3-plow tractors it varied from 23 gallons for plowing to 15 gallons for drawing the hay loader. The 2-plow tractors covered 6.6 acres per day in spring plowing and the 3-plow machines 8.6 acres. The quantity of fuel required per acre was 2.7 gallons for each size.

The average cost per acre of power for the plowing done with 2-plow tractors was about $2 and with the 3-plow about $2.20. The cost of power for the plowing done with horses on these farms was about $2.90 per acre. Based on the present prices of feed, fuel, and oil (September, 1921), the cost of power for plowing with horses would be about $1.60 per acre, and with tractors about $1.70.

For most of the other operations the cost of power furnished by horses during the year of the investigation was slightly less than that furnished by tractors. The cost per acre of power for disking with tractors was $0.67; with horses, $0.64; for cutting grain with tractors, $0.67; with horses, $0.59. These figures represent the cost of power only, and do not include either the cost of man labor or that of the implements used.

The average cost per day of 2-plow tractors for drawbar work on the home farm was about $12.67, and of 3-plow tractors about $17.73.

The total cost of power furnished by the tractors for drawbar work at home during the year averaged $341. Based on the present price of fuel and oil (September, 1921), the cost would be about $280. This drawbar work on the home farm constituted 76 per cent of the total work done by the tractors, and only 76 per cent of the total annual charge for depreciation, repairs, and interest on investment is included in it. No charges for taxes, insurance, or shelter are included in the costs for either tractors or workstock.

Nine of these men started farming with tractors; the others increased the size of their farms by an average of about 20 acres after the tractors were purchased. No change occurred in the size of 172 of the farms, 81 were increased in size, and 24 were decreased.

On the 172 farms where no change in acreage occurred the number of workstock was reduced by 2.2 head, an average reduction of 26 per cent. Forty-four of these 172 men did not reduce the number of workstock, 62 disposed of 1 or 2 head, 43 disposed of 3 or 4 head, and 23 of more than 4 head. On these 172 farms 1 horse was kept for each 28.0 acres (total acres, not crop acres) before purchase of tractors, and at the time of the survey there was 1 horse for each 37.7 acres. For all the farms an average of 1 horse was kept for each 27.6 acres before the purchase of tractors, and there was 1 for each 37.9 acres at the time of the investigation.

With the tractors doing the bulk of the work of plowing and fitting the ground, the cultivation of corn was the operation which required

the greatest amount of horse labor in the shortest time on most of these farms. However, on only 105 of the 286 farms were all the workstock used for cultivation, and on only 38 of the remainder were they all used for any other one operation. On just half of the farms the workstock were not all used for any one operation.

Individual farms varied greatly in the cost of power furnished by both horses and tractors; and by more careful management many farmers could doubtless reduce this cost. Repair costs and fuel consumption of the tractors in many cases could have been reduced by more careful operation. The cost of keeping workstock could have been reduced on many farms by more careful feeding practices. The facts that on 20 of the farms the workstock did less than 40 days of work per head during the year and that on half of the farms they were not all used for any single operation indicate that the greatest possible use was not being made of the available power represented by the horses. Either more work could have been accomplished by more efficient use of the horses on hand, or the number of horses kept could have been reduced and the cost of the operation of the farm correspondingly decreased.

The average annual cost of power for the drawbar work on the home farm which was done with tractors was equal to the cost of keeping 2.1 head of workstock, and this is practically the average number displaced per farm. On the basis of present prices, however, the cost of keeping workstock has declined considerably more than the cost of operating tractors.

Since, during the year covered by the investigation, the cost of power on the average farm was no greater than if it had all been furnished by horses, any saving in man-labor costs, any gain due to getting a larger amount of work done in a given time, and possibly other advantages connected with the use of tractors which can not be measured directly in dollars and cents, might be considered clear profit. On many of the farms, however, where there was no change in acreage, and where no workstock was displaced it is doubtful if such gains were great enough to balance the cost of operating the tractors.

AREAS IN WHICH INVESTIGATION WAS MADE.

Table 1 shows the counties visited in each State, the number of farmers from whom records were obtained, and the average size of their farms. The location of the counties is shown in figure 1.

In each area the average size of the farms where tractors are owned is considerably greater than the average size of all farms, and this fact must be borne in mind in interpreting any of the data contained in this bulletin. The proportions of the entire acreage devoted to different crops, the practices followed in preparing the ground, planting, cultivating, and harvesting the crops on the farms

visited, however, are very similar to those on other farms in the respective areas.

TABLE 1.—*Location, number, and size of farms.*

Location.	Number of farms.	Average size of farms (acres).	Average number of crop acres.
Madison County, Ohio	34	363	276
Seneca County, Ohio	34	202	140
Madison County, Indiana	42	218	176
Montgomery County, Indiana	56	270	205
Livingston County, Illinois	60	247	211
Knox County, Illinois	60	256	198
All	286	258	201

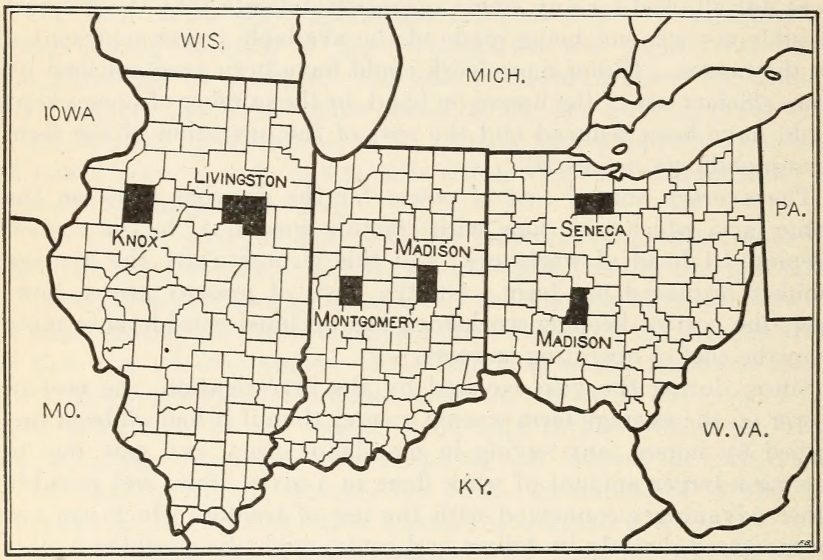

FIG. 1.—Areas in which investigation was made.

Madison County, Ohio.—The average size of all farms in this county, as determined by the 1920 census of agriculture, is 164 acres. Corn is the principal crop, occupying in 1919 about 46 acres per farm. A considerable part of the corn is cut by hand and husked by hand from the shock. Where this practice is followed no horse labor is used in the corn harvest except for hauling the husked corn from the field to the crib.

Wheat is the crop next in importance from the standpoint of acreage. There was an average of 28 acres per farm in this crop in 1919. Wheat usually follows corn in the rotation. It is sown after the corn is cut, without any preparation of the ground except disking. Oats is usually planted in the same way. Oats occupied an acreage less than half as great as that of wheat in 1919.

Seneca County, Ohio.—The average size of all farms in this county, as determined by the census of agriculture, is about 107 acres. The principal crops in order of the acreage occupied in 1919 are wheat, corn, hay, and oats. The acreage in corn in 1920 on the farms visited was slightly greater than the acreage in wheat, but the percentage of the acreage in corn was less on the farms visited in this county than in any other area.

A large part of the corn grown is ensiled, or cut and shocked and later run through a husker-shredder. Corn binders are used more generally in this county than in any other visited. As in Madison County, Ohio, wheat usually follows corn in the rotation, and is planted after the corn is cut, with no seed-bed preparation except disking. Commercial fertilizer is applied with wheat on most farms in both areas.

Madison County, Indiana.—The average size of all farms in this county is 84 acres, less than in any other county included in the investigation. The size of the farms visited in this county, however, was larger than of those visited in Seneca County, Ohio.

The principal crops in order of the acreage occupied in 1919 are corn, wheat, oats, and hay. The portion of the corn in this area husked from the standing stalk is greater than in either of the Ohio areas.

Wheat usually follows corn in the rotation, and on some farms part of it is sown with a one-horse drill between the rows of standing corn, without any preparation of the ground.

Montgomery County, Indiana.—The average size of all farms in this county is 118 acres. The chief crops in order of the acreage occupied in 1919 were corn, oats, hay, and wheat. In both of the Ohio areas and in Madison County, Indiana, wheat occupies a greater acreage than oats, while the reverse is true of this county and the two visited in Illinois.

Oats is usually sown on land which was planted to corn the previous year, and with end-gate seeders capable of covering an average of 30 to 50 acres per day. A large part of the corn is husked from the standing stalk.

In both the Indiana areas motor trucks are used very generally for hauling on the road. A few of the farmers visited in these areas owned motor trucks with which they did the bulk of their road hauling during the year, and nearly all the remainder hired trucks to haul part of their produce to market. On this account the amount of road hauling done with horses was less in these areas than in the Ohio and Illinois areas.

Livingston County, Illinois.—According to the 1920 census the farms in this county have an average size of 171 acres. Corn and oats are the principal crops. In 1919 there were on the average only

7 acres per farm in wheat and practically the same acreage in hay. The acreage devoted to these two crops was less in this county than in any other studied.

The average size of the farms in this county is greater than in any other county studied in the investigation. However, the average size of the farms visited in this county was considerably less than those visited in some of the other areas.

Knox County, Illinois.—The average size of the farms in this county is 153 acres. In 1919 there were about 42 acres per farm in corn, 20 acres in oats, 9 acres in wheat, and 15 acres in hay.

In both Illinois areas corn is practically all husked from the standing stalk. A considerable part of the corn is sold, most of which is shelled before being marketed. Endgate seeders are used almost universally for sowing oats.

Table 2 gives the acreages in different crops during the year covered by the investigation on the farms visited in the different areas.

TABLE 2.—*Acreages in different crops in different areas.*

[Averages.]

Area.	Number of farms.	Crop acres.								Acres not cropped.	Total size of farms, acres.
		Corn.	Wheat.	Oats.	Other small grain.	Other inter-tilled crops.	Hay and seed.	Rotation pasture.	Total.		
Madison County, Ohio	34	129.0	50.8	43.7	0.6	.....	29.6	22.4	276.1	86.9	363.0
Seneca County, Ohio	34	40.6	38.9	18.0	2.1	1.4	32.2	6.9	140.1	61.8	202.0
Madison County, Ind	42	66.0	39.4	18.9	3.1	.4	30.1	18.3	176.2	41.9	218.1
Montgomery County, Ind	56	83.1	32.3	38.7	4.9	.1	28.0	17.6	204.7	64.8	269.5
Livingston County, Ill	60	109.5	7.6	76.3	.....	.....	12.2	5.2	210.8	36.5	247.3
Knox County, Ill	60	97.7	17.4	49.5	1.9	.....	25.2	6.3	198.0	58.0	256.0
All	286	89.6	28.0	44.1	2.1	.3	25.1	12.0	201.2	56.4	257.6

In each area corn is the principal crop; it has the greatest acreage and makes the heaviest demands upon power and man-labor. The practices in growing and harvesting the different crops are quite similar in the different areas, with the exception of the harvesting of corn, and the common methods used in each area have been outlined above.

The land is generally level in all areas, and on the farms visited the fields were usually large enough to permit the efficient operation of tractors. On very few farms were any fields less than 10 acres in size included in the regular rotation.

SIZE AND AGE OF TRACTORS.

Table 3 shows the number of tractors of different sizes on the farms in the different areas.

TABLE 3.—*Number of tractors of the different sizes on the 286 farms studied.*

Area.	Number of farms.	1-plow tractor.	2-plow tractors.	3-plow tractors.	4-plow tractors.	5-plow tractor.
Madison County, Ohio	34	1	26	6	1	.....
Seneca County, Ohio	34	.....	22	11	1	.....
Madison County, Ind	42	.....	34	7	.....	1
Montgomery County, Ind	56	.....	31	25	.....	.....
Livingston County, Ill	60	.....	29	27	4	.....
Knox County, Ill	60	.....	32	28	.....	.....
Total	286	1	174	104	6	1

The 2-plow size predominated in each area. However, the proportion of farmers using this size was considerably greater in the Ohio areas and in Madison Co., Indiana, than it was in Montgomery Co., Indiana and in the two Illinois areas.

Every farmer visited had used his tractor for at least one full year's work. The number of months the tractors of different sizes had been owned at the time of the investigation is given in Table 4.

TABLE 4.—*Number of tractors of different ages on the 286 farms studied.*

Age.	1-plow tractor.	2-plow tractors.	3-plow tractors.	4-plow tractors.	5-plow tractor.	All sizes.
14 months or less	1	74	29	2	.....	106
15 to 26 months	.....	60	39	1	.....	100
27 to 38 months	.....	28	20	1	.....	49
39 months and over	.....	12	16	2	1	31
All ages	1	174	104	6	1	286

The one 1-plow tractor had been used just one year, and the 5-plow tractor had been used four years.

The farmers were visited in October and November, and those who had owned their tractors 14 months or less had used them for just one full year's work. The men who had owned their tractors from 15 to 26 months had used them for one and a half or two years; those who had owned their tractors 27 to 38 months had used them two and a half or three years; and those who had owned their tractors 39 months and over had done more than three full years of work with them.

Sixty-five per cent of the tractors which had been owned two years and less were 2-plow machines. However, only 50 per cent of those that had been owned over 2 years were of the 2-plow size. On the average, the 2-plow tractors had been owned 21 months, the 3-plow tractors 25 months, and all tractors 23 months.

WORKSTOCK.

The total number of workstock of different kinds, their weight, and their value on the farms in different areas at the time of the investigation are given in Table 5.

TABLE 5.—*Number of workstock, their weight and value, in different areas.*

Area.	Number of farms	Mares.			Geldings.			Mules.		
		Number.	Average weight.	Average value.	Number.	Average weight.	Average value.	Number.	Average weight.	Average value.
			Lbs.	*Dolls.*		*Lbs.*	*Dolls.*		*Lbs.*	*Dolls.*
Madison County, Ohio	34	168	1,409	156	75	1,394	150	19	1,143	161
Seneca County, Ohio	34	103	1,448	148	56	1,446	142	6	1,075	212
Madison County, Ind	42	136	1,405	134	69	1,355	125	4	1,050	120
Montgomery County, Ind	56	162	1,338	128	111	1,344	131	47	1,075	186
Livingston County, Ill	60	293	1,367	151	172	1,331	126	36	1,189	159
Knox County, Ill	60	222	1,320	123	165	1,298	119	34	1,130	204
All	286	1,084	1,372	140	648	1,350	129	146	1,125	180

The larger number of mares than geldings in each area indicates that when disposing of surplus workstock these farmers have usually sold geldings in preference to mares. Mules were found on 56 of the 286 farms, and on most of these 56 there was but one span, the average number per farm where mules were used being 2.6.

The number of colts in comparison to the number of workstock on these farms is shown in Table 6. The number of "other" colts includes all young stock which had not been broken to harness. Most of them were foaled in 1919 and 1918, but some young horses and mules foaled in 1917 had never been worked. For all farms there was only one 1920 colt for each 16.9 head of workstock, and on more than three-fourths of the farms there were no 1920 colts. Only 10 per cent of the mares on these farms raised colts during the year of the investigation.

TABLE 6.—*Number of workstock and number of colts in different areas.*

Area.	Number of farms.	Number of workstock.	Number of 1920 colts.	Number of other colts.
Madison County, Ohio	34	262	21 (11 farms)	127 (24 farms).
Seneca County, Ohio	34	165	8 (6 farms)	30 (16 farms).
Madison County, Indiana	42	209	19 (12 farms)	68 (16 farms).
Montgomery County, Indiana	56	320	11 (8 farms)	40 (17 farms).
Livingston County, Illinois	60	501	27 (15 farms)	83 (30 farms).
Knox County, Illinois	60	421	25 (14 farms)	63 (20 farms).
All	286	1,878	111 (66 farms)	411 (123 farms).

The practices with regard to keeping workstock and raising colts on these farms where tractors are owned are probably not exactly typical of all farms in the same communities, but the figures do indicate that there has been a marked decrease in the number of colts raised on these farms, and that at the present rate not enough colts are being produced for replacement.

SIZE OF FARM.

On farms of similar type, the number of crop acres is closely correlated with the amount of horse and tractor work, and for the purpose of comparing these items the farms here have been arranged according to the number of crop acres in each. The area in rotation pasture during the year of the investigation has been included in the crop area, so that the number of crop acres in a farm as used here is the total number of acres in the regular rotation. Land in bluegrass and other land which has been in pasture for a number of years, even though improved and tillable, was not included in the crop area. Of course, the rotation on different farms and in different areas varied somewhat, and the practices on different farms also varied, so that the number of crop acres in a farm did not determine entirely the amount of power required for operating it.

The number of crop acres in the different farms was as follows:

Farms.	Crop acres.
7	Less than 80
28	80 to 119
71	120 to 159
56	160 to 199
47	200 to 239
36	240 to 279
19	280 to 319
22	320 or more

These figures indicate that most of the tractors owned in these areas are on the larger farms. The average total size of all farms in the 6 counties is not over 120 acres.

On the average, the number of crop acres on the farms visited is about 80 per cent of the total acres. If the same ratio of crop acres to total acres holds for all farms in these counties, the average number of crop acres for all farms is not far from 100. In other words, something like half the farms in these 6 counties contain 100 or less crop acres. But only 35 of the 286 farms on which tractors are owned, one-eighth of the total, contain less than 120 crop acres.

The number of acres in the different crops on the farms of different sizes is shown in Table 7. In each group, corn is the principal crop and occupies a greater acreage than all the small grains combined.

TABLE 7.—*Acreages in different crops on farms of different sizes.*

Crop acres in farm.	Number of farms.	Acres in crops.								Acres not cropped.	Total size of farm, acres.
		Corn.	Wheat.	Oats.	Other small grain.	Other inter-tilled crops.	Hay and seed.	Rotation pasture.	Total.		
Less than 80	7	25.6	10.7	11.3	.8	.....	15.0	1.4	64.8	38.0	102.8
80–119	28	41.8	18.0	19.6	.6	1.1	16.9	3.4	101.4	38.1	139.5
120–159	71	60.2	18.2	28.5	1.7	.3	20.7	7.5	137.1	42.0	179.1
160–199	56	79.2	24.4	37.5	2.3	.4	25.7	9.8	179.3	54.2	233.5
200–239	47	96.8	25.1	53.2	1.9	.....	21.7	16.7	215.4	61.1	276.5
240–279	36	121.3	35.7	58.1	3.4	.....	30.2	9.7	258.4	59.1	317.5
280–319	19	130.1	34.4	74.1	3.2	.....	27.8	23.7	293.3	71.9	365.2
320 and over	22	189.6	75.4	83.9	3.2	.....	48.0	30.6	430.7	109.2	539.9
All	286	89.6	28.0	44.1	2.1	.3	25.1	12.0	201.2	56.4	257.6

SIZE OF FARM AND SIZE OF TRACTOR.

The number of tractors of different sizes on the farms of different sizes (as measured by the number of crop acres) is shown in Table 8.

TABLE 8.—*Number of tractors of different sizes on farms of different sizes.*

Size of farms (crop acres).	Number of farms.	1-plow tractor.	2-plow tractors.	3-plow tractors.	4-plow tractors.	5-plow tractor.
Less than 80	7	.....	5	2	.....	.....
80 to 119	28	1	22	5	.....	.....
120 to 159	71	.....	52	19	.....	.....
160 to 199	56	.....	29	26	1	.....
200 to 239	47	.....	27	18	2	.....
240 to 279	36	.....	18	18	.....	.....
280 to 319	19	.....	10	9	.....	.....
320 or more	22	.....	11	7	3	1
Total	286	1	174	104	6	1

Seventy-five per cent of the farms with less than 160 crop acres were equipped with 2-plow tractors, and 53 per cent of those with 160 or more crop acres were equipped with this size of machine.

WORKSTOCK ON FARMS OF DIFFERENT SIZES.

The average number of workstock, the number of days of horse labor per farm, and the number of days' work per head on the farms of different sizes during the year of the investigation are shown in Table 9. The number of days' work per head was obtained by dividing the number of days' work on the farm by the number of workstock kept. Each farmer gave the number of hours which are considered a full day's work on his farm both for the workstock and for the tractor, and the average is practically 10 hours for each.

The number of workstock varied considerably on farms of the same size. Likewise the number of days of horse labor per farm varied considerably, depending upon the acreages and yields of the different crops, upon the practices followed in preparing the seed bed, planting,

cultivating, and harvesting, upon the amount of horse labor used in caring for live stock and for miscellaneous work, and upon the amount of work done with the tractor.

TABLE 9.—*Number of workstock, days' of horse labor, and days' work per head on farms of different sizes.*

Size of farm (crop acres).	Number of farms.	Number of work-stock.	Horse labor per farm per year, days.	Days' work per head per year.
Less than 80	7	3.4	203.2	59.7
80 to 119	28	3.9	239.4	64.0
120 to 159	71	5.1	319.0	66.4
160 to 199	56	6.2	416.5	70.1
200 to 239	47	7.4	449.6	62.5
240 to 279	36	8.0	532.9	70.9
280 to 319	19	9.3	587.6	66.4
320 and over	22	12.5	1,070.1	91.7
All	286	6.8	451.5	68.6

The number of days' work per head, being dependent upon both the entire amount of horse labor used on the farm and the number of workstock kept, likewise showed great variations, ranging from less than 40 to more than 100 days. The size of the farm in itself had very little bearing on the number of days' work per horse. While the average for the farms with 320 or more crop acres is considerably higher than for the other sizes, the horses worked less than 70 days per head on 6 of the 22 farms. Figure 2 shows the number of farms with different amounts of work per horse during the year.

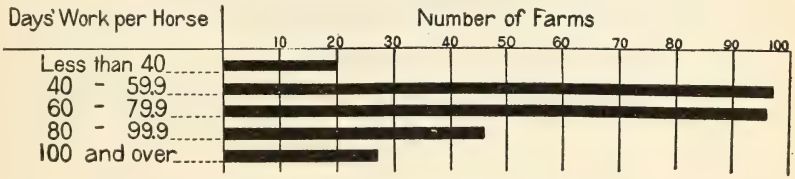

FIG. 2.—Variation in number of days' work per horse

WORK DONE BY TRACTOR.

The average number of days of drawbar and belt work on the home farm and of custom work done by the tractors on farms of different sizes are shown in Table 10.

There was a larger percentage of small machines on the smaller farms than on the larger ones, and to this extent the number of days work per year is not a true index of the actual amount of work done by the tractors on the farms of different sizes. The table does show, however, the relative importance of the different classes of work. The number of days of drawbar work on the home farm increases quite regularly with the increase in the size of the farm, and on the

average the men on the smaller farms did a somewhat greater amount of custom work with their tractors during the year of the investigation.

For the entire 286 farms, 76.3 per cent of the work the tractors did, as measured in days, was drawbar work on the home farm, 8.8 per cent was belt work at home, 6.5 per cent was drawbar custom work, and 8.4 per cent was belt custom work.

TABLE 10.—*Days of tractor work on farms of different sizes.*

Size of farm (crop acres).	Number of farms.	Days of work on home farm.		Days of custom work.		Total days.
		Drawbar.	Belt.	Drawbar.	Belt.	
Less than 80	7	11.1	2.0	4.0	5.9	23.0
80 to 119	28	17.5	2.3	2.3	3.1	25.2
120 to 159	71	19.1	3.1	2.6	3.7	28.5
160 to 199	56	22.1	3.0	2.2	2.4	29.7
200 to 239	47	26.0	2.1	1.3	1.3	30.7
240 to 279	36	28.5	2.1	1.9	1.6	34.1
280 to 319	19	31.7	2.0	1.5	0.4	35.6
320 and over	22	32.6	3.9	1.0	4.3	41.8
All	286	23.5	2.7	2.0	2.6	30.8

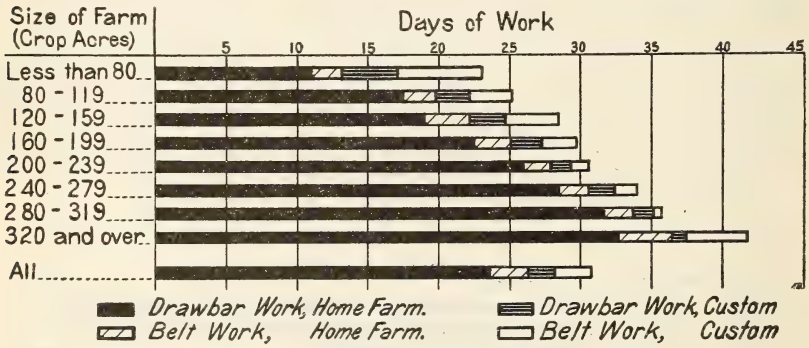

FIG. 3.—Days of work per year done by tractors on farms of different sizes.

On the farms with less than 80 crop acres the drawbar work on the home farm constituted only about 48 per cent of the total; and on those with 80 to 119 crop acres it constituted about 69 per cent of the total. On the farms with 280 to 319 crop acres, drawbar work at home constituted 89 per cent of the total, and on those with 320 or more crop acres, it constituted about 78 per cent of the total.

Figure 3 shows graphically the relative importance of the different kinds of work on the farms of different sizes, and illustrates the error which would be made in assuming that the entire usefulness of a tractor is confined to work where it competes directly with horses.

The number of days of work done by an individual tractor depended upon the particular field operations for which it was used, the amount of belt and custom work done, and to a certain extent upon the

amount of time it was out of running order when it was needed, as well as upon the size of the farm. The variation in the number of days' work done during the year by the entire 286 machines is shown in figure 4. Nine of the machines were used for less than 10 days and 7 for 60 or more.

The number of days of drawbar and belt work on the home farm and of custom work done by the 2-plow and 3-plow tractors is given in Table 11. The number of tractors of sizes other than the 2 and 3 plow is not great enough to afford an accurate comparison. The 3-plow tractors did considerably more belt work both on the home farm and for the neighbors than did the 2-plow machines. The drawbar work on the home farm constituted 80 per cent of the total work done by the 2-plow tractors and only 71 per cent of that done by the 3-plow machines.

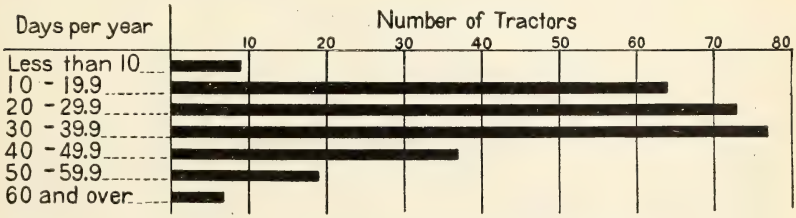

FIG. 4.—Variation in number of days tractors were used per year.

TABLE 11.—*Days work per year done by 2-plow and 3-plow tractors.*

Size of tractor.	Number.	Days of work on home farm.		Days of custom work.		Total.
		Drawbar.	Belt.	Drawbar.	Belt.	
2-plow	174	25.8	2.1	2.6	1.8	32.3
3-plow	104	20.2	3.5	1.3	3.5	28.5

DRAWBAR WORK.

The 23.5 days of drawbar work on the home farm which the average tractor did was divided among the following operations:

	Days.
Plowing	12.4
Disking, harrowing, and other work in fitting ground	7.6
Cutting grain	1.5
Loading and hauling hay	.4
Other	1.6

Although the tractors on these farms were used more for plowing than for any other drawbar operation, the amount of time spent on other work almost equaled that spent in plowing.

The "other" drawbar work, which amounted to 1.6 days for the average tractor, consisted of many operations, such as cultivating

corn, drawing the corn binder or corn picker, hauling manure, and drilling grain, but less than 10 per cent of the farmers used their tractors for any one of these operations and on the average the length of time the tractors were used for any one was less than the time they were used for drawing the wagon and hay loader.

The average number of days the 2 and 3 plow tractors were used on the different drawbar operations and the average number of acres covered per day by each are shown in Table 12.

TABLE 12.—*Average number of days per year 2-plow and 3-plow tractors were used for different drawbar operations and average number of acres covered per day.*

[174 two-plow tractors and 104 three-plow tractors.]

Operation.	2-plow.		3-plow.	
	Days per year.	Acres per day.	Days per year.	Acres per day.
Spring plowing	7.9	6.62	6.3	8.63
Fall plowing	5.1	6.46	5.2	8.62
Disking	4.0	21.60	2.3	30.78
Disking in combination	3.4	19.69	4.0	23.83
Harrowing, rolling, etc	1.1	39.05	.2	51.38
Drawing hay loader	.4	10.50	.4	11.57
Cutting grain	1.9	19.73	.9	23.22
Other work	2.0	.....	.9	.....
Total	25.8	.....	20.2	.....

There was little variation in the amount of ground covered per day by the tractors at the various operations in the different areas. The average number of acres covered per day, at least in plowing, on the farms visited in this investigation is evidently very near the average of all farms in this section. Reports from over 600 Illinois tractor owners to the Department of Agriculture in 1917 and 1918, as summarized in Farmers' Bulletin 963, "Tractor Experience in Illinois," showed that the 2-plow machines covered an average of 6½ acres per day of 10 net working hours and 3-plow machines 8¾ acres. Reports from about 70 farmers in McLean County, Illinois, in 1918 and 1919, and summarized in Department Bulletin 814, "A Standard Day's Work in Central Illinois," showed that 2-plow tractors covered 7.0 acres per day in spring plowing and 6.4 acres per day in fall plowing, and that 3-plow tractors covered 8.7 acres per day in the spring and 8.1 acres in the fall.

Table 12 shows that the 2-plow tractors were used more extensively than the 3-plow machines for the light operations of harrowing, rolling, etc., and cutting grain. In disking, the 2-plow machines pulled disks alone a greater part of the time while the 3-plow machines usually pulled harrows or other light implements in combination with the disks.

Table 13 shows the number of owners of 2 and 3 plow tractors who used their machines on the different operations:

TABLE 13.—*Number of owners using their tractors on the different operations.*

Operation.	Owners using 2-plow tractors for operation specified.		Owners using 3-plow tractors for operation specified.	
	Number.	*Per cent.*	*Number.*	*Per cent.*
Plowing (spring or fall)	All	100	All	100
Pulling disks alone	95	55	46	44
Pulling disks in combination with harrows, rollers, or plankers	101	58	64	62
Pulling harrows, rollers, etc., alone	53	30	7	7
Drawing hay loaders	24	14	13	12
Drawing grain binders	101	58	27	26
Other draw-bar work on home farm	62	36	16	15

FIG. 5.—Tractors did 85 per cent of all the plowing on these farms.

Plowing.—Table 14 shows the average number of acres plowed during the year, and the number plowed with tractors and with horses in both the spring and fall on farms of different sizes. A little over half of the crop area of the farms was plowed during the year. Eighty-five per cent of all this plowing was done with the tractors; 81 per cent of the spring plowing was done with them, and 91 per cent of the fall plowing. Every man interviewed had used his tractor for some plowing during the year, and 140 of the 286 had done all of their plowing with tractors. (See fig. 5.)

TABLE 14.—*Plowing done with tractors and with horses on farms of different sizes.*

Size of farm (crop acres).	Number of farms.	Average acres plowed per farm.	Spring plowing.		Fall plowing.		Per cent of total plowed with tractor.
			Acres with tractors.	Acres with horses.	Acres with tractors.	Acres with horses.	
		Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Per cent.*
Less than 80	7	33.0	26.0	2.3	4.7	0	93.0
80 to 119	28	55.9	35.2	2.9	16.5	1.3	92.5
120 to 159	71	72.0	37.5	5.3	27.7	1.5	90.6
160 to 199	56	95.4	49.1	9.3	34.4	2.6	87.5
200 to 239	47	113.5	60.4	5.6	45.3	2.2	93.1
240 to 279	36	140.8	59.8	14.4	58.5	8.1	84.0
280 to 319	19	147.6	67.0	11.2	65.2	4.2	89.6
320 and over	22	213.9	93.0	63.2	42.2	15.5	63.2
All	286	105.4	52.1	11.8	37.7	3.8	85.2

For all farms about 60 per cent of the plowing was done in the spring and in each size group a greater acreage was plowed in the spring than in the fall. The areas differed considerably, however, in their practice with regard to spring and fall plowing. The percentage of the plowing done in the spring on the farms visited in the different areas was as follows:

	Per cent.
Madison County, Ohio	88
Seneca County, Ohio	67
Madison County, Ind	74
Montgomery County, Ind	72
Livingston County, Ill	23
Knox County, Ill	59

The areas did not differ greatly in the percentage of the total plowing done with tractors. In all, 267 of the 286 men did some plowing in the spring and 225 did some fall plowing.

Spring plowing.—The number of men on farms of different sizes who did all the spring plowing with tractors, those who used both tractor and horses, and those who used horses only was as shown in Table 15.

TABLE 15.—*Kind of power used for spring plowing on farms of different sizes.*

Size of farms (crop acres).	Number of farmers.	Farmers using tractors only.	Farmers using tractors and horses.	Farmers using horses only.
Less than 80	7	5	2	.....
80 to 119	28	21	7	.....
120 to 159	65	41	23	1
160 to 199	53	27	25	1
200 to 239	43	23	19	1
240 to 279	31	12	19	.....
280 to 319	18	9	9	.....
320 or more	22	4	17	1
Total	267	142	121	4
Per cent	100	53	45	2

As the size of farm, and consequently the amount of plowing, increased, the percentage of those who did it all with tractors decreased. Sixty-seven per cent of the men with less than 160 crop acres, 52 per cent of those with 160 to 239 crop acres, and only 35 per cent of those with 240 or more crop acres did all their spring plowing with their tractors.

The number of acres plowed with horses on the smaller farms, as shown in Table 14, indicates that on many of these farms the horses were used only for finishing or for plowing small and irregular fields. On many of the larger farms, however, the amount of spring plowing to be done was so great that the tractors could not do it all in the time available, and horses were worked regularly at plowing during the plowing season. This condition existed on nearly all of the 22 farms with 320 or more crop acres, where an average of 63 acres of spring plowing was done with horses.

Fall plowing.—Table 16 shows the number of men on farms of different sizes who did all their fall plowing with tractors, those who used both tractors and horses, and those who used horses only.

TABLE 16.—*Kind of power used for fall plowing on farms of different sizes.*

Size of farms (crop acres).	Number of farmers.	Farmers using tractors only.	Farmers using tractors and horses.	Farmers using horses only.
Less than 80	2	2	.....	.....
80 to 119	20	16	4	.....
120 to 159	62	55	6	1
160 to 199	42	35	5	2
200 to 239	38	34	3	1
240 to 279	29	23	5	1
280 to 319	16	15	1	.....
320 or more	16	10	3	3
Total	225	190	27	8
Per cent	100	84	12	4

A much larger percentage used tractors exclusively for fall plowing than for spring plowing, and no marked tendency was shown on the large farms to supplement the tractors with horses. Except where land is being plowed for winter wheat, the season for fall plowing is long, compared with the season for spring plowing. Furthermore, the hot weather which usually occurs during the fall plowing season and the harder plowing give the tractor a somewhat greater advantage over horses than it has in spring plowing.

Disking.—Though the tractors were used more for plowing than for any other operation on these farms, 73 per cent of the total disking was done with them. On the farms where winter wheat followed corn and occupied an important place in the rotation, the seed bed was prepared almost entirely with the tractor and disk. The method usually emplo¯ed was first to cut and shock the corn and then disk

the land, following with the disk drill drawn by horses. In Illinois and to a less extent in Indiana the land planted in oats was prepared with the tractor. The cornstalks from the preceding year were broken with the disk and the seed bed put in shape for planting the crop.

On some farms the tractors had not been used to any great extent for disking freshly plowed ground in the spring, because of danger of packing the soil. On many of the larger farms, where it was necessary to supplement the tractor with horses in preparing the seed bed, horses were used for disking while the tractor was being used for plowing.

The fact that a smaller portion of the disking than of the plowing was done with horses was in the main due to these two conditions.

Of the 286 operators, 284 did some disking during the year. In Table 17 is given the number of men on the various sized farms who did all their disking with their tractors, those who used both tractors and horses, and those who used horses only. The disking has not been separated into spring and fall work, or into work on plowed and unplowed ground.

TABLE 17.—*Kind of power used for disking on farms of different sizes.*

Size of farms (crop acres).	Number of farmers.	Farmers using tractors only.	Farmers using tractors and horses.	Farmers using horses only.
Less than 80	7	4	1	2
80 to 119	28	24	3	1
120 to 159	70	39	28	3
160 to 199	56	33	18	5
200 to 239	46	24	20	2
240 to 279	36	18	17	1
280 to 319	19	10	9	.....
320 or more	22	8	13	1
Total	284	160	109	15
Per cent	100	57	38	5

Sixty-four per cent of the men with less than 160 crop acres, 56 per cent of those with 160 to 239 crop acres, and 47 per cent of those with 240 or more crop acres did all their disking with tractors. The fact that more than half of these men did all the disking with their tractors and 95 per cent used them for part of the work indicates a well established place for the tractor in this work as well as in plowing.

Harrowing, rolling, planking, and packing.—In most cases not more than two of these operations were performed on a farm during the year. Six operators had not used spike-tooth or spring-tooth harrows, rollers, plankers, or packers during the year, but had fitted their ground entirely with disks.

When tractors furnished the power, the implements were generally used in combination rather than individually, the most common

practice being to pull one or more of these implements behind the disk. In all, 207 men did at least part of this work with tractors. One hundred and sixty-four of them used these implements behind their disk harrows, and 43 used them alone. (See fig. 6.)

The number of men on the various-sized farms who used these implements and the kind of power employed are given in Table 18.

FIG. 6.—Tractor preparing corn ground for winter wheat with a double disk and packer.

TABLE 18.—*Kind of power used for harrowing, rolling, planking, and packing on farms of different sizes.*

Size of farms (crop acres).	Number of farmers.	Farmers using tractors only.	Farmers using tractors and horses.	Farmers using horses only.
Less than 80	7	3	3	1
80 to 119	28	11	14	3
120 to 159	70	20	33	17
160 to 199	53	12	26	15
200 to 239	47	7	26	14
240 to 279	35	7	19	9
280 to 319	18	4	9	5
320 or more	22	2	11	9
Total	280	66	141	73
Per cent	100	24	50	26

Here again the size of the farm had some influence on the portion of this work done with tractors. On 32 per cent of the farms with less than 160 crop acres, and on only 18 per cent of those with 160 or more crop acres, all this work was done with tractors. The implements used for this work are normally of light draft, and where the tractor and horses were used simultaneously for fitting the ground, the former was often used on the plow or disk and the latter for harrowing, etc.

In all, 72 per cent of the harrowing, planking, rolling, and packing done with tractors was done with one or more of these implements

behind a disk, and 28 per cent independent of the disk. The size of the tractor had a direct bearing upon the combination used, for the 3-plow outfits were able to pull greater loads than the 2-plow machines. Only 61 per cent of the work done with 2-plow tractors was done with harrows, rollers, etc., behind disks, while 92 per cent of that done with 3-plow tractors was done behind disks.

Farms where all work previous to planting was done with tractors.—While the larger part of the plowing and disking and a considerable portion of the lighter work of harrowing, planking, rolling, and packing on these farms was done with tractors, on only 39 of the 286—14 per cent of the total—was all of the work of preparing the seed bed done with tractors. Even on farms whose operators considered their machines suitable for all this work, horses usually did part of it.

Most of the farms where tractors were used exclusively were operated by one man alone. Where an extra man was available a part of this work was nearly always done with horses.

The seed-bed preparation was done with tractors entirely on 21 per cent of the farms with less than 160 crop acres, but horses were used for some seed bed preparation on all but 9 per cent of the farms with 160 or more crop acres. Thirty-four of these 39 men operated 2-plow outfits and 5 of them 3-plow outfits. Thus 20 per cent of all the men who owned 2-plow machines and only 5 per cent of those who owned 3-plow machines did all of this work with tractors. Even though a larger percentage of the men on smaller farms owned 2-plow machines, apparently the greater versatility of the smaller machines made them more satisfactory for all the kinds of work required in preparing the seed bed.

Cutting grain.—Seven of the 286 men interviewed either raised no small grain or paid to have it cut by others. The kinds of power used by the remaining 279 were as follows:

108 or 39 per cent used tractors only.
22 or 8 per cent used tractors and horses.
149 or 53 per cent used horses only.

The 22 men who used both tractors and horses did not always use them simultaneously. More often the two sources of power were used at different times, one on oats and the other on wheat for example.

The size of the farm apparently had little to do with the kind of power used in cutting grain. Forty per cent of the men who had less than 160 crop acres, 42 per cent of those with 160 to 239 crop acres, and 33 per cent of those with 240 or more crop acres cut all their grain with tractors. The size of the tractor however, did have some influence on its use for cutting grain. Fifty-four per cent of the grain was cut with tractors on the farms where 2-plow machines were owned and only 26 per cent on the farms where 3-plow machines

were owned. On the average the smaller tractors were used 1.9 days while the larger outfits were used 0.9 day for this work. (See Table 12.)

On nearly every farm only a single binder was owned, as one was usually sufficient for handling the acreage in small grain. On the 22 farms with 320 or more crop acres there was an average of 75 acres of wheat and 84 acres of oats. Either horses or tractor should cut each of these crops with a single binder in not more than 5 days (see Tables 12 and 22), and in favorable seasons at least this much time is available.

The principal reasons given by these men for using the tractor for cutting grain were that it relieved the horses of hard work in hot weather, and made it possible to get the work done in a shorter time when the season was unfavorable.

Loading hay.—On 59 of the 286 farms no hay was raised during 1920. On 37, or 16 per cent, of the remaining 227 farms, the tractors were used for at least a part of the work of pulling the wagon and hay loader. Twelve of the 37 men used their tractors not only for loading the hay in the field but also for drawing the wagons to the barn for unloading. The remaining 25 used their horses for part of the work of loading and hauling hay. The most common practice on these 25 farms was to use two or more wagons for haying. The tractor was used in the field drawing a wagon and hay loader while the horses drew the loaded wagons to the barn.

The amount of hay grown on these farms was small, compared with the amount of corn and small grain, the average acreage of both hay and seed being only 25 acres (see Table 2). On most of the farms only the second cutting of clover was thrashed for seed but on a few the entire crop was thus used. On account of the small acreage of hay a considerable number of these farmers did not own hay loaders, but loaded their hay by hand. The tractors were never used in connection with haying where this practice was followed, and this accounts in part for the comparatively small number who used their tractors for haying. In an investigation of the influence of the tractor on the use of horses made in 7 corn-belt States in 1918 and reported in Farmers' Bulletin 1093 it was found that "12 per cent of the operators interviewed used their machines for pulling the wagon and loader." Labor shortage was responsible in part for the use of the tractors at that time. On most of the farms the work was done with one man fewer than when horses were used.

While the number of corn-belt tractor owners who use their tractors in haying is evidently small, the results of both these investigations indicate that under certain conditions tractors can be used advantageously for this work.

BELT WORK.

The use of the tractor for belt work does not influence horse labor and should really be considered a separate enterprise. However, the doing of such work with the tractor adds to its usefulness and reduces the cost per day of work for such items as depreciation, interest, and repairs. As shown in Table 10, these 286 tractors were used an average of 2.7 days for belt work on the home farm during the year. However, 91, nearly a third, of the 286 were used for no belt work on the home farm during the year.

Table 11 shows that on the average the 3-plow tractors were used considerably more for belt work than the 2-plow machines. Eighty-five or 82 per cent of the 104 three-plow machines and only 103 or 59 per cent of the 174 two-plow machines were used for belt work on the home farm during the year. (See fig. 7.) Table 19 shows

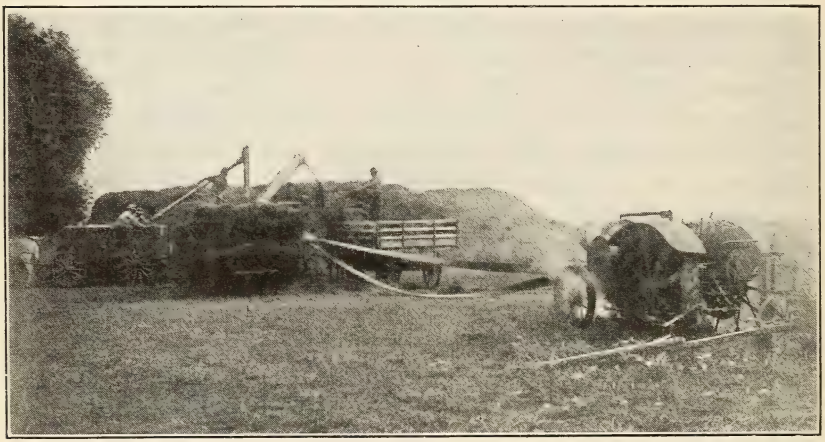

FIG. 7.—Three-plow machines were used more for belt work than the two-plow machines.

the number of men who used their tractors for different kinds of belt work during the year and the average time spent on each kind of work:

TABLE 19.—*Belt work on home farm.*

Operation.	Number performing.	Days used.	Operation.	Number performing.	Days used.
Sawing wood	110	1.4	Shredding	35	3.8
Grinding feed	101	1.5	Shelling corn	15	1.1
Filling silos	58	1.8	Other work	29	2.5
Thrashing	40	3.2			

A large number of the men who sawed wood or ground feed during the year used their tractors for this work. A few owned small stationary engines which were used. On the average 1.4 full days was sufficient for sawing the year's supply of firewood and 1.5 days

for grinding the year's supply of feed. Usually the wood was sawed at one or two different times, while for grinding feed the tractor was run for only a few hours per week in the winter months.

The tractors were often not powerful enough for the heavier work of filling silos, thrashing, shredding, and shelling corn, and this accounts in part for the small number of men who used their tractors for these operations. However, there were no silos on many of the farms; shredding was not common in any except the Ohio areas and in the Madison County, Indiana, area; the practice of shelling corn on the farm was common only in the Illinois areas; and on a majority of the farms thrashing was still done with custom outfits.

CUSTOM WORK.

One hundred and eighty-three farmers did some custom work with their tractors during the year. This work amounted to an average of 4.6 days for all tractors (see Table 10), or 7.2 days for the 183 which were used for custom work. The number of men who used their tractors for different kinds of custom work and the average number of days spent by them at each operation are given in Table 20. In all, 116 tractors were used for custom drawbar work, and 113 for custom belt work.

TABLE 20.—*Custom work.*

Operation.	Number performing.	Days used.
Drawbar:		
Plowing	74	5.0
Disking	35	2.0
Other work	45	3.1
Belt:		
Filling silos	42	3.3
Thrashing	31	8.5
Sawing wood	28	1.9
Shredding	23	7.2
Other work	37	3.6

More than half of the drawbar custom work done by the tractors was plowing. The "other" drawbar work shown in the table included dragging roads, cutting grain, and other kinds of field work, but less than 10 per cent of the owners did any one kind of this work for hire. Comparatively few men did any one belt operation for hire, but from the standpoint of the time spent at the different operations by the men who actually performed them for hire, thrashing and shredding were more important than plowing.

TRACTORS WHICH WERE USED FOR NEITHER BELT NOR CUSTOM WORK.

While drawbar work on the home farm amounted on the average to only 76 per cent of the total work done by the tractors, 55 of the 286

tractors were used for nothing but this class of work during the year covered by the investigation.

The location of the farms on which these 55 tractors were owned is as follows:

Madison County, Ohio	4
Seneca County, Ohio	0
Madison County, Ind	4
Montgomery County, Ind	14
Livingston County, Ill	21
Knox County, Ill	12

On most of the farms visited in Illinois and in Montgomery County, Ind., there was no wood to cut. Silos were not as common in these three areas as in the others. Less livestock was kept on the farms in Livingston County, Ill., than in any other area, and consequently few of the tractors there were used for grinding feed. In fact, on many of the farms in both Illinois areas the only belt work done was thrashing and shelling corn, and the power for this work in most cases was furnished by steam engines.

The greater the percentage of farmers in a community who own tractors, the less will be the opportunity of doing custom work with them, even if the tractor owners desire to do it. Tractors were more numerous in Livingston County, Ill., than in any other area visited, and only 25 of the 60 men interviewed there had used their tractors for custom work during the year.

WORK DONE BY HORSES.

The average number of days of horse labor used for the various operations on the farms of different areas is shown in Table 21, and the daily duty of one horse for each of the field operations in Table 22. The daily duty of one horse, i. e., the number of acres covered per day per horse, at the different operations varied somewhat in the different areas, and to this extent the number of days of horse labor is not a true index of the actual amount of work done by the horses.

Plowing.—Since the tractors did 85 per cent of the plowing on these farms, the average number of days of horse labor used for this work is necessarily small. On the average it amounted to less than 20 days per year in each area except in Madison County, Ohio. The greater use of horses for plowing in this area was due to the fact that several of the farms were so large and the amount of spring plowing so great that the tractors could not do all of it in the time available and the horses were used regularly to supplement the tractors. Table IX shows that the tractors covered slightly less ground per day in fall plowing than in spring plowing. Similarly, the average daily duty of one horse was slightly less for fall plowing than for spring plowing.

TABLE 21.—*Days of horse labor at various operations in different areas.*

Operations.	Madison County, Ohio.	Seneca County, Ohio.	Madison County, Ind.	Montgomery County, Ind.	Livingston County, Ill.	Knox County, Ill.	All.
Spring plowing	42.8	11.1	14.6	15.6	6.8	5.1	14.1
Fall plowing	4.2	3.1	4.0	3.0	8.4	4.7	4.8
Total	47.0	14.2	18.6	18.6	15.2	9.8	18.9
Disking	17.9	5.6	3.3	4.9	37.9	14.1	15.2
Harrowing, rolling, etc	10.5	23.3	10.7	17.8	21.9	26.8	19.3
Total, fitting ground other than plowing	28.4	28.9	14.0	22.7	59.8	40.9	34.5
Broadcast seeding	.2	.1	.7	2.0	3.6	2.4	1.8
Drilling grain	24.1	11.9	13.2	13.1	.7	4.5	10.0
Total, seeding grain	24.3	12.0	13.9	15.1	4.3	6.9	11.8
Planting corn	18.8	6.9	10.2	11.9	12.8	11.8	12.2
Cultivating, 1-row	80.5	34.5	38.4	57.2	80.9	92.2	66.2
Cultivating, 2-row	14.9	4.9	15.5	26.4	12.0	8.8	14.2
Total, cultivating	95.4	39.4	53.9	83.6	92.9	101.0	80.4
Mowing	5.9	8.0	6.4	8.3	3.2	4.8	5.9
Raking and tedding	1.7	4.9	1.2	2.5	2.1	2.5	2.4
Loading and hauling hay	10.2	15.2	9.8	9.4	4.1	9.0	9.1
Total, haying	17.8	28.1	17.4	20.2	9.4	16.3	17.4
Cutting grain	13.0	12.2	7.6	12.6	11.7	6.7	10.7
Thrashing	39.5	20.9	30.5	29.6	30.1	35.9	31.3
Cutting corn	.9	14.2	4.3	7.3	1.5	1.5	3.5
Silage	12.4	4.7	7.6	4.4	1.2	3.5	5.0
Husking from stalk	70.2	3.1	71.5	90.6	95.7	109.8	81.0
Cribbing corn	43.9	2.4	1.4	.0	.0	.0	5.7
Shredding fodder	.4	24.1	3.6	1.0	.8	.1	3.8
Total, corn harvest	127.8	48.5	88.4	103.3	99.2	114.9	99.0
Other field work	1.9	7.7	6.4	6.4	2.4	2.7	4.4
Hauling manure	91.5	49.2	43.8	30.5	32.8	37.4	43.8
Miscellaneous work on farm	115.9	45.1	40.7	48.4	32.3	37.0	49.1
Road hauling	40.2	41.1	28.8	22.3	44.3	42.0	35.4
Custom work	2.2	6.1	2.7	5.4	.2	.3	2.6
Horse labor hired	.0	.2	.4	3.3	.2	1.2	1.0
Total	653.7	360.1	376.5	427.3	447.2	462.4	451.5

TABLE 22.—*Daily duty of one horse at various operations in different areas.*

[Acres per day per horse.]

Operations.	Madison County, Ohio.	Seneca County, Ohio.	Madison County, Ind.	Montgomery County, Ind.	Livingston County, Ill.	Knox County, Ill.	All.
Spring plowing	0.86	0.74	0.73	0.88	0.81	1.00	0.84
Fall plowing	.80	.75	.62	.80	.75	1.03	.80
Disking	3.17	2.56	2.64	3.13	4.08	4.26	3.79
Harrowing, rolling, etc	5.28	5.14	5.27	5.50	9.23	8.09	7.08
Broadcast seeding	18.86	15.50	14.23	16.60	22.97	20.18	20.15
Drilling grain	4.08	5.08	3.88	3.42	4.57	4.02	3.98
Planting corn	6.92	5.85	6.55	8.64	8.63	8.28	7.79
Cultivating, 1-row	3.40	2.98	3.34	3.33	3.67	3.40	3.42
Cultivating, 2-row	4.06	4.33	3.90	4.30	4.20	4.93	4.28
Mowing	4.84	4.99	4.65	3.86	4.54	5.50	4.64
Raking	12.68	7.94	8.77	9.12	5.85	8.73	8.40
Loading hay	2.21	2.30	2.07	2.76	2.11	2.56	2.49
Cutting grain	3.78	3.88	3.79	3.89	4.32	4.36	4.10
Cutting corn	2.73	2.43	2.59	2.05	2.26	2.12	2.49
Husking corn	.57	.55	.60	.71	1.03	.84	.79

Fitting ground other than plowing.—The tractors did the greater part of the work of disking, harrowing, and rolling, but on the average the amount of horse labor used for these operations was nearly twice as great as that used for plowing. Twice as much horse labor was used for disking in Livingston County, Ill., as in any other area, which was due mainly to soil conditions in that area. It had been found on some of the farms that the use of the tractor on plowed ground packed the soil seriously, and on such farms the horses did practically all the disking of plowed ground during the year covered by the investigation.

Seeding grain.—The table shows that small grain was drilled almost exclusively in the Ohio areas and in Madison County, Ind., but that endgate seeders were in common used in other areas. A few farmers in each of the first three areas used endgate seeders for sowing their

FIG. 8.—One man and three horses on a two-row cultivator accomplish nearly twice as much work as one man and two horses on a one-row machine.

oats, but the common practice was to use the drill for both oats and wheat. In the three latter areas practically all the oats was sown with endgate seeders. The use of the endgate seeder reduces both horse-labor and man-labor requirements for this operation, the average daily duty of one horse with the endgate seeder being 20 acres and with the drill only 4 acres.

Planting corn.—Corn planting was done entirely with horses on every farm and the 2-row, 2-horse machine was used exclusively. The differences in the average requirements per farm for this operation are due largely to the differences in the acreage devoted to this crop in the different areas (see Table 2).

Cultivating corn.—Two men cultivated all their corn with their tractors, and 14 others used their machines for part of this work. The table shows that on the average more horse labor was used in corn

cultivation than for any other work except corn harvest. Corn harvest, however, was usually spread over a greater length of time than cultivation, and on most of the farms corn cultivation was the operation which required the greatest amount of horse labor in the shortest time.

Eighty-four of the 284 men who used horses for cultivating used 2-row cultivators for at least part of the work, and 22 of the 84 used 2-row implements exclusively. (See fig. 8.)

On the average the daily duty of one horse on a 2-row cultivator was about 25 per cent higher than the duty of one horse on a 1-row implement, and if 2-row cultivators had been used exclusively the amount of horse labor required for cultivating would have been 25 per cent less than if 1-row cultivators had been used exclusively.

FIG. 9.—Horses only were used for mowing hay on these farms.

Corn cultivating represented the peak of man labor as well as of horse labor requirements on many of the farms, and since one man with a 2-row cultivator accomplished nearly twice as much as one man with a 1-row, the more extended use of the 2-row machine on some of the farms where the acreage in corn was too great to be cultivated with a single 1-row implement would have made it possible to reduce both the number of horses kept on the farm and the number of men employed during the cultivating season.

Haying.—Hay occupied only a small acreage on most of the farms visited, and while the horses did 92 per cent of the total work on this crop the amount of horse labor required for it was small compared with the amount used in cultivating and harvesting corn and in harvesting and thrashing grain. (See fig. 9.)

Variations in practices on individual farms had considerable effect on the amount of horse labor used. On some farms the hay was loaded with a hay loader directly from the swath; on others it

was tedded at least once and raked into windrows before loading. Tedders were used on only a small portion of the farms and no figures for the daily duty of one horse at this work are given. The large acreage covered per day per horse in raking in Madison County, Ohio, is due to the fact that on many of the farms there only one horse was used on the rake although in the other areas 2 horses were nearly always used regardless of the size of the rake. The daily duty of a horse at loading and hauling hay depended almost entirely on whether a loader was used and upon the size of the crew. The figures in Table 22 are simply averages of all farms in each area, regardless of the method of loading employed and the number of men and teams used for the work.

Cutting and thrashing grain.—The small amounts of horse labor used for cutting grain in Madison County, Ind., and Knox County, Ill., are due to the fact that tractors did a larger portion of the work in these counties than in the other areas. Tractors were used for cutting over 50 per cent of the grain in both of these areas. Tractors were used for cutting nearly 50 per cent of the grain in Madison County, Ohio, but the acreage of small grain on the farms visited there (see Table 2), was so great that the amount of horse labor used for this operation was greater than for any other area.

The horse labor listed under thrashing includes all the labor used on these farms for hauling the bundles from the fields to the thrasher and for hauling the thrashed grain to the elevator or market when done by the regular thrashing crew. A large part of this work was "exchange labor," but in practically every case the horses owned by the men interviewed did approximately an equal amount of work in thrashing on neighboring farms. While this work required on the average 31 days of horse labor and on most farms the thrashing was all done in one or two days, the use of the horses owned on a particular farm usually extended over a period of one to two weeks.

Harvesting corn.—The amount of horse labor used for the different corn-harvesting operations reflects the practices in the different areas. The use of horses in cutting corn was confined entirely to the corn binder, and these machines were not in general use in any area except Seneca County, Ohio. The horse labor listed under "Silage" is only that used in hauling corn from the field to the ensilage cutter. On the average, husking from the standing stalk (see fig. 10) required a greater use of horses than any other of the corn harvesting operations, but in Seneca County, Ohio, very little corn was harvested in this way, and in Madison County, Ohio, a considerable part of the crop was ensiled or cut and husked from the shock. The common practice there was to husk the corn by hand from the shock and throw it in piles, the only horse labor used being that required to haul the husked corn from field to the bin or crib. The amount of horse

labor used for this particular operation is listed under "Cribbing corn." The horse labor listed under "Shredding fodder" is that required for hauling fodder to the husker and shredder and any other used for hauling the husked corn from the machine to the bin. The husker-shredder was used on practically every farm in Seneca County, Ohio.

Although the methods of harvesting corn varied considerably in the different areas, these differences in method apparently had little influence on the total amount of horse labor per acre required for harvesting corn. For all farms an average of 1.1 days of horse labor

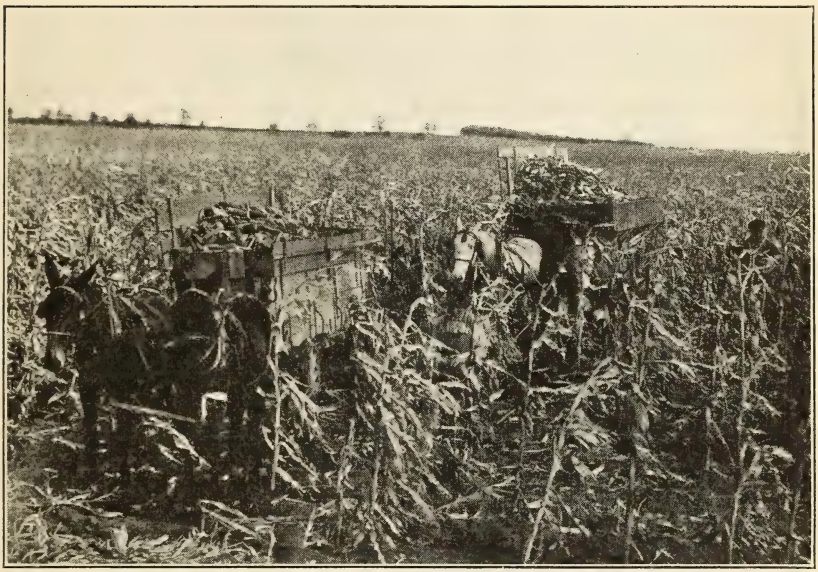

FIG. 10.—Husking corn from the standing stalk was more common in Illinois than in Indiana and Ohio.

per acre were used for corn harvest, and the average number of days of horse labor used in the different areas is as follows:

	Days.
Madison County, Ohio	1.0
Seneca County, Ohio	1.2
Madison County, Ind	1.3
Montgomery County, Ind	1.2
Livingston County, Ill	0.9
Knox County, Ill	1.2

The small amount of labor used in Livingston County, Ill., was due to the fact that the yield per acre in this area was low in 1920 and the number of acres covered per day in husking from the standing stalk depends almost entirely upon the yield. In Madison County, Ohio, a larger portion was cut by hand than in any other area and this resulted in a slight reduction in the amount of horse labor used.

Other field work.—All horse labor used for field operations other than those listed above is included under this item in Table 21. This work consisted of such operations as planting, cultivating, and harvesting potatoes, tomatoes, and sugar beets; applying fertilizer and sowing grass seed wherever done as separate operations; and hulling clover seed. While on the average this work was not important, on some of the farms more horse labor was used on it than on part of the operations that have been listed separately. In all, 107 of the 286 men used horses for some work of this character and on these 107 farms it amounted to 12 days on the average.

Hauling manure.—The amount of horse labor used for this work varied greatly on individual farms, depending upon the number and kinds of live stock kept, the methods of feeding, and the disposition of the manure. On the average more horse labor was used for hauling manure than for any other field operation except cultivating and harvesting corn. In Seneca County, Ohio, where the acreage in corn was low, more horse labor was used for manure hauling than for either corn cultivation or corn harvest.

Miscellaneous work on the farm.—Under this heading in Table 21 is placed all horse labor used on the farm itself which is not classified elsewhere. It includes such work as hauling stover from the field to the barn or feed lot, hauling straw from the stack to the barn, moving feed or hauling feed and water for live stock, hauling wood, building and repairing fences, mowing weeds, and work in the orchard and garden. Most of this work was done at times when field work was not pressing and a large part of it was light work, but on the average horses were used on it for a greater length of time than on hauling manure.

Road hauling.—All of the horse labor used for hauling produce from the farm and supplies to the farm, excepting the comparatively small amount used in hauling grain directly from the separator to to market, is included here. In the two Indiana areas a considerable portion of this hauling was done with motor trucks (see page 7) and on that account the amount of horse labor used for road hauling there was less than in other areas.

Custom work.—Some of the farmers interviewed had hired out horses to neighboring farmers or had used them for building or repairing roads during the year. The figures in Table 20 show the average amount of such work done per farm in the different areas. The workstock on 33 of the farms had done some such work during the year, and while for all farms this work amounted to an average of 2.6 days, it amounted to an average of over 22 days for the 33 farms.

Horse labor hired.—Twenty-three of the men interviewed had hired some of the horse labor which was used on their farms during the year. The amount of horse labor used for the various operations

as given in Table 21 includes all the horse labor used, no difference being made between horses owned and horses hired, and to determine the actual number of days of labor performed by horses owned on these farms the labor performed by hired horses is subtracted from the total. Although this hired horse labor amounted to an average of only 1.0 day for all farms, it amounted to about 13 days on the 23 farms. If it is possible to hire horses when they are needed, this practice is preferable to keeping one or two horses throughout the year for only a few days work during the rush season.

Work done with 2-horse teams.—Loading and hauling hay from the field to the barn or stack, hauling grain to and from the thrashing machine, all the work of corn harvest (except cutting corn and drawing the mechanical picker on a few of the farms), and hauling to and from the farm were almost universally done with 2-horse teams. On a large majority of the farms manure was hauled, whether in wagon or spreader, with two horses, and wagons drawn by two horses were used for a large percentage of the miscellaneous work on the farm. On the average a total of 265 days of horse labor was used for these operations.

A few farmers used three horses for drawing their manure spreaders, and a few used four horses for drawing the wagon and hay loader and for road hauling when the roads were muddy. But even after making a liberal allowance for the portion of this work which was done with 3 or 4 horse teams, approximately 50 per cent of the time during which horses were used was occupied in hauling or other wagon work with 2-horse teams.

This work does not require an expenditure of energy on the part of horses proportionate to the amount of time used for it. In nearly all of this work the horses and wagon are standing still a considerable part of the time, and the horses are drawing only an empty wagon approximately half of the time they are in motion.

On practically all of the farms, teams of at least three horses were used for work in preparing the seed bed, for drilling and cutting grain, for cutting corn, and for drawing a 2-row cultivator. Teams of more than two horses were never used, however, for broadcast seeding of small grain, planting corn, drawing 1-row cultivators, and mowing, raking, and tedding hay. These operations occupied on the average a total of 88 days of horse labor per farm. In all, a total of 353 days of horse labor were used on the average farm for the wagon work listed above, and for these 2-horse field operations. This is over 75 per cent of the total horse labor used during the year.[1]

[1] Detailed records kept by the Office of Farm Management and Farm Economics on 14 farms in west-central Illinois where tractors were not owned show that 62 per cent of the horse labor was used in 2-horse units.

HORSE LABOR EQUIVALENT OF TRACTOR WORK.

Table 23 shows the horse labor equivalent of the drawbar work done at home by the tractors in the different areas. Table 14 (page 18) shows that on the average the tractors did 52.1 acres of spring plowing and 37.7 acres of fall plowing per farm, and Table 22 (page 27) shows that the daily duty of one horse was 0.84 acre at spring plowing and 0.80 acre at fall plowing. Thus on the average, 62.1 days of horse labor would have been required to do the spring plowing which the tractors did and 47.1 days to do the fall plowing. In other words the average tractor did the equivalent of 109.2 days of horse labor in plowing. The figures for each operation in the various areas were obtained in a similar manner.

TABLE 23.—*Horse-day equivalent of tractor work in different areas.*

Operations.	Madison County, Ohio.	Seneca County, Ohio.	Madison County, Ind.	Montgomery County, Ind.	Livingston County, Ill.	Knox County, Ill.	All areas.
	Horse-days.	*Horse-days.*	*Horse-days.*	*Horse-days.*	*Horse-days.*	*Horse-days.*	*Horse-days.*
Plowing	126.0	80.9	103.1	106.3	131.6	96.1	109.2
Fitting ground after plowing	88.8	67.0	76.2	99.7	52.6	72.1	68.4
Haying	.....	1.2	4.6	1.8	.2	1.8	1.5
Cutting grain	16.6	2.8	12.3	6.1	6.5	9.0	7.4
Other drawbar work	14.3	3.6	12.2	6.5	4.0	9.0	7.9
Total	245.7	155.5	208.4	220.4	194.9	188.0	194.4

Comparison of the number of days of drawbar work actually done by the tractors with the horse-labor equivalent shows that in each area the tractors did as much work per day as would have been done by eight or nine horses. The average number of days the tractors were used for drawbar work on the home farm in the different areas was as follows:

	Days.
Madison County, Ohio	30.0
Seneca County, Ohio	17.0
Madison County, Ind	23.7
Montgomery County, Ind	25.4
Livingston County, Ill	21.3
Knox County, Ill	24.0

For the entire 286 farms the tractors did as much work per day as would have been done by 8.3 horses. When plowing, each 2-plow tractor performed the equivalent of 7.9 days of horse labor per day in the spring and 8.1 days in the fall. The 3-plow tractors performed the equivalent of 10.3 days of horse labor in the spring and 10.8 days in the fall. (See tables 12 and 22).

The average number of days of horse labor per year per head in the different areas was as follows:

	Days.
Madison County, Ohio	79.2
Seneca County, Ohio	72.3
Madison County, Ind	72.3
Montgomery County, Ind	72.4
Livingston County, Ill	54.9
Knox County, Ill	68.0

Comparison of these figures with those in table 23 shows that on the average each tractor did as much drawbar work during the year as was done by 2.8 horses. In Seneca County, Ohio, the work done by each tractor was equivalent to the number of days of horse labor performed by 2.2 horses during the year, while in Livingston County, Ill., it was equivalent to that performed by 3.5 horses. The horse labor equivalent of the work done by tractors in this area was not as great as in some of the other areas, but the workstock were used a considerably smaller number of days per year than in any other area.

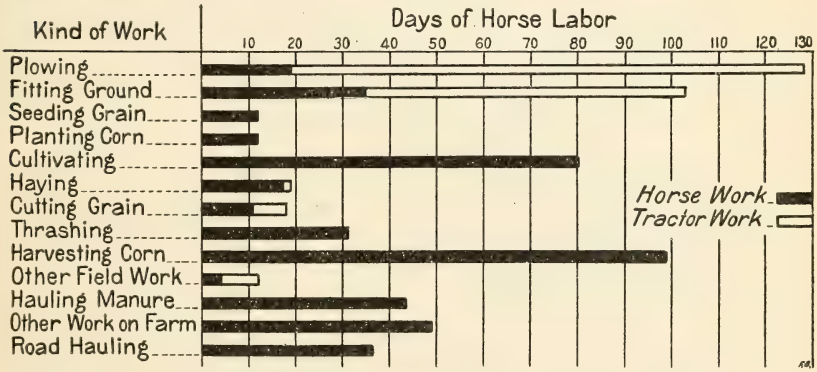

FIG. 11.—Proportion of different kinds of work done with horses and tractors.

PROPORTION OF WORK DONE BY HORSES AND BY TRACTORS.

Table 24 shows the average number of days of horse labor per farm used on the different operations, the horse labor equivalent of the work done by the tractors, the number of days of horse labor which would have been necessary if tractors had not been owned, and the percentage of the different operations done with tractors. The same items are shown graphically in figure 11. The horse labor listed under "Other field work" is the same as that shown in Table 21, but the tractor work listed there consisted partly of seeding grain, cultivating, and harvesting corn (see page 15).

TABLE 24.—*Proportion of different operations done with horses and with tractors (all farms).*

Operation.	Days of horse labor per farm.	Horse-day equivalent of tractor work.	Total.	Percentage done with tractors.
Plowing	18.9	109.2	128.1	85.2
Fitting ground after plowing	34.5	68.4	102.9	66.5
Seeding grain	11.8	.....	11.8	.....
Planting corn	12.2	.....	12.2	.....
Cultivating	80.4	.....	80.4	.....
Haying	17.4	1.5	18.9	7.9
Cutting grain	10.7	7.4	18.1	40.9
Thrashing	31.3	.....	31.3	.....
Corn harvest	99.0	.....	99.0	.....
Other field work	4.4	7.9	12.3	.....
Hauling manure	43.8	.....	43.8	.....
Other work on farm	49.1	.....	49.1	.....
Road hauling	36.4	.....	36.4	.....
Total	449.9	194.4	644.3	30.1

As measured in terms of the days of horse labor required for it, the tractors did 30.1 per cent of the drawbar work on these farms. The proportion of the work done with the tractors varied among the individual farms, but there was no great variation in the average for the different areas.

The percentage of the work, in terms of days of horse labor, done by the tractors in the different areas was as follows:

	Per cent.
Madison County, Ohio	27.0
Seneca County, Ohio	30.2
Madison County, Ind	35.6
Montgomery County, Ind	34.0
Livingston County, Ill	30.5
Knox County, Ill	28.9

The tractors on the larger farms did considerably more drawbar work than the machines on the smaller farms, but the size of the farm had very little influence on the proportion of the total done with the tractor.

If it had been possible to measure the work done by the tractor and workstock in terms of drawbar pull and distance traveled, the proportion of the total done by the tractors would have been considerably greater. A large proportion of the work done by the tractors was plowing and other work in preparing the seed bed, which requires steady pulling of a heavy load, while a large part of the work done by the horses was hauling and other work which does not require steady pulling of heavy loads.

The 2-plow tractors were used more for disking and for the lighter operations of harrowing, rolling, etc., and for cutting grain than were the 3-plow machines (see Table 12). The proportion of the total work required for plowing and preparing the seed bed and for

cutting grain which was done with the 2-plow and 3-plow outfits on the farms where they were owned is shown in Table 25.

TABLE 25.—*Percentage of different operations done with 2-plow and with 3-plow tractors.*

Operation.	2-plow (174 farms).	3-plow (104 farms).
	Per cent.	*Per cent.*
Spring plowing	83.7	80.6
Fall plowing	88.5	93.3
Disking	82.0	63.3
Harrowing, rolling, etc	49.1	36.2
Cutting grain	53.8	25.9

NUMBER OF WORKSTOCK USED ON DIFFERENT OPERATIONS.

The number of workstock used for each operation as well as the number of workstock owned was obtained from the operators of the farms visited. Table 26 gives the number of workstock on the different farms and the number of operators who used all for cultivating corn or some other one operation.

TABLE 26.—*Number of workstock owned on different farms and number of farms where all were used for some one operation.*

Number of workstock owned.	Number of farms.	Number of farms where all workstock were used for cultivation.	Number of farms where workstock were not all used for cultivation, but were all used for some other operation.	Number of farms where all workstock were never used for any one operation.
2	11	10	1	0
3	15	9	6	0
4	43	29	9	5
5	41	18	5	18
6	57	27	7	23
7	32	4	3	25
8	39	5	4	30
9	15	1	1	13
10	12	1	2	9
11	1	0	0	1
12	4	0	0	4
13	6	0	0	6
14	5	0	0	5
16	1	0	0	1
18	1	0	0	1
20	2	1	0	1
24	1	0	0	1
Total	286	105	38	143

Ninety-three per cent of the men with 4 or less head of workstock, 57 per cent with 5 or 6, 23 per cent with 7 or 8, 19 per cent with 9 or 10, and 5 per cent with over 10 used them all for some one operation. One-half of the operators never used all of their workstock for any one operation.

On most of the farms the cultivation of corn required more horse labor than any other single operation in the limited amount of time available for the work. Of the 143 men who used all of their work-stock for some one operation 73 per cent used them for the cultivation of corn.

Two men cultivated their corn entirely with their tractors, 14 used their tractors for part of the work, and 270 used horse-drawn cultivators only. The acreage in corn on these 270 farms and the number of horses used on each for cultivating were as shown in Table 27.

TABLE 27.—*Number of horses used for cultivating corn on farms of different sizes using horse-drawn cultivators only.*

Acres in corn.	Number of farms.	Farms using 2 horses.	Farms using 3 horses.	Farms using 4 horses.	Farms using 5 horses.	Farms using 6 horses.	Farms using 7 horses.	Farms using 8 horses.	Farms using 9 horses.	Farms using 10 horses.	Farms using 11 horses.	Farms using 12 or more horses.
Less than 35	20	17	1	2								
35 to 54	42	7	11	18	4	2						
55 to 74	51		2	32	8	8	1					
75 to 94	49			21	15	12		1				
95 to 114	43			14	7	16	2	4				
115 to 134	20				1	16	1	2				
135 to 154	24				1	13	3	5	1			1
155 or more	21					4	3	3	3	3	1	4

Apparently some of these men used more horses than necessary for their corn cultivation. Two horses should be ample for cultivating 35 acres or less, but three men used more than two horses. Three or four horses, drawing one 2-row or two 1-row cultivators, should be sufficient for 35 to 54 acres of corn, and a majority of the men with 55 to 74 acres used only 4 horses for cultivating, yet 23 of the 93 men with 35 to 74 acres in corn used more than 4 horses for cultivating. Similarly, the cultivating could evidently have been done with fewer horses on some of the farms with greater acreages in corn.

If 2-row cultivators had been used exclusively on the farms where two 1-row outfits were used, only three horses and one man would have been required for the work. A more extended use of 2-row machines on the farms with larger acreages in corn would have often made it possible to do the cultivating with fewer horses, and fewer men as well.

On some of these farms more horses were needed for some other operation than for corn-cultivating. If machines and men are available for cultivation on such farms, it might be profitable to use the horses which would otherwise be idle. This practice is responsible for the large number of horses used for cultivating on some of the farms.

On 38 of the farms the workstock were not all used for cultivation, but were used for some other one operation. The particular operation for which all the horses were used depended on the amount and kind of crops raised and the operations for which the tractor was used. On some of the farms where only 3 or 4 head were owned they were all used for cutting grain. On some few they were all used for fitting ground, haying, or husking corn.

In some seasons hay must be made and grain must be cut before corn cultivating is finished. On this account it can not be said that all of the men who did not use all of their horses for any one operation could have reduced the number kept with safety. Many farmers, however, used their tractors for cutting grain and some for drawing a wagon and hay loader. Even though an operator may not consider it profitable to use his tractor for such work, it might be more economical to perform these operations with the tractor than to keep extra horses throughout the year.

Every man who owned 2 or 3 head of workstock used them all for some one operation, and every man who owned 4 or 5 head used all but one. Sixty-six of the 155 men who owned 6 to 10 head and all but one of the 21 who owned more than 10 head had at least 2 more horses than were used for any one operation. On 26 of the 286 farms there were at least 4 more horses than had been used for any one operation during the year.

The reliability of the tractor was such that on most of the farms it was not necessary to keep extra horses for use in case the tractors were out of commission when needed (see page 53). On many of the farms the acreage had not been increased and the number of workstock had not been reduced since the purchase of the tractor (see page 56). In view of these facts it is evident that either more work could have been accomplished by more efficient use of the horses on hand, or the number of horses kept could have been reduced and the cost of the operation of the farm correspondingly decreased.

COST OF KEEPING WORKSTOCK.

A record of the amount and value of the feed consumed by the workstock during the year ending October 31, 1920, and the value of these feeds was obtained from each farmer. The amount of time spent in taking care of the horses, the value and depreciation of work harness, the change in value of the workstock, the value of colts foaled during the year, and the cash outlay for shoeing and veterinary services were also obtained. In computing the cost of keeping the workstock these items, together with interest at 6 per cent on the average value, were included. A manure credit of $15 per head was deducted from this total cost to obtain the net cost per farm and per head. Table 28 shows the cost per head in the different areas.

TABLE 28.—*Cost of keeping workstock in different areas.*

Area.	Number of farms.	Average number of workstock per farm.	Cost per head.							Total.	Manure credit.	Net cost per head.
			Feed.	Shoeing.	Veterinary.	Chores.	Interest.	Harness.	Depreciation.			
Madison County, Ohio	34	8.1	$135.96	$3.05	$0.58	$15.43	$9.57	$5.43	$3.36	$173.38	$15.00	$158.38
Seneca County, Ohio	34	5.0	160.25	3.75	.66	22.58	9.02	5.21	4.64	206.11	15.00	191.11
Madison County, Ind	42	5.4	135.56	3.13	1.19	16.52	7.87	4.87	1.20	170.34	15.00	155.34
Montgomery County, Ind	56	6.0	123.10	2.23	1.04	16.47	8.49	3.52	13.68	168.53	15.00	153.53
Livingston County, Ill	60	8.4	128.78	1.27	1.69	14.07	8.86	5.10	6.72	166.49	15.00	151.49
Knox County, Ill	60	7.0	135.13	1.41	1.03	14.65	8.08	4.97	12.09	177.36	15.00	162.36
All	286	6.8	133.64	2.16	1.13	15.83	8.62	4.82	7.79	173.99	15.00	158.99

The average net cost per farm of keeping the workstock during the year was $1,076. The costs per farm in the different areas were:

Madison County, Ohio	$1,278
Seneca County, Ohio	956
Madison County, Ind	839
Montgomery County, Ind	926
Livingston County, Ill	1,280
Knox County, Ill	1,133

The greater number of workstock kept on the larger farms (see Table 9) naturally makes the cost per farm greater. The average cost per farm on the farms of different sizes was:

Less than 80 crop acres	$621
80 to 119 crop acres	660
120 to 159 crop acres	849
160 to 199 crop acres	1,006
200 to 239 crop acres	1,120
240 to 279 crop acres	1,292
280 to 319 crop acres	1,367
320 or more crop acres	1,966

No attempt was made to obtain figures on the cost of housing the animals or on taxes and insurance. These items, however, would amount to only a small percentage of the total. United States Department of Agriculture Bulletin 560, "The Cost of Keeping Farm Horses and the Cost of Horse Labor," based on detailed cost account records, shows that for the period of 1909 to 1914 these charges amounted to about 10 per cent of the total cost of keeping horses in Illinois and Ohio. Figures presented in the University of Illinois Agricultural Experiment Station Bulletin 231, "The Horse and the Tractor," shows that for the six years, 1913 to 1918, the charge for shelter there amounted to 3.1 per cent of the total cost of keeping

workstock, and for the years 1917 and 1918 amounted to a little over 2 per cent.

Feed.—Table 29 shows the average annual feed consumption per head in the different areas. The detailed rations for the workstock were obtained on only 253 of the 286 farms. On the remaining 33 farms the value of the feeds consumed was obtained but the amounts were not.

TABLE 29.—*Feed for workstock.*

Area.	Number of farms.	Average annual feed consumption per head.									Cost of feed per head.
		Hay (tons).	Straw (tons).	Stover (acres).	Corn (bushels).	Oats (bushels).	Pasture and grass.		Stalk pasture.		
							Number of months or acres.	Number of farms.	Number of months or acres.	Number of farms.	
Madison County, Ohio.	32	1.63	0.13	2.60	36.1	4.6	5.8 months..	12	.....	....	$135.96
							3.2 acres.....	20			
Seneca County, Ohio...	23	2.72	.12	1.06	37.4	29.2	4.2 months..	15	.....	....	160.25
							3.2 acres.....	5			
							None.....	3			
Madison County, Ind..	22	1.66	1.04	.22	37.0	13.5	5.9 months..	13	3.0 months..	1	135.56
							2.3 acres.....	9	None.....	21	
Montgomery County, Ind.	56	1.54	.98	.11	36.2	23.4	5.3 months..	46	3.0 months..	48	123.10
							2.1 acres.....	10	None.....	8	
Livingston County, Ill.	60	.47	2.49	.02	39.9	29.2	4.2 months..	26	3.1 months..	25	128.78
							2.1 acres.....	32	4.3 acres.....	21	
							None.....	2	None.....	14	
Knox County, Ill.....	60	1.15	1.23	.04	38.3	24.4	4.1 months..	32	3.3 months..	23	135.13
							1.6 acres.....	21	2.6 acres.....	30	
							None.....	7	None.....	7	
All.....	253	1.32	1.22	.20	37.8	22.3	4.8 months..	144	3.1 months..	97	133.64
							2.3 acres.....	97	3.3 acres.....	51	
							None.....	12	None.....	105	

The feeding practices varied considerably in the different areas. In the Ohio areas and on a number of the farms visited in Indiana corn stover made up a substantial part of the winter ration of the workstock. In Illinois and on the Indiana farms where most of the corn was husked from the standing stalk the horses were usually turned into the stalk fields when husking was finished, and the stalk pasture took the place of the stover. On many farms, especially in Ohio and Indiana, the workstock had access to the straw piles, but the owners usually considered that the straw thus consumed by the horses was of little value and would make no charge for it. Whenever the farmers considered that the straw used for bedding had any value, this was included in the ration, and no attempt was made to differentiate between it and straw used for feed. The large amount of straw and the small amount of hay in the ration for Livingston County, Ill., is due to the fact that in the year 1919 very little hay was produced in this county, and on many of the farms the horses had been wintered on straw and stalk pasture only.

On some farms it was rather difficult to obtain an accurate estimate of the amount and value of both the grass and stalk pasture which

should be charged to the workstock. The number of months the horses were on pasture and the value of pasture per head per month was obtained from part of the men and from others the number of acres of pasture which the horses used and the value per acre for the season.

Exclusive of the grass and stalk pasture, the average ration per head consisted of 6,120 pounds of roughage and 2,830 pounds of grain. This is probably somewhat lower than the average amount of feed per year consumed by the horses on the farms where tractors are not owned in these same areas. It was impossible to obtain accurate figures on this subject, but many of these tractor owners stated that their horses were idle most of the time when horses on other farms were being used daily for the heavy work of plowing and preparing the seed bed, and that during such times their horses were on pasture, or received only a light ration of grain and hay.

The average prices of feeds for the year as obtained from the farmers in the different areas are given in Table 30.

TABLE 30.—*Prices of horse feeds in different areas.*

Location.	Hay per ton.	Stover per acre.	Straw per ton.	Corn per bu.	Oats per bu.	Pasture.		Stalks.	
						Per acre.	Per month.	Per acre.	Per month.
Madison County, Ohio	$23.93	$5.58	$3.57	$1.48	$0.69	$7.17	$2.85	.....	.....
Seneca County, Ohio	24.17	8.34	5.00	1.50	.81	7.00	2.23	.....	.....
Madison County, Ind	23.91	10.55	7.90	1.52	.75	9.11	2.19	.....	$1.50
Montgomery County, Ind	22.61	6.11	8.74	1.47	.75	6.80	2.18	.....	1.74
Livingston County, Ill	28.62	10.80	9.56	1.43	.73	6.81	2.33	$1.35	1.79
Knox County, Ill	25.76	8.38	9.02	1.47	.73	7.50	2.51	1.11	1.59
All	24.94	6.96	8.74	1.47	.74	7.25	2.34	1.14	1.73

The value of grain and hay is now (Sept., 1921) considerably less than during the year covered by the investigation. Based on the prices for grain and roughage given below, the cost of the average ration per year would be about $60.

Corn, 53 cents per bushel.
Oats, 29 cents per bushel.
Loose hay, $13 per ton.
Straw, $4.50 per ton.
Stover, $3.50 per acre.

The figures for corn, oats, and hay are the average prices to farmers in Sept., 1921, for the States of Ohio, Indiana, and Illinois, as reported by the Bureau of Crop Estimates. The prices of the straw and stover have been obtained by reducing the prices given in Table 30 by the percentage of decline in the price of hay since the time of the investigation.

The average cost per farm of feed for the workstock for the year 1920 as obtained in the investigation was $904. If the feed had

been charged to the workstock at the 1921 prices shown above, the cost per farm would have been about $400, a reduction of about 55 per cent below the 1920 cost. Assuming no change in other costs and credits, the 1921 cost per farm of maintaining the workstock would be about $575, or $85 per head.

Chores.—The total time spent in feeding and caring for the workstock amounted to 430 hours per farm for the year, or about 63 hours per head. The figures given in Table 28 represent the value of this time at 25 cents per hour. This rate is approximately the average value per hour of all farm labor in this section during the year of the survey. It must be remembered that all this work was done either by the farmer himself or by the regular labor without any actual cash outlay for it, and that a considerable part of the time thus used would not have been profitably employed otherwise.

Depreciation.—The total value of all workstock on the farm at the time of the investigation, the value of the workstock on the farm at the beginning of the year covered by the investigation, the cost of any which had been bought during the year, and the amount received for any which had been sold were obtained from each farmer. Colts which were foaled during the year of the investigation were credited to the workstock at their value (minus the breeding fee) at the time of the survey. All these figures were combined to obtain the total appreciation or depreciation of the workstock on the farm.

On all the 286 farms a total of only 111 colts had been foaled during the year. (See Table 6.) The average value of these colts at the time of the survey was not far from $50 and the breeding fee in most cases had been $15. Thus, for all farms, the credit for colts amounted to about $2 per head of workstock.

On this basis the workstock had depreciated on 154 of the farms during the year of the investigation by an average of $136 per farm. They had appreciated on 64 farms by an average of $92 per farm, and there had been no change of value on the remaining 68 farms, thus making a net depreciation of about $53 per farm, or $7.79 per head. This depreciation amounted to a little over 5 per cent of the value of the workstock. If the credit for colts had not been included the depreciation would have amounted to nearly 7 per cent of the value of the workstock.

Only a part of the feed consumed by the workstock is salable, and a large part of the costs other than feed do not represent any outlay of cash on the part of the farmer. Likewise the manure produced, for which a credit of $15 per head has been allowed, had no sale value on a large majority of these farms.

The corn, oats, and hay consumed by the workstock was practically all salable, and in most cases the straw which was included as part of the ration could have been sold. Stover, however, could rarely have

been sold; the pasture, both grass and stalk, charged to the horses is principally a by-product of the general system of farming practiced in this section, and only in isolated cases could it have actually been sold.

On this basis the value of salable feed consumed during the year was $113 per head or about $772 per farm. On nearly all the farms, the only other costs which involved either the use of salable material or labor or the expenditure of cash were the shoeing and veterinary bills, which together amounted to $22 per farm. Thus salable feed and cash expense together amounted on the average to about 74 per cent of the net cost of keeping the workstock.

Cost of horse labor.—The cost per day of horse labor on each farm was found by dividing the total cost of keeping the workstock on that farm by the number of days of horse labor used during the year. For all farms the average cost per day was $2.43. The average length of the working day for the horses was nearly 10 hours (see page 12), and consequently the cost per hour of horse labor on these farms

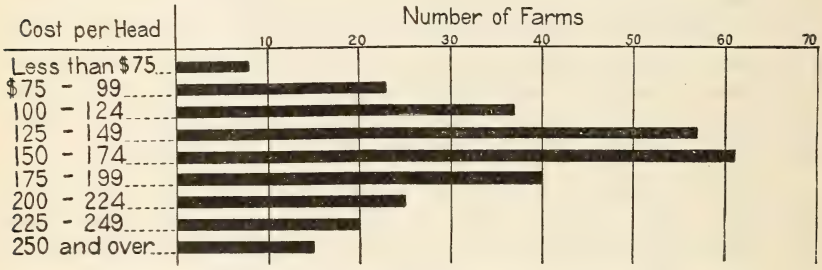

FIG. 12.—Variation in 1920 cost per head of keeping horses.

was between 24 and 25 cents. The cost per day on any farm is dependent upon the number of workstock kept, the cost of keeping them, and the number of days work during the year. The different farms varied greatly in the cost per head of keeping workstock, owing to variations in the different items of cost. The cost per head of feed was twice as great on some of the farms as on others. It has already been pointed out that farms of the same size varied considerably in the number of workstock kept, and that similar variations occurred in the number of days the horses worked per year. Figures 12 and 13 show the variations in the cost per head of keeping the workstock and in the cost per day of horse labor on these farms. It is apparent that by more careful management both the cost per day of horse labor and the total cost of keeping the workstock could have been reduced on many farms.

The acres per day covered by 1 horse at various operations on these farms have been given in Table 22. The cost per day of horse labor divided by the number of acres covered by one horse gives the

cost per acre of power as furnished by horses for the different operations. While the costs vary widely from farm to farm, the average gives a basis of comparing the cost of power as furnished by horses with that furnished by tractors for the different operations.

The average cost of power per acre furnished by horses for the principal operations on which tractors were also used was as follows:

Spring plowing	$2.89
Fall plowing	3.04
Disking	.64
Harrowing, rolling, etc	.34
Drawing hayloader	.98
Drawing grain binder	.59

These figures represent the cost of power only and not the total cost of performing the different operations. The cost of man labor and the cost of the implements must be added to the cost of power, to obtain the total cost.

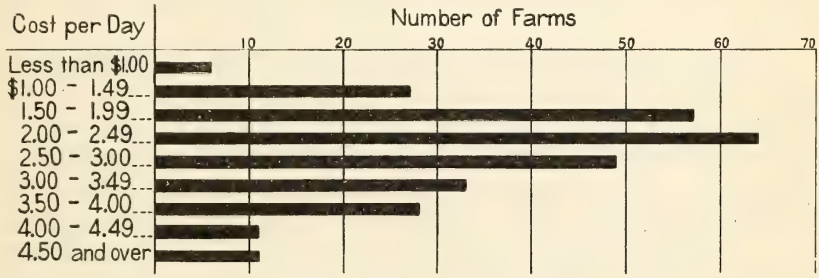

FIG. 13.—Variation in cost per day of horse labor (1920).

If the 1921 prices of feeds (as given on page 42) were used in computing the cost of horse labor, the cost per day would be $1.29 and the cost of power as furnished by horses for the different kinds of work would be 53 per cent of the figures given above.

The cost per unit of horse labor on these farms where tractors are owned can not be considered as exactly representative of the costs on the farms where tractors are not owned, as on many of the farms the cost per head of keeping the workstock was lower than it would have been if tractors had not been owned, and the number of days' work per head also would have been considerably different on many of the farms.

COST OF USING TRACTORS.

The first cost of each tractor and the owner's estimate of its life were given. The cost of any equipment not included in the price of the tractor was added to the reported first cost. This equipment consisted of belt pulleys, fenders, and in a few cases governors. The annual depreciation of each tractor was determined by dividing its first cost by the owner's estimate of its life.

The cash outlay for repairs during the year and the amount of time spent by the owner in repairing or overhauling the tractor

were obtained. Interest was charged at 6 per cent on the average investment.

The total annual cost for depreciation, repairs, and interest was divided by the number of days of work done by the tractor during the year to obtain the cost per day of work for these items. To this was added the cost of fuel and oil used per day to obtain the total cost per day of use, and the sum divided by the number of acres covered in a day to obtain the acre-cost of using the tractor on the different operations. No charges for shelter, insurance, and taxes are included. These charges would amount to only a small percentage of the total cost, however.

In the following discussion the 2-plow and 3-plow machines are treated separately in order to afford a comparison between the two sizes. On all the 286 farms there were only 8 tractors of sizes other than these (see page 9), and no figures for them are given. The 286, however, are included in every case in the figures for "All tractors."

First cost.—The average first cost of the 174 2-plow machines was $972; of the 104 3-plow machines, $1,354, and of the entire 286, $1,140. These figures include the first cost of all extra equipment, for the tractors themselves, but do not include the cost of new implements purchased. Every farmer owned a tractor plow and a majority had also purchased tractor disks. Some had also procured belt machines for use with the tractors. On the average the amount which had been spent by the owners of the 2-plow tractors for implements and machines was $271, and by the owners of 3-plow tractors $430. For all farms this item amounted to an average of $343.

Life.—The average estimated life of the 286 tractors was 6.7 years. The average of the estimates for the 2-plow tractors was 6.4 years, and for the 3-plow 7.0 years.

TABLE 31.—*Estimated life of tractors.*

Estimated life of tractor (years).	Number of owners estimating life of tractor as specified.	
	Owners of 2-plow tractors.	Owners of 3-plow tractors.
3	5	5
4	17	4
5	51	30
6	33	13
7	17	13
8	22	14
9	7	2
10	21	16
11		1
12	1	3
15		3

The estimates of the 174 owners of 2-plow tractors and the 104 owners of 3-plow tractors were as given in Table 31.

It is seen that for each size the largest number estimated the life at 5 years. The wide range in the estimates was due not only to the condition of the tractors at the time of the investigation and the amount of work which would be done with them in the future but also to a considerable extent to each individual owner's idea as to when it would be more profitable to discard his tractor than to spend more time and money in keeping it in running order.

The averages of the estimates for the 2-plow and 3-plow tractors of different ages are given in Table 32. There evidently was no tendency on the part of the men who had owned their machines only a short time to over-estimate the length of time their tractors would last. For each size the average of the estimates of the men who had owned their tractors 14 months or less; i. e., those who had done just one full year's work with them, was less than the average of all estimates.

TABLE 32.—*Estimated life of 2-plow and 3-plow tractors of different ages.*

Age of tractor (months).	2-plow tractors.		3-plow tractors.	
	Number.	Estimated life (years).	Number.	Estimated life (years).
14 and less	74	6.3	29	6.6
15 to 26	60	6.6	39	7.2
27 to 38	28	6.5	20	7.0
39 and over	12	6.2	16	7.6
All	174	6.4	104	7.0

Depreciation.—The annual depreciation charge for each tractor was determined by dividing its first cost by the owner's estimate of its life. The wide range in the estimated life necessarily caused a wide range in the annual depreciation charges for the different machines, but this method is probably the best available, and the average determined in this way will at least show the importance of this item of cost.

The average annual depreciation for all tractors was $185. For 2-plow tractors it was $164, and for the 3-plow $217. For most of the machines this charge was the greatest single item of cost connected with their use.

Repairs.—The average amount which was spent during the year on the 286 machines for repairs, including both the cost of parts and the cash outlay for labor, was $29.95. The costs for 2-plow and 3-plow tractors of different ages are shown in Table 33. The cost for the year was $20 or less for over half the machines in each age group, and the greater average cost for the older tractors was due to high

repairs on a few machines. Forty-eight of the men spent nothing for repairs during the year.

TABLE 33.—*Annual repair cost of 2-plow and 3-plow tractors of different ages.*

Age of tractor (months).	2-plow.		3-plow.	
	Number.	Average repair cost.	Number.	Average repair cost.
14 and less	74	$20.73	29	$24.93
15 to 26	60	38.88	39	22.64
27 to 38	28	38.18	20	37.55
39 and over	12	44.25	16	43.25
All	174	31.42	104	29.32

Table 34 shows the number of owners of tractors who spent different amounts for repairs during the year.

TABLE 34.—*Cost of tractor repairs.*

Amount spent for repairs.	Owners who spent amounts specified.	
	Owners of 2-plow tractors.	Owners of 3-plow tractors.
Nothing	30	18
$20 or less	78	43
$21 to $40	22	18
$41 to $60	18	10
$61 to $80	6	7
$81 to $100	9	3
Over $100	11	5

The average annual cost for repairs on the 2-plow tractors had been 3.2 per cent of the first cost of the tractors, and the repairs on the 3-plow machines had been 2.2 per cent of their first cost. For the 2-plow machines which had been used 39 months or over, i. e., had done at least three full years of work at the time of the investigation, the repairs during the year had amounted to 4.6 per cent of the first cost, and for the 3-plow tractors 3.2 per cent.

Unpaid labor.—In addition to the cash outlay for labor and repairs, each farmer was asked the amount of time spent by him or by the regular farm labor during the year in repairing the tractor. On an average, this labor amounted to 1.8 days for the year, but no such labor was used on 78 of the 286 tractors. Part of these 78 tractors required no repairs during the year and most of the remainder were machines whose owners were not capable of doing the repair work.

The actual number of days used on the different machines is shown in Table 35.

TABLE 35.—*Unpaid labor used in repairing tractors.*

Labor used (days).	Tractors on which specified amounts of labor were used.	
	2-plow tractors.	3-plow tractors.
0	49	28
1	41	29
2	47	17
3	16	12
4	10	9
5 and over	11	9

Nearly all of the men who spent more than one or two days on repair work gave their machines a general overhauling during the year.

The value of this labor at $5 per day has been included in the cost of operating the tractors Five dollars per day, or 50 cents per hour, is considerably higher than the value of ordinary farm labor during the year of investigation, but is considerably lower than the prices charged by regular experts and repair men. On the average this charge amounted to $8.55 for the 2-plow tractors, $9.45 for the 3-plow tractors, and $9.06 for all tractors.

Interest.—Interest is charged at 6 per cent on the average investment. The average investment has been found by the rule:

$$\text{Average investment} = \frac{\text{first cost} \times (\text{years of service} + 1.)}{\text{years of service} \times 2.}$$

This is the generally accepted formula for determining the average investment in equipment where a fraction of the first cost is charged off each year for depreciation. The interest charge when computed on this basis is slightly greater than when computed on one-half of the first cost.

The average interest charge for the 2-plow tractors was $34, for the 3-plow $47, and for all tractors $40.

Fuel and oil.—The average amounts of fuel and oil used per day by the 2-plow machines at the different drawbar operations are given in Table 36 and the amounts used by the 3-plow tractors in Table 37. The fuel and oil required per day by the 3-plow tractors was considerably greater for every operation than that required by the 2-plow machines, but this was offset by the greater number of acres covered per day by the larger machines (see Table 12), so that there was practically no difference in the requirements per acre between the 2-plow and the 3-plow machines for any of the operations.

TABLE 36.—*Fuel and oil requirements per day and per acre of 2-plow tractors for different operations.*

Operation.	Number of tractors.	Requirements per day.		Requirements per acre.	
		Fuel.	Oil.	Fuel.	Oil.
		Gals.	*Gals.*	*Gals.*	*Gals.*
Spring plowing	164	17.97	1.10	2.71	0.17
Fall plowing	129	18.46	1.06	2.86	.16
Disking	95	17.98	1.03	.83	.05
Disking in combination	101	17.78	1.09	.90	.06
Harrowing, etc	53	16.23	1.01	.42	.03
Drawing hay loader	24	11.45	.85	1.09	.08
Drawing grain binder	101	14.50	.92	.73	.05

TABLE 37.—*Fuel and oil requirements of 3-plow tractors for different operations.*

Operation.	Number of tractors.	Requirements per day.		Requirements per acre.	
		Fuel.	Oil.	Fuel.	Oil.
		Gals.	*Gals.*	*Gals.*	*Gals.*
Spring plowing	94	23.12	1.29	2.68	0.15
Fall plowing	80	23.33	1.32	2.71	.15
Disking	46	22.02	1.34	.71	.04
Disking in combination	64	22.74	1.30	.95	.05
Harrowing, etc	7	21.60	1.51	.42	.03
Drawing hay loader	13	15.06	1.09	1.30	.09
Drawing grain binder	27	17.31	1.16	.75	.05

Between 75 and 80 per cent of the tractors were operated on kerosene. Some of the tractors which were operated on gasoline only were not designed for burning kerosene, and the owners of the others believed that the better service given by their machines when operated on gasoline was sufficient to pay for the difference in cost between gasoline and kerosene.

The average costs of fuel and oil to these farmers during the year of the investigation were: Gasoline 28 cents, kerosene 19 cents, and cylinder oil 72 cents. The price of fuel and oil increased considerably during the year. The average price of each kind of fuel was practically the same for all areas. The quality and price of the lubricating oil used varied considerably, depending upon the owner's idea of what constituted proper lubrication, and to some extent upon the make of the tractor.

Costs per day and per acre.—The average costs per day and per acre of using the 2-plow and the 3-plow tractors for different drawbar operations on the home farm are shown in Table 38. The fuel consumption per day for the lighter operations was less than for the heavy work of plowing and disking, and this is partly responsible for the somewhat lower cost per day of using the tractors for harrowing and for drawing the hay loader and the grain binder.

TABLE 38.—*Average cost per day and per acre of using tractors for various operations.*

Operation.	2-plow tractors.			3-plow tractors.		
	Number of tractors.	Cost per day.	Cost per acre.	Number of tractors.	Cost per day.	Cost per acre.
Spring plowing	164	$12.78	$2.01	94	$18.07	$2.15
Fall plowing	129	12.86	2.06	80	18.69	2.22
Disking	95	13.35	.71	46	17.13	.59
Disking in combination	101	12.55	.70	64	16.82	.76
Harrowing, etc.	53	11.97	.35	7	19.14	.49
Drawing hay loader	24	10.02	1.14	13	14.18	1.05
Drawing grain binder	101	11.60	.64	27	16.45	.76

Much of the variation in these average costs, however, is due to the fact that the machines were not all used for the same operations. For instance, 95 2-plow tractors were used to pull disks alone, and the average cost per day for these 95 was $13.35. One hundred and one tractors were used for disking in combination with harrows or other light implements, and the average cost per day was $12.55. This does not mean that for any particular tractor the cost per day was less when it was used for pulling both a disk and a harrow than when it was used for pulling a disk alone. It simply indicates that the daily charges for depreciation, repairs, interest, fuel, and oil for the 95 used for pulling disks alone was greater than for the 101 used for pulling both disks and harrows. Similarly the high cost of $19.14 per day shown for harrowing with the 3-plow tractors was due simply to the fact that the charges mentioned above were high for the 7 tractors which were used for this work. When these variations in the cost of operating individual tractors are taken into account, there is little significance in the differences shown between 2-plow and 3-plow tractors in the cost of power for the different operations.

The average cost per day of using the 2-plow tractors for drawbar work was $12.67, the 3-plow tractors $17.73, and all tractors $14.51. Except for possible differences in the amounts of fuel and oil used, the costs per day of using the tractors for belt and custom work would be approximately the same as the costs for drawbar work.

The marked decline in the prices of gasoline, kerosene, and lubricating oil since the investigation was made has resulted in a considerable decrease in the cost of operating tractors. At present (September, 1921) the average price of gasoline to farmers in the areas studied is about 19 cents, kerosene 10 cents, and lubricating oil 40 cents. The cost of fuel and oil for the tractors as computed on these prices is 57 per cent of the cost as based on the 1920 prices. Assuming no change in depreciation, interest, and repair costs, the present cost per day and per acre of operating the tractors would be 82 per cent of the 1920 costs given above. (See Table 42.)

Effect of amount of work done per year on cost of using tractors.—Table 39 shows the cost per day and per acre of plowing with the 2-plow machines, classified according to number of days of work during the year. Table 40 gives similar information for the 3-plow tractors. Annual depreciation, repairs, and interest charges did not increase in proportion to the amount of work done for either size of machine, and consequently the daily costs of these items were least for the machines which did the greatest amount of work.

For each size the average daily charge for depreciation, interest, and repairs on the tractors which were used 50 days or more during the year was less than a third of that for machines which were used less than 20 days, and the cost per acre of power for plowing done by the machines which did over 50 days' work was less than a half the cost for those which did less than 20 days' work during the year. Such differences are reflected directly in the cost per acre or per bushel of producing crops and show how the man whose farm is large and so organized that he obtains large use from his equipment can produce at low cost.

These figures do not indicate, however, that the farmer should endeavor to use his tractor as many days during the year as possible simply for the sake of reducing the cost per day of operating it. Even though the cost per day decreases rapidly with increased use, the total cost per year must increase. For instance, the cost per day of power for plowing with the 2-plow tractors which were used 20 to 30 days during the year was $13.45. On the average these machines did approximately 25 days of work during the year and the total cost per year of use was $325 to $350. The cost per day of use of the 2-plow machines which did from 40 to 50 days of work during the year was only $10.81, but the total cost per year was $475 to $500.

These figures further indicate that, since the number of days of work has only a slight effect upon the total annual charges for depreciation, interest, and repairs, the tractor owner need consider only the cost of fuel and oil when deciding whether or not to use his machine for operations where its use is of doubtful value.

TABLE 39.—*Effect of number of days of work per year on cost of using 2-plow tractors for plowing.*

Days of work per year.	Number of tractors.	Annual cost.				Daily cost (depreciation, interest, and repairs).	Cost for plowing.	
		Depreciation.	Interest.	Repair and upkeep.	Total.		Per day.	Per acre.
Less than 20	37	$150	$34	$30	$214	$14.50	$19.14	$3.00
20 to 29.9	41	158	35	37	230	8.90	13.45	2.24
30 to 39.9	54	168	34	39	241	6.97	11.49	1.76
40 to 49.9	25	167	33	61	261	6.08	10.81	1.76
50 and over	17	195	35	32	262	4.60	8.55	1.26

TABLE 40.—*Effect of number of days of work per year on cost of using 3-plow tractors for plowing.*

Days of work per year.	Number of tractors.	Annual cost.				Daily cost (depreciation, interest, and repairs).	Cost for plowing.	
		Depreciation.	Interest.	Repair and upkeep.	Total.		Per day.	Per acre.
Less than 20	33	$183	$44	$29	$256	$21.07	$25.88	$3.13
20 to 29.9	30	204	48	42	293	11.72	17.37	2.13
30 to 39.9	22	257	50	39	346	10.17	15.87	1.78
40 to 49.9	11	239	46	48	332	7.58	13.16	1.58
50 and over	8	261	52	58	371	6.22	11.61	1.29

RELIABILITY OF TRACTORS.

The reliability of a tractor has a very decided effect upon its profitableness. In order to obtain definite information on this point each farmer visited was asked how many days during the year his tractor was not in running order when needed. On the average, the 286 tractors were out of commission when needed 1.9 days during the year. One hundred and fifty-three, or 53 per cent of the total, were always ready for work when needed, and 54, 19 per cent of the total, were out of commission more than 2 days.

There was little difference in this respect between the 2-plow and the 3-plow machines. On the average, the 2-plow machines were out of order when needed 1.8 days during the year and the 3-plow, 2.1 days. Just 50 per cent of the smaller machines and 60 per cent of the larger ones were not out of commission at all. The age of the tractors likewise had no marked influence upon their reliability. Forty-one of the 106 which had been in use just one year and 15 of the 31 which had been in use over 3 years were out of commission at least one day.

The actual number of days the 174 two-plow tractors and the 104 three-plow tractors were out of order during the year is shown in Table 41.

TABLE 41.—*Number of tractors that were out of order different numbers of days.*

Days out of order.	Number of 2-plow tractors.	Number of 3-plow tractors.
0	87	62
1 or 2	56	22
3 or 4	11	3
5 or 6	12	9
7 or more	8	8

Most of the men whose tractors were out of commission more than two days had bad breaks while the machines were being used, and it was impossible to procure repair parts or the services of experts promptly. A delay of one or two days may not result in any serious loss, but a tractor which is out of commission a week or more at a time when its services are needed can scarcely be considered profitable.

COST OF POWER FOR DIFFERENT OPERATIONS AS FURNISHED BY HORSES AND BY TRACTORS.

The cost per acre of power during the year covered by the investigation for the different operations for which both horses and tractors were used on these farms is shown in Table 42. The costs based on present prices (Sept., 1921) of feed, fuel, and oil are also shown.

The 1920 cost per acre of power furnished by horses is given on page 45. The 1921 horse costs are based on an annual cost per head of $85 for keeping workstock, or $1.29 per day of horse labor (see page 45). The 1921 tractor costs are 82 per cent of the 1920 costs. (See page 51).

Disking in combination, i. e., drawing a disk and a harrow or roller at one operation, was not done with horses on any of the farms, and the cost of power for harrowing and rolling with horses has been added to that for disking to obtain a cost comparable to the cost of performing the two operations at once with the tractors.

The cost of power for plowing done with tractors during the year of the investigation was only about 70 per cent of that for the plowing done with horses, but with the exception of disking in combination the cost of power furnished by the tractors for each of the other operations was slightly greater than that furnished by horses. These figures, of course, represent the cost of power only, and they do not include either the cost of man labor or of the implements used for the different operations. Neither do they take into account possible differences in the quality of work resulting from the use of the two sources of power.

TABLE 42.—*Cost of power for different operations as furnished by horses and by tractors.*

[Cost per acre.]

Operation.	1920				1921	
	Horses.	Tractors.			Horses.	Tractors.
		2-plow.	3-plow.	All.		
Spring plowing	$2.89	$2.01	$2.15	$2.07	$1.53	$1.70
Fall plowing	3.04	2.06	2.22	2.13	1.62	1.75
Disking	.64	.71	.59	.67	.34	.55
Disking in combination	.98	.71	.76	.72	.52	.59
Harrowing, rolling, etc	.34	.35	.49	.37	.18	.30
Drawing hayloader	.98	1.14	1.05	1.11	.52	.91
Drawing grain binder	.59	.64	.76	.67	.31	.55

NOTE.—The cost of man labor and of the implements used must be added to the cost of power to obtain the total cost of performing the different operations. The horse costs shown for 1921 are 53 per cent and the tractor costs 82 per cent of the 1920 costs.

ANNUAL COST OF POWER FOR DRAWBAR WORK.

Table 43 shows the average cost of the power furnished by the 2-plow, 3-plow, and all tractors for drawbar work on the home farm during the year covered by the investigation. On the average, this

drawbar work on the home farm constituted 80 per cent of the total work done by the 2-plow machines, 71 per cent of that done by the 3-plow machines, and 76 per cent of that done by all tractors. Consequently the figures represent approximately these percentages of the total cost of operating the tractors.

TABLE 43.—*Total annual cost of tractors for drawbar work on home farm.*

[Averages.]

Operation.	2-plow tractors.			3-plow tractors.			All tractors.		
	Days work per year.	Cost per day.	Cost per year.	Days work per year.	Cost per day.	Cost per year.	Days work per year.	Cost per day.	Cost per year.
Spring plowing	7.9	$12.78	$100.96	6.3	$18.07	$113.84	7.3	$14.85	$108.40
Fall plowing	5.1	12.86	65.59	5.2	18.69	97.19	5.1	15.23	77.67
Disking	4.0	13.35	53.40	2.3	17.13	39.40	3.4	14.59	49.61
Disking in combination	3.4	12.55	42.67	4.0	16.82	67.28	3.5	14.29	50.02
Harrowing, etc.	1.1	11.97	13.17	.2	19.14	3.83	.7	12.04	8.43
Drawing hayloader	.4	10.02	4.01	.4	14.18	5.67	.4	11.57	4.63
Drawing grain binder	1.9	11.60	22.04	.9	16.45	14.81	1.5	12.61	18.92
Other work	2.0	[1] 12.50	25.00	.9	[1] 18.00	16.20	1.6	[1] 14.50	23.20
Total	25.8	.....	$326.84	20.2	.....	$358.22	23.5	.....	$340.88

[1] Approximate.

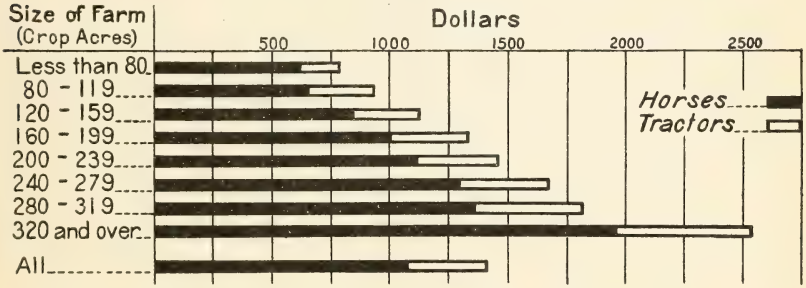

FIG. 14.—Cost of power for drawbar work on farms of different sizes (1920).

The cost of the power for drawbar work furnished by the average tractor was equal to the cost of keeping 2.1 head of workstock. The cost of keeping horses has declined considerably more than the cost of operating tractors since the investigation was made (see page 54) and based on present prices (Sept., 1921) the cost of the power furnished by the tractors would be equal to the cost of keeping 3.3 head of workstock.

The cost of keeping the workstock on the average farm during the year of the investigation was $1,076. Thus the total cost of power, both horse and tractor, for drawbar work was $1,417. Seventy-six per cent of this total was chargeable to the workstock and 24 per cent to the tractor.

The cost of power, both horse and tractor, for drawbar work on farms of different sizes is shown in Table 44, and in figure 14.

TABLE 44.—*Cost of power on farms of different sizes.*

Size of farm (crop acres).	Number of farms.	Cost of keeping horses.	Cost of tractor for drawbar work.	Total cost of power.	Per cent tractor cost was of total. cost.
Less than 80	7	$621	$172	$793	21.7
80 to 119	28	660	279	939	29.7
120 to 159	71	849	279	1,128	24.7
160 to 199	56	1,006	331	1,337	24.8
200 to 239	47	1,120	340	1,460	23.3
240 to 279	36	1,292	386	1,678	23.0
280 to 319	19	1,367	452	1,819	24.8
320 and over	22	1,966	576	2,542	22.6
All	286	1,076	341	1,417	24.1

CHANGES IN SIZE OF FARM AND NUMBER OF WORKSTOCK AFTER PURCHASE OF TRACTORS.

The average size of farm and the number of workstock in the different areas both before the purchase of tractors and at the time of the investigation, are shown in Table 45. For all farms, there was an increase of about 20 acres after the tractors were purchased, and during the same time a decrease of 1.8 head of workstock. The number of acres (total acres in farm) per horse increased from 27.6 to 37.9, or about 37 per cent. Where there was a change in the size of the farm the number of crop acres in the farm before the purchase of the tractor was not obtained; consequently figures showing the average number of crop acres per horse for all farms before the purchase of tractors are not available.

TABLE 45.—*Size of farm and number of workstock before and after purchase of tractors in different areas.*

Area.	At time of investigation.				Before purchase of tractor.		
	Size of farm.	Work-stock.	Total acres per horse.	Crop acres per horse.	Size of farm.	Work-stock.	Total acres per horse.
	Acres.	*Number.*	*Acres.*	*Crop acres*	*Acres.*	*Number.*	*Acres.*
Madison County, Ohio	363.0	8.1	44.8	34.1	317.1	9.2	34.5
Seneca County, Ohio	202.0	5.0	40.4	28.0	182.0	6.1	29.8
Madison County, Ind.	218.1	5.4	40.4	32.6	199.4	7.9	25.6
Montgomery County, Ind.	269.5	6.0	44.9	34.1	251.8	8.7	28.9
Livingston County, Ill.	247.3	8.4	29.4	24.7	240.4	9.4	25.6
Knox County, Ill.	256.0	7.0	36.6	28.3	235.6	9.2	25.6
All	257.6	6.8	37.9	29.6	237.5	8.6	27.6

The greatest increase in size of farm was in Madison County, Ohio, and the least in Livingston County, Ill. The greatest increase in acres per horse was in Montgomery County, Ind., and the least in Livingston County, Ill.

Nine of the 286 men started farming with tractors, 81 increased the size of their farms after purchasing tractors, 24 decreased the

size of their farms and there was no change in acreage on the remaining 172. All of those who were farming smaller acreages than before the purchase of tractors were renters who had moved to smaller farms or owners who in 1920 rented out some ground which they formerly farmed themselves. On the average these men were farming 84 less acres and using 5.1 less horses than before the purchase of tractors.

Farms which were increased in size.—The 81 men who were farming greater acreages than before they purchased tractors were located in the following areas:

	Men.
Madison County, Ohio	11
Seneca County, Ohio	9
Madison County, Ind	14
Montgomery County, Ind	17
Livingston County, Ill	13
Knox County, Ill	17

One-third of the men interviewed in Madison County, Ind., were farming greater acreages, while less than one-fourth of those in Livingston County, Ill., had increased the size of their farms.

The average size of the farms operated by these 81 men before they purchased tractors was 206.4 acres and at the time of the survey the average size was 296.8 acres. They kept on the average 7.6 head of workstock—one for each 27.0 acres (total not crop acres)—before the purchase of tractors. At the time of the investigation they were keeping 6.9 head, or one for each 42.3 acres.

The number of men who increased the size of their farms by different amounts were as follows:

41	Less than 80 acres.
28	80 to 159 acres.
12	160 acres and over.

The changes in the number of workstock kept were as follows:

Of the 41 who were farming less than 80 additional acres

23 had reduced their workstock by an average of 3.5 head.
13 were keeping the same number of workstock as before.
5 had increased their workstock by 1 head.

Of the 28 who were farming 80 to 159 additional acres

10 had reduced their workstock by an average of 2.5 head.
8 were keeping the same number as before.
10 had increased their workstock by an average of 2.3 head.

Of the 12 who were farming 160 or more additional acres

5 were keeping the same number as before.
7 had increased their workstock by an average of 3.7 head.

Farms where acreage was not changed.—The average size of the 172 farms where the acreage was the same as before the purchase of tractors was 244.5 acres, and the number of crop acres was 187.8. Those who increased the size of their farms after the purchase of tractors, had in general been farming somewhat smaller acreages than these men. The men who had not changed their acreage had kept on the average, 8.7 head of workstock before the purchase of tractors—one head for each 28.0 acres, and one for each 21.5 crop acres. At the time of the investigation they had 6.5 head—one for each 37.7 acres and one for each 29.0 crop acres.

The size of the tractor evidently had no influence on the reduction in workstock. One hundred and seven of the 172 men who did not change their acreage owned 2-plow, and 61 owned 3-plow machines. Before the purchase of tractors, the owners of each size kept one horse for each 21.7 crop acres. At the time of the investigation the owners of the 2-plow machines had one head for each 28.8 crop acres, and the owners of the 3-plow machines one for each 29.6 crop acres. On the average, the owners of each size reduced their workstock by 2.2 head.

Every farmer was keeping at least two head of workstock in addition to his tractor, and no one who did not increase his acreage owned less than three head before the purchase of his tractor.

Table 46 shows the actual number owned before the purchase of the tractors and the number disposed of by the 172 men.

TABLE 46.—*Changes in number of workstock after purchase of tractor made by 172 owners whose acreage remained the same.*

Number of workstock before purchase of tractors.	Number of owners.	Number of owners who disposed of—								
		None.	1 head.	2 head.	3 head.	4 head.	5 head.	6 head.	7 head.	9 head.
3 or 4	7	4	2	1						
5 or 6	38	11	8	11	4	4				
7 or 8	44	10	9	13	6	5	1			
9 or 10	41	8	1	13	8	5	2	4		
11 or 12	30	4	1	2	6	5	7	4	1	
More than 12	12	7		1					3	1
Total	172	44	21	41	24	19	10	8	4	1

The organization of the farm must be known in detail before one can say definitely how many head of workstock a farmer should keep for the greatest profit after he purchases a tractor, but it is apparent that some of these men were still keeping more workstock than needed. (See page 37.) Table 47 shows the average number of crop acres, and the number per horse before and after the purchase of tractors on the farms where different numbers of workstock were disposed of.

TABLE 47.—*Relation of number of horses disposed of to size of farm and to crop acres per horse.*

Number of horses disposed of.	Number of farms.	Crop acres per farm.	Crop acres per horse.	
			Before purchase of tractor.	After purchase of tractor.
0	44	205.9	23.4	23.4
1	21	155.5	23.2	27.2
2	41	178.3	22.1	29.4
3	24	178.5	20.3	30.8
4	19	187.6	21.4	39.2
5 or more	23	209.6	18.3	37.4
All	172	187.8	21.5	29.0

Some of the men who did not dispose of any workstock had owned only 3 or 4 head and probably needed all of them for some one operation even with a tractor on the place (see Table 26). This was not true of nearly all of the 44, however. The table shows that they had not been keeping appreciably fewer workstock in proportion to the size of their farms than had most of the men who reduced their workstock after the purchase of tractors; and that the number of crop acres per horse at the time of the investigation was less than on the other farms.

INCREASE IN INVESTMENT DUE TO PURCHASE OF TRACTORS.

Table 48 shows the net increase in investment due to the purchase of tractors.

The costs of the tractors and of the implements purchased for use with them are given on page 46. The owners of both the 2-plow and the 3-plow tractors who did not change the size of their farms disposed of 2.2 head of workstock on the average. The acres per horse before and after the purchase of tractors on these farms were practically the same as on the farms which were changed in size, and on account of this fact it seems fair to assume that the men who changed the size of their farms would have been keeping 2.2 more head of workstock if they had not owned tractors. The average value per head of the workstock on the farms was $144, and while the value of the workstock which was disposed of was not obtained in detail, an investigation made in the Corn Belt in 1918 (see Farmers' Bulletin 1093) showed that after the purchase of tractors "it was not the poorest horses which were sold but those of about average quality."

TABLE 48.—*Increase in investment due to purchase of tractor.*

Item.	2-plow tractors.	3-plow tractors.	All tractors.
Cost of tractor	$972	$1,354	$1,140
Cost of implements for tractor	271	430	343
Total	1,243	1,784	1,483
Value of workstock disposed of (2.2 head, at $144)	317	317	317
Value of horse-drawn implements disposed of	11	14	12
Total	328	331	329
Net increase in investment	915	1,453	1,154

In all 67 men disposed of some of their horse-drawn implements after purchasing tractors, and the average amount received by these 67 men for such implements was $51. As shown in the table, this item amounted to an average of $12 for all farms. Most of the implements sold were plows and disks. Many farmers who did not sell any horse-drawn equipment stated that they had not used some of their old equipment since the purchase of tractors, but at best the value of the implements which could have been sold was small as compared with the other items shown in the table.

While the purchase of tractors resulted in an increase in investment of more than $1,000 on the average, the cost per year of power for operating the farms did not increase. The cost of the drawbar work done by the average tractor during the year of the investigation was equal to the cost of keeping 2.1 head of work stock, but 2.2 head had been displaced on the average farm, and the cost per head of keeping the remaining work stock was somewhat less than it would have been if tractors had not been owned.

SAVING OF MAN LABOR DUE TO USE OF TRACTORS.

The total amount of man labor used for the operation of these farms before tractors were purchased was not obtained and consequently it is impossible to give definite figures as to the saving of man labor effected by the tractors on individual farms. However, a comparison of the accomplishment of the tractors with that of one man when using horses should give an indication of the average reduction in man labor effected by the tractors.

The acres covered per day by the 2-plow and the 3-plow tractors at the different drawbar operations are given in Table 12 (page 16), and the daily duty of one man in the different areas when using horses for spring and fall plowing, disking, harrowing, etc., and cutting grain is given in Table 49.

TABLE 49.—*Daily duty of one man with horses at operations on which tractors were also used.*

[Acres per day.]

Operation.	Madison Co., Ohio.	Seneca Co., Ohio.	Madison Co., Indiana.	Montgomery Co., Indiana.	Livingston Co., Illinois.	Knox Co., Illinois.	All.
Spring plowing	2.18	2.22	2.21	2.61	3.88	3.94	2.68
Fall plowing	1.88	2.33	1.92	2.85	3.60	3.11	2.65
Disking	12.46	9.83	10.33	14.30	18.95	18.80	16.67
Harrowing, etc	16.80	16.00	15.21	19.93	38.09	33.10	26.28
Cutting grain	14.05	13.36	13.27	15.88	17.64	17.61	15.55

The greater amount of work accomplished per man when plowing and fitting ground in the two Illinois areas was due to the use of larger teams and implements. A team of four horses is the common unit on the farms in these areas, while in Ohio and Indiana teams of three, and sometimes only two, horses are used with proportionally smaller implements. With the rate of doing work when using horses the same as given in the table the drawbar work which the average 2-plow tractor did in 25.8 days and that which the average 3-plow tractor did in 20.2 days would have required 50 to 55 days for one man with horses. Thus the 2-plow machines saved on the average 25 to 30 days of man labor during the year, and the 3-plow machines 30 to 35 days.

Since disks and harrows or other light implements were never used in combination when horses furnished the power, the operation of "disking in combination" as done with tractors is practically equivalent to the two separate operations of disking and harrowing or rolling as done with horses. In "Loading hay" and "Other work" done with the tractors as shown in Table 12, it is not possible to make a direct comparison of the man-labor requirements, but on the average the tractors probably saved not far from one day for each day of use. (See page —.)

One man always operated both tractor and implement in plowing and other work of fitting ground. One man usually operated both tractor and binder in cutting grain, but on some farms a second man was used on the binder.

The tractors did 85 per cent of the plowing on these farms and much of that done with horses was finishing up or plowing small and irregular fields. For such work 2-horse or 3-horse teams were generally used. If these tractor owners had done all their plowing with horses some of them probably would have used larger units, and the saving of man labor effected by the tractor would not have been as great as that indicated above.

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