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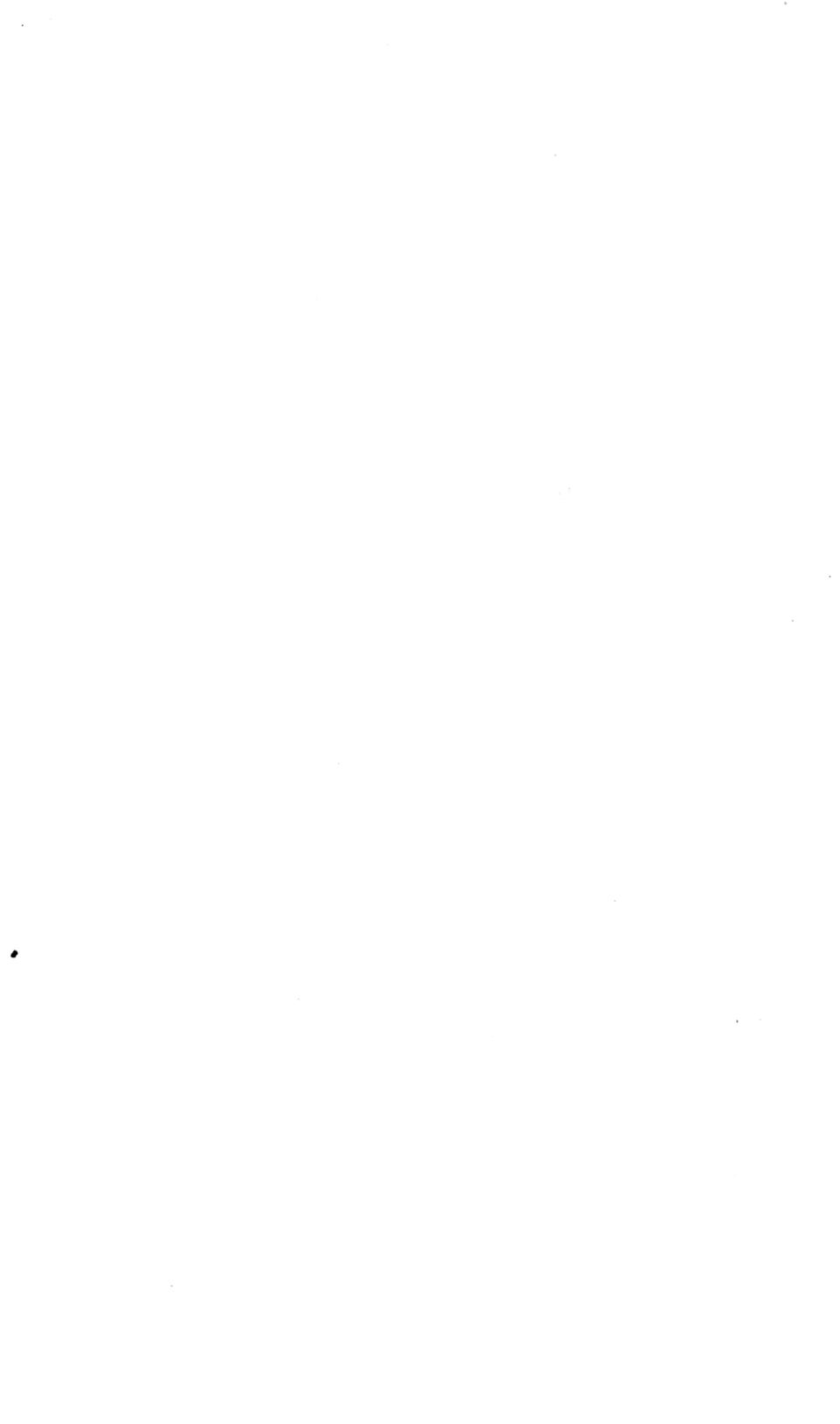
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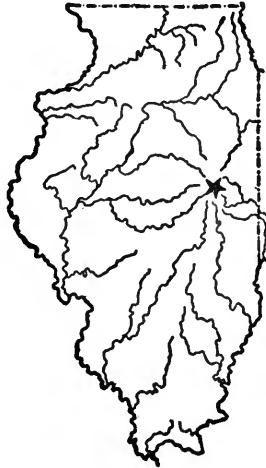


UNIVERSITY OF ILLINOIS
Agricultural Experiment Station

BULLETIN No. 240

THE PRODUCTION AND UTILIZATION
OF MANURE ON ILLINOIS
DAIRY FARMS

By H. A. ROSS



URBANA, ILLINOIS, JULY, 1922

SUMMARY OF BULLETIN No. 240

The aim of this study was to ascertain with some accuracy the amounts of manure recovered and applied to the fields under general dairy farm conditions in Illinois, to show the common practice of progressive farmers in the utilization of manure, and to present data on the labor cost of hauling and spreading.

The data were derived from 224 farm records of one year each and involve an aggregate amount of 65,471 loads of manure recovered.

The average amount of manure recovered annually was 6.6 loads for each of the 7,161 dairy cattle units, and 5.45 loads for each of the 2,229 work animal units which were maintained on these farms. These amounts include both the clear excrement and the bedding.

With the system of manure management which was practiced on these farms, an average of thirty dairy cattle units per 100 acres of tillable land would be necessary in order to provide sufficient manure to annually cover one-fifth of the land at the rate of 10 loads per acre.

Approximately one-third of the acreage of these farms was in corn, and to this one-third was applied two-thirds of the recorded manure. The greater part of the remaining one-third was applied to hay and small grain crops.

On the farms studied, nearly half (45.5 percent) of the total amount of manure recovered was hauled during the months of March, April, and May, and of this amount over 70 percent was applied to corn. June, July, September, and October were the months in which the least amount of manure was hauled.

The average amount of labor required in hauling and spreading a load of manure was 1.05 man hours and 2.19 horse hours. The labor per load was least during the months when the greatest amount of manure was hauled.

THE PRODUCTION AND UTILIZATION OF MANURE ON ILLINOIS DAIRY FARMS

BY H. A. ROSS, ASSOCIATE IN DAIRY ECONOMICS

INTRODUCTION

Dairy farming is generally considered to be particularly well adapted to the maintenance of soil fertility and the building up of depleted soils because of the relatively small amounts of plant foods which are removed from the farm by the sale of milk or cream. It is usually assumed that the rest of the fertilizing constituents of the crops are returned to the soil in the manure; an assumption which is far from the truth as regards the majority of Illinois dairy farms.

The amount of manure produced annually by farm animals varies widely because of differences in the amount and kind of feed consumed and the efficiency with which the feed is utilized by the animals. Estimates of the annual production of manure are, for the most part, based upon feeding experiments in which the excrement of one or more animals has been weighed for periods ranging from one to ten days. The average production per day, for these periods, multiplied by 365 has usually been taken as the average annual production. In the case of dairy cows, the feeding experiments have usually been conducted when the cows were producing heavily on full feed, and the estimates of the annual production of manure are probably somewhat greater than the amounts actually produced.

In planning systems of cropping and soil treatment looking toward the maintenance of fertility by the use of farm manure, it has been customary to use these estimates of production. The difficulty in so using them, however, is the fact, shown by numerous studies, that great losses of both soluble plant foods and organic matter result from the very common, wasteful methods of handling manure. In Illinois it is the common practice of dairymen to pile the manure in the barn yard as it is produced, and to haul it to the fields as time and field conditions permit. When it is left loosely piled, much of the fertilizing constituents are leached out by rain and melting snow and part of the organic matter is destroyed by fire-fanging. The tramping of manure into the mud of the barn lot by live stock also increases the loss.

The hauling and spreading of manure upon the fields each day as it is produced is one of the methods of conservation often advocated. However, the injury to wet fields or to growing crops, the press of

work during the crop season, and similar difficulties prevent this plan from being commonly followed. The practice of allowing manure to accumulate in the stall during the winter also conserves manure, but this method is objectionable from the standpoint of clean milk production and is usually barred by the health regulations which govern the production of city milk. A few dairymen who have a sufficient amount of barn room permit the cows to run loose in a large enclosure and put them in the stalls only during the time they are being milked. The manure is allowed to accumulate in the enclosure during the winter and, as it is well packed and under shelter, little waste results. If plenty of bedding is used, the cows can be kept in a fair condition of cleanliness, but the excessive cost of housing a large herd in this manner ordinarily prevents the adoption of the method. Storing manure under sheds or in concrete pits until it is hauled out upon the field reduces the waste, but if the cost of the building or pit is too great the saving in manure may do little more than offset the added expense.

This study aims—

1. To ascertain the amount of manure that is actually recovered from barns and feed lots and applied to the fields under general dairy farm conditions in Illinois.

2. To show the common practice of progressive dairy farmers in utilizing manure, in respect both to seasonal application and to crops treated.

3. To present data on the labor cost of hauling and spreading manure.

No recommendations or suggestions are made as to modifying the practices described. It is hoped, however, that the data presented may serve as a basis for future studies on methods of manure management and utilization which will not only be well adapted to maintaining the productivity of the soil but will also be economical.

SOURCE AND CHARACTER OF DATA

This study is based upon data obtained from detailed cost accounting investigations conducted by the Department of Dairy Husbandry during the eight years 1912 to 1919. Eighty-seven different farms were studied for periods ranging from one to eight years. Records for one year were available on 39 percent of the farms; for two years on 21 percent; for three years on 16 percent; and for four or more years on 24 percent. A total of 224 farm accounts were included in the study, each of which covered the production and utilization of manure on a farm during one year.

Seventy-five of the eighty-seven farms were located in the northern part of the state, forty being in the dairy district tributary to Chicago.

The farms varied as to acreage and as to the size of the herd, but the group as a whole was representative of the better class of dairy farms operated by efficient and progressive men. The methods of these farmers in utilizing manure were determined largely by experience and custom.

Practically all the farms were equipped with one or more manure spreaders, but in hauling out manure in the spring it was common practice to use wagons in addition. The spreaders were largely of the two-horse type, altho a small number required three horses.

The data in this study were obtained directly from practical farming operations, and the work was in no sense experimental. The farmers recorded daily the kind of manure hauled, the number of loads, the fields upon which it was spread, and the amounts of man and horse labor required in handling it. Maps with numbered fields were used in keeping the records. It is realized that slight errors may have resulted from this method of collecting data, but because of the extensiveness of the data, both as to number of farms involved and as to time covered, and because of its close supervision, it is believed that such errors could have no influence upon the general significance of the data.

The amounts of manure recovered per animal and the amounts applied to the various crops are here reported in terms of loads, the weight of which varied with the size of the spreader and the kind and condition of the manure. Most of the farmers estimated that the average spreader load weighed one ton. Farmers think in terms of loads of manure per acre rather than in terms of tons per acre, so that for the purpose of this study loads are more significant.

AMOUNT OF MANURE RECOVERED ANNUALLY

It is evident that only a part of the total manure produced annually on a farm is hauled to the fields. Some is lost by rotting and leaching, some is tramped into the mud, and during the summer months a large amount is dropped on pastures. This study deals only with the manure and bedding that was recovered from the barns and feed lots, no account being taken of the manure dropped while the stock was on pasture. All but a very small part of the pastures of the farms studied were permanent. Many of them were boggy or hilly, and whatever manure was dropped there during the pasture season of approximately five and one-half months could fertilize the pasture grasses only, because it will be years before many of these fields come under cultivation.

The total number of the various kinds of live stock on the farms and the loads of manure recovered annually are shown in Table 1. It was impossible to determine separately the amounts of manure recovered from cows and from young stock, because often both classes

TABLE 1.—MANURE RECOVERED ANNUALLY ON 224 DAIRY FARMS

Kind	Live stock kept			Manure recovered		
	Number	Ratio	Animal units	Loads recovered	Percent of total	Loads per animal unit
Cows.....	4 762	1.00	4 762.0			
Bulls.....	259	1.00	259.0			
Young stock.....	4 279	.50	2 139.5			
Total dairy cattle.....			7 160.5	47 238	72.2	6.60
Horses.....	1 813	1.00	1 813.0			
Mules.....	204	1.00	204.0			
Colts.....	423	.50	211.5			
Total work animals.....			2 228.5	12 153	18.6	5.45
Sows.....	2 870	.20	574.0			
Shoats.....	4 484	.20	896.8			
Pigs.....	7 247	.10	724.7			
² Total swine.....			2 195.5	3 809	5.8	1.73
Hens.....	28 333	.01	283.3			
Ducks.....	218	.01	2.2			
Guineas.....	118	.01	1.2			
Geese.....	85	.03	2.5			
Turkeys.....	62	.02	1.2			
Total poultry.....			290.4	549	.8	1.89
² Total steers.....	406	1.00	406.0	480	.7	1.18
Ewes.....	796	.14	111.5			
Lambs.....	149	.07	10.4			
Total sheep.....			121.9	101	.2	.83
³ Miscellaneous.....				1 141	1.7	.....
Total.....			12 402.8	65 471	100.0	.....

¹Average of the numbers inventoried at the beginning and the end of the year.

²Not kept on the farms thru the entire year.

³The following miscellaneous refuse was hauled out upon the fields: 717 loads of old straw, 318 loads of clover chaff, 90 loads of stockyards manure, 9 loads of rotten silage, 5 loads of shredded fodder, and 2 loads of old hay.

of live stock were kept in the same barn. Animal units have therefore been used to afford a fairly comparable basis for showing the relative amounts of the various kinds of manure recovered. One animal unit is equivalent to one mature cow, horse, or steer; to two head of young stock; to five hogs, seven sheep, or one hundred chickens.¹ This method of computing animal units is frequently used in reducing varied groups of animals to a common basis for comparison, and when applied to the first two classes of live stock (dairy cattle and work animals) it is sufficiently accurate for the purpose of this study. Swine and beef cattle, however, are rarely kept on the farm thru the entire year and the amounts of manure per animal unit shown by the above table to have been produced by them are therefore not comparable with the amounts shown for dairy cattle and horses.

¹Warren, G. F., *Farm Management*, p. 210. 1916.

RECOVERED FROM DAIRY CATTLE

Altho dairy cattle constituted only a little over one-half of the total number of animal units on these farms, they produced almost three-fourths of the total manure recovered. The average amount of manure recovered per cattle unit was 6.6 loads. As already pointed out, this amount was exclusive of the manure dropped on pasture and of the loss which occurred when the manure was left about the barn lot to rot.

The manure recovered per cattle unit on the different farms varied widely, owing to the different methods of handling the manure and to the kinds of feed and the amounts of bedding used. On some of the farms, a portion of the bedding was purchased and the farmer therefore attempted to keep the amount used at a minimum. On other farms, large amounts of straw were produced; and because of clauses in the leases of rented farms prohibiting the sale of roughages, or because of the endeavor of farm owners to maintain fertility, as much bedding was used as could be worked up into manure. These large amounts of straw of course tended to absorb the liquid portion of the manure, and not only was a large amount of fertility saved that would otherwise have been wasted, but also the straw was made easier to handle in spreading.

The variation in the amount of manure recovered per cattle unit on the different farms is shown by Table 2. On approximately one-half the farms, between 5 and 8 loads were recovered annually; and on one-fifth of the farms, less than 5 loads.

RECOVERED FROM WORK ANIMALS

Of the total manure recovered on the 224 farms, almost one-fifth was produced by the horses, mules, and colts. The average amount recovered annually per animal unit was 5.45 loads. Altho the horses were on pasture only a short time during the summer, a large amount of manure was dropped while they were being worked in the fields or on the roads, and this of course was not accounted for in the study. The manure dropped while the horses were working in the fields, however, was of direct benefit to the tillable land.

The variation in the amount of manure recovered from the work animals on the different farms is shown by Table 2. On half the farms the average amount recovered per animal unit was between 4 and 7 loads.

RECOVERED FROM OTHER SOURCES

The manure produced by the hogs, steers, sheep and poultry on these farms constituted 7.5 percent of the total amount recovered. In addition, 1,141 loads of rotten straw, silage, clover chaff, and similar refuse were hauled which were not, strictly speaking, manure, but

TABLE 2.—SHOWING HOW THE AMOUNT OF MANURE RECOVERED ANNUALLY, PER ANIMAL UNIT, VARIED AMONG THE 224 DAIRY FARMS

Manure recovered per dairy cattle unit	Number of farms	Manure recovered per work animal unit	Number of farms
Less than 1 load.....	6	Less than 1 load.....	2
1 to 2 loads.....	7	1 to 2 loads.....	4
2 to 3 loads.....	6	2 to 3 loads.....	16
3 to 4 loads.....	7	3 to 4 loads.....	19
4 to 5 loads.....	23	4 to 5 loads.....	38
5 to 6 loads.....	36	5 to 6 loads.....	43
6 to 7 loads.....	40	6 to 7 loads.....	28
7 to 8 loads.....	33	7 to 8 loads.....	29
8 to 9 loads.....	22	8 to 9 loads.....	18
9 to 10 loads.....	18	9 to 10 loads.....	10
10 to 11 loads.....	7	10 to 11 loads.....	6
11 to 12 loads.....	9	11 to 12 loads.....	2
12 to 13 loads.....	—	12 to 13 loads.....	2
13 to 14 loads.....	2	13 to 14 loads.....	4
14 to 15 loads.....	3	14 to 15 loads.....	1
15 to 16 loads.....	1	15 to 16 loads.....	1
16 to 17 loads.....	1	16 to 17 loads.....	—
17 to 18 loads.....	1	17 to 18 loads.....	—
18 to 19 loads.....	—	18 to 19 loads.....	—
19 to 20 loads.....	—	19 to 20 loads.....	—
20 to 21 loads.....	1	20 to 21 loads.....	1
21 to 22 loads.....	1		

such materials have been here included because the data do not permit the separation of the labor of hauling them from the labor of hauling the animal manure.

POSSIBLE RATES OF APPLYING MANURE

It is evident that in planning a system of permanent soil productivity, the number of cattle necessary to furnish sufficient manure to carry out the manurial program must be based upon the probable amount that will be recovered and not upon the total production calculated from experimental data. In order to determine the frequency with which the tillable land could have been manured on these farms having different numbers of cows, the 224 farms were divided into seven groups on the basis of the number of crop acres in the farm (exclusive of pasture) for each cattle unit. Consideration is here directed only to the manure recovered from the dairy cattle, the amounts of manure recovered from other sources being in no way related to the number of cattle kept.

Fourteen of these farms, as shown by Table 3, had less than two crop acres for each cattle unit. The maintenance of so many cows on this basis was possible because of the large amount of pasture in these farms, less than half of the total acreage being under cultivation. The average amount of cow manure recovered annually in this group was 279 loads per farm, or 3.37 loads per crop acre. If none of this manure had been applied to pasture, each acre under cultivation could

have been treated with 10 loads of manure every three years. Had the amount of manure recovered on these fourteen farms been as high as the average amount recovered on all the farms studied (6.6 loads per cattle unit), one-third of the tillable land could have been manured each year at the rate of 13 loads per acre. These fourteen farms, with relatively large numbers of cows and small crop acreages, did not produce so great a surplus of straw for bedding as did the farms which were less heavily stocked, and this accounts to a large extent for the smaller amount of manure recovered per cattle unit.

TABLE 3.—RELATION BETWEEN THE NUMBER OF DAIRY CATTLE UNITS PER 100 CROP ACRES AND THE AMOUNT OF MANURE RECOVERED

Group	Crop acres per cattle unit	Number of farms	Average number of cattle units		Loads of manure recovered annually from dairy cattle		
			Per farm	Per 100 crop acres	Per crop acre	Per cattle unit	Per farm
I.....	1-1.9	14	53.7	65	3.37	5.2	279
II.....	2-2.9	49	46.0	41	2.68	6.5	304
III.....	3-3.9	51	34.5	29	2.09	7.2	247
IV.....	4-4.9	40	25.2	22	1.54	6.9	173
V.....	5-5.9	18	22.4	18	1.47	8.0	178
VI.....	6-6.9	13	16.7	16	1.05	6.6	111
VII.....	7-over	39	19.4	7	.37	5.7	110

In the succeeding groups of farms the loads of manure recovered per crop acre decrease rather uniformly as the crop acres per cattle unit increase. The last group, consisting of 39 farms, averaged 15.3 crop acres per cattle unit, and the amount of manure recovered was so small (.37 loads per crop acre) that 22 years would have been required to cover all of the tillable land at the rate of 8 loads per acre.

Having some basis for knowing the average amount of manure likely to be recovered per dairy cattle unit under common farm practice, it becomes a simple matter, in planning a cropping system, to compute the number of cows, or their equivalent, that will be required to provide sufficient manure for any desired rate of application. Table 4 gives a number of such calculations. For instance, if the proposed system called for an application of 10 loads of manure per acre during a four-year rotation, according to the data supplied by this study 38 cows or their equivalent, per 100 crop acres, would be required. From these data, also, the possible rates of applying manure may be calculated if the number of dairy cattle units per acre is known. For instance, a farmer having 30 cows, or their equivalent, for each 100 crop acres would have sufficient manure to annually cover one-third of his crop land at the rate of 6 loads per acre. If he favored heavier applications he could manure one-fourth of his tillable land at the rate of 8 loads per acre, or one-fifth at the rate of 10 loads per acre, or one-sixth at the rate of 12 loads per acre.

It is apparent that the relatively small amount of manure recovered per cattle unit (6.6 loads) was due, in part, to the wasteful methods of handling, but so long as these methods are the common practice they must be taken into account in planning for the maintenance of the fertility of the soil by the use of farm manure.

TABLE 4.—NUMBER OF DAIRY CATTLE UNITS PER 100 CROP ACRES REQUIRED FOR THE PRODUCTION OF SUFFICIENT MANURE TO BE APPLIED AT VARIOUS RATES AND INTERVALS

Figured on the Basis of 6.6 Loads of Manure per Cattle Unit being Recovered Annually

Frequency of manuring	6 loads per crop acre	8 loads per crop acre	10 loads per crop acre	12 loads per crop acre
	<i>Cattle units</i>	<i>Cattle units</i>	<i>Cattle units</i>	<i>Cattle units</i>
Every 3 years.....	30	40	51	61
Every 4 years.....	23	30	38	45
Every 5 years.....	18	24	30	36
Every 6 years.....	15	20	25	30
Every 7 years.....	13	17	22	26
Every 8 years.....	11	15	19	23
Every 9 years.....	10	13	17	20
Every 10 years.....	9	12	15	18

CROPS MANURED

In classifying the disposal of the manure, the crop which first followed the application of manure to a field is recorded as having been the crop manured. This crop may have been grown the same year in which the application was made, or it may have been grown the following year if the field was manured in the fall. Manure applied in midsummer, after the removal of a grain crop, is listed as having been applied for the crop grown in the field the next year.

The disposal of 5,093 loads of manure, or 8.09 percent of the total amount hauled, is classed as "unknown." The amount and kind of this "unknown" manure, the season it was hauled, and the man and horse labor used in handling it have been included in the data, but the crops which utilized the manure were not recorded. The absence of this part of the record for the "unknown" manure is largely due to the fact that during the eight-year period covered by this study a number of the cost accounts were discontinued and for these farms the records are incomplete as to the crops utilizing the manure that was applied in the autumn and winter preceding the spring in which the accounts were dropped.

Table 5 shows the aggregate amount of manure applied to each crop on the 224 farms. There was hauled to the fields a total of 62,884 loads. The difference between this amount and the total amount recorded in Table 1 is due to the difference in the amounts of unhauled manure inventoried at the beginning and at the end of the year.

TABLE 5.—TOTAL MANURE HAULED ANNUALLY ON 224 DAIRY FARMS AND THE CROPS RECEIVING IT

Crop manured	Loads	Percent of total
Corn.....	37 641	59.86
Alfalfa.....	4 154	6.61
Timothy.....	2 651	4.22
Wheat.....	2 589	4.12
Clover.....	2 575	4.09
Pasture.....	2 572	4.09
Rye.....	1 205	1.92
Oats.....	976	1.55
Garden.....	805	1.28
Clover and timothy...	699	1.11
Potatoes.....	623	.99
Barley.....	362	.58
Cowpeas.....	331	.53
Melons.....	218	.35
Orchard.....	208	.33
Soybeans.....	103	.16
Beets.....	29	.05
Strawberries.....	25	.04
Sudan grass.....	15	.02
Sorghum.....	7	.01
Pumpkins.....	3	..
Unknown.....	5 093	8.09
Total.....	62 884	100.00

Three-fifths of the total manure hauled was applied to corn land. This was over nine times as much as was applied to any other crop. Altho alfalfa received the next largest amount, that amount was but one-sixteenth of the total manure hauled. Timothy, wheat, clover, and pastures each received approximately one-twenty-fifth of the total amount of manure. The other 5,609 loads for which there are records were distributed in varying amounts among fifteen different crops, no one of which received as much as 2 percent of the total manure.

RELATIVE ACREAGE OCCUPIED BY THE VARIOUS CROPS

The proportion of the manure which was applied to each of the various crops would have greater significance if the relative acreages of these crops were known. Because of the fact that manure applied in the spring was utilized by the crops of one year, and manure applied in the autumn and winter was utilized by the crops of the following year, the exact acreage of the crops manured could not be determined. However, the acreage of the crops grown during the year in which the manure was hauled (Table 6) represents fairly accurately the relative areas of the crops receiving manure, since 85 percent of the records are from farms which were included in the study for two or more consecutive years.

Corn was grown on almost one-third of the total area of these 224 dairy farms. The pasture acreage was practically the same as that of corn (30.81 percent of the total area). The oats crop ranked third in respect to acreage (11.26 percent), and wheat ranked fourth (7.27 percent). Timothy, clover, and alfalfa came next, occupying 4.58 percent, 3.11 percent, and 2.92 percent respectively of the total acreage. On the remaining area (8.60 percent) twenty miscellaneous crops were grown.

TABLE 6.—TOTAL ACREAGE DEVOTED TO THE VARIOUS CROPS GROWN ON THE 224 DAIRY FARMS

Crop	Acres	Percent of total
Corn.....	14 719	31.45
Pasture.....	14 420	30.81
Oats.....	5 267	11.26
Wheat.....	3 403	7.27
Timothy.....	2 145	4.58
Clover.....	1 456	3.11
Alfalfa.....	1 366	2.92
Barley.....	954	2.04
Rye.....	849	1.81
Clover and timothy...	481	1.03
Orchard.....	419	.90
Cowpeas.....	375	.80
Garden.....	151	.32
Potatoes.....	147	.31
Millet.....	114	.25
Strawberries.....	105	.23
Wild hay.....	100	.21
Oats and peas.....	94	.20
Soybeans.....	81	.17
Melons.....	49	.11
Vetch.....	30	.07
Sudan grass.....	23	.05
Buckwheat.....	23	.05
Sorghum.....	15	.03
Beets.....	8	.02
Pumpkins.....	1	..
Sunflowers.....	1	..
Total.....	46 796	100.00

METHODS OF UTILIZING MANURE

In order to better study the practices of these farmers in regard to manuring the different crops, the data in Tables 5 and 6 have been summarized in Table 7 and are shown graphically in Fig. 1. In this table the 5,093 loads of manure classed as "unknown" have been omitted in calculating the proportion of the total manure which was applied to the various crops.

Altho corn land constituted only 31.5 percent of the total crop acreage, the corn crop received 65.1 percent of all the manure hauled exclusive of the "unknown" manure (Table 7). In Table 8 is shown

TABLE 7.—MANURE HAULED ANNUALLY FOR EACH CROP AND THE AGGREGATE ACREAGE OF EACH CROP ON THE 224 DAIRY FARMS

Crops grown	Manure hauled		Acreage of each crop		Loads of manure per acre
	Loads	Percent of total	Acres	Percent of total area	
Corn.....	37 641	65.1	14 719	31.5	2.56
Hay.....	10 528	18.2	5 927	12.7	1.78
Small grains.....	5 132	8.9	10 473	22.4	.49
Pasture.....	2 572	4.5	14 420	30.8	.18
Orchard and garden....	1 038	1.8	675	1.4	1.54
Potatoes.....	623	1.1	147	.3	4.24
Miscellaneous.....	257	.4	435	.9	.59
Total (exclusive of unknown).....	57 791	100.0	46 796	100.0	....
Unknown.....	5 093	....	.....	....	....
Total.....	62 884	....	.....	....	....

the variation among the different farms in the proportion of manure which was applied to corn land. Since the choice of crops to be manured was a matter of judgment with the individual farmer, the inclusion of eight years' records of one farmer and only one year's records of another, would, of course, give undue weight to the method of the farmer having the greater number of records. Where records for more than one year were available, an average was therefore taken for the entire period so that equal weight was given to the practice of each of the eighty-seven different farmers included in the study. Approximately one-third of these eighty-seven farmers applied from 80 to 100 percent of the manure to their corn, and three-fourths of them applied more than 50 percent to the corn.

The various hay crops, including timothy, clover, alfalfa, mixed hay, cowpeas, millet, vetch, etc., constituted 12.7 percent of the total acreage (Table 7). The manure applied to these crops amounted to 10,528 loads, or 18.2 percent of the total known manure. It was the usual practice of the farmers who applied manure to meadows to follow a hay crop with corn. This gave the hay the benefit of the manure the first year, and gave the corn, which followed, the benefit of both the residual effect of the manure and the increased growth of roots and stubble left from the hay crop. In Table 8 there is shown the variation among the different farms in the proportion of manure which was applied to the hay crops. Over one-half of these farmers applied less than 20 percent of the manure to hay ground; three-fourth applied less than 30 percent; and only four applied as much as 80 percent.

The small grains (wheat, oats, barley, and rye) almost doubled hay in acreage, but they received less than half as much manure as did the hay crops. Three-fourths of the farmers applied less than 10

TABLE 8.—SHOWING HOW THE PRACTICES OF THE 87 DAIRY FARMERS VARIED IN RESPECT TO THE PROPORTION OF MANURE APPLIED TO THE VARIOUS CROPS

Percentage of total manure applied to corn	Number of farms	Percentage of total manure applied to hay	Number of farms	Percentage of total manure applied to small grains	Number of farms
Less than 10%...	2	Less than 10%...	36	Less than 10%..	66
10 to 20%.....	6	10 to 20%.....	12	10 to 20%.....	15
20 to 30%.....	3	20 to 30%.....	17	20 to 30%.....	2
30 to 40%.....	3	30 to 40%.....	9	30 to 40%.....	1
40 to 50%.....	9	40 to 50%.....	6	40 to 50%.....	3
50 to 60%.....	8	50 to 60%.....	2	50 to 60%.....	—
60 to 70%.....	13	60 to 70%.....	1	60 to 70%.....	—
70 to 80%.....	15	70 to 80%.....	—	70 to 80%.....	—
80 to 90%.....	15	80 to 90%.....	3	80 to 90%.....	—
90 to 100%.....	13	90 to 100%.....	1	90 to 100%.....	—

percent of the manure to small grains, and none of them applied more than 45 percent.

Pastures constituted 30.8 percent of total farm area, but they received only 2,572 loads, or 4.5 percent of the total manure. This

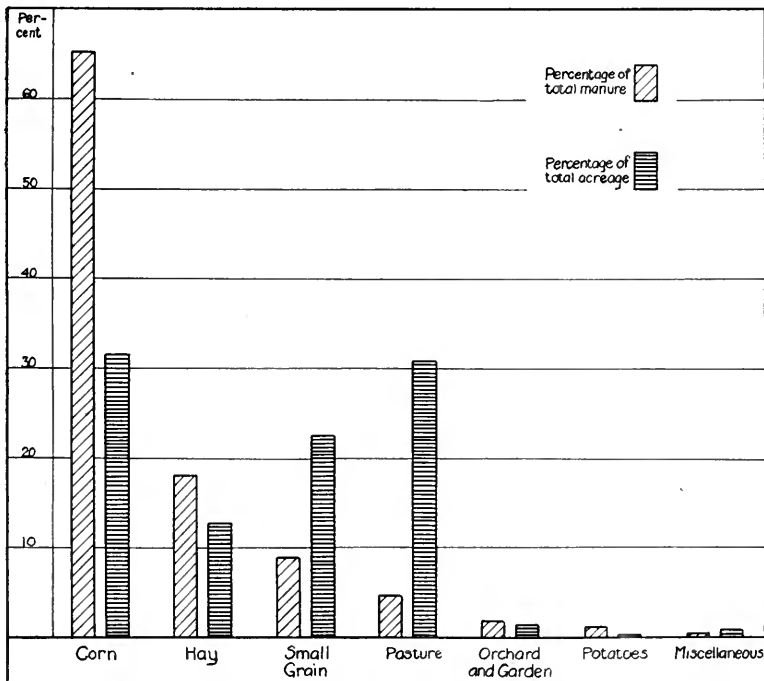


FIG. 1.—RELATIVE ACREAGES OF THE VARIOUS CROPS, AND THE PROPORTION OF THE TOTAL MANURE APPLIED TO EACH

was, of course, exclusive of the manure dropped while the live stock was on pasture. Probably the chief reason that pastures received even this much manure was their accessibility at all seasons of the year. When growing crops or muddy ground prevented manure from being hauled upon other fields, the pastures offered a convenient place for its disposal.

The acreages in orchards and gardens and in potatoes and the amounts of manure hauled upon them have been grouped separately merely to show the relatively heavy application of manure to these crops.

SEASONAL APPLICATION OF MANURE

The amount of manure applied during the different months to corn, hay, small grains, pasture, miscellaneous crops, and to those fields for which there were no records of the crops, is shown by Table 9 and Fig. 2. As would be expected, the least amount of manure was applied in June (1,857 loads) and but very little more was applied in July. It is during these two months that field work is heaviest, much of the live stock is on pasture, and all the spring-sown crops are too far advanced to permit the hauling of the manure upon the fields without doing the crop injury. The amount applied to pasture, however, during June, was greater than in any other month. This was probably due to the fact that the fields devoted to crops are not accessible at this time.

TABLE 9.—LOADS OF MANURE APPLIED MONTHLY TO THE VARIOUS CROPS ON THE 224 DAIRY FARMS

Month	Corn	Hay	Small grain	Pas-ture	Mis-cella-neous	Un-known	Total for the month	Percent of total for year
January.....	3 198	802	294	97	32	355	4 778	7.6
February.....	3 188	952	519	144	139	578	5 520	8.8
March.....	5 546	1 183	460	278	372	456	8 295	13.2
April.....	8 339	1 386	626	320	708	201	11 580	18.4
May.....	6 447	782	255	431	306	490	8 711	13.9
June.....	776	237	79	495	71	199	1 857	3.0
July.....	585	712	287	190	24	425	2 223	3.5
August.....	1 785	1 440	1 084	265	11	778	5 363	8.5
September....	1 303	672	507	23	55	287	2 847	4.5
October.....	1 185	603	169	76	15	426	2 474	3.9
November.....	2 246	863	367	150	92	527	4 245	6.8
December.....	3 043	896	485	103	93	371	4 991	7.9
Total for the year.....	37 641	10 528	5 132	2 572	1 918	5 093	62 884	100.0
Percent of total	59.9	16.7	8.2	4.1	3.0	8.1	100.0	....

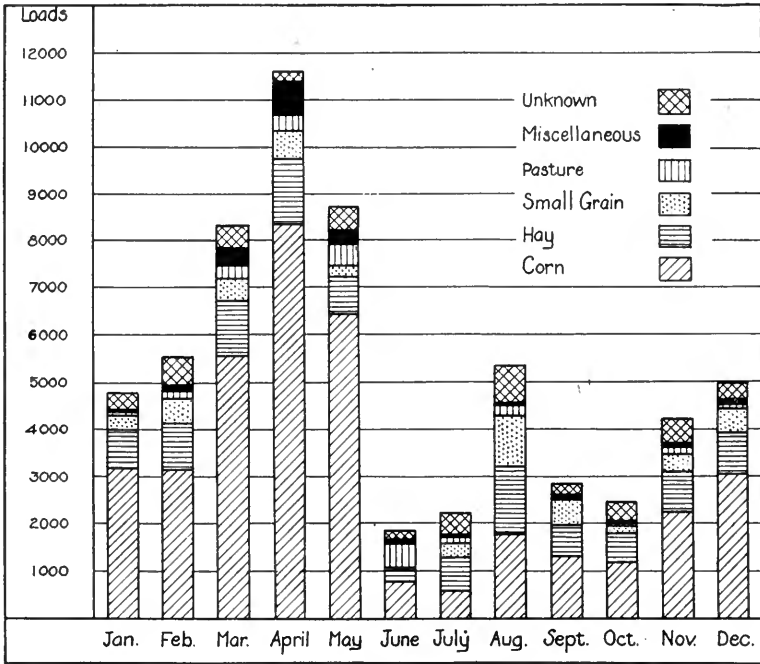


FIG. 2.—AMOUNTS OF MANURE APPLIED TO THE VARIOUS CROPS DURING THE DIFFERENT MONTHS OF THE YEAR

The amount of manure hauled during August (5,363 loads) was almost three times as great as was hauled during June. Much of this was spread upon wheat and oat stubble, which had been seeded in the spring to clover, alfalfa, or timothy; and hence the manure so applied was listed under hay crops. The 1,785 loads which were applied to corn ground during August were hauled largely on hay stubble. Winter wheat and rye were the two crops which received most of the manure applied to small grains during this month.

From September until the peak was reached in April, the amount of manure applied to the various crops tended to increase rather uniformly. During the latter month 11,580 loads of manure were hauled, 8,339 of which were applied to corn. During May, 6,447 loads of manure were applied to corn land despite the fact that corn was usually planted about the middle of May on the farms studied. After corn is planted, manure hauling is practically discontinued for two or three months on most farms because of the relatively large amount of labor which is required for field work.

LABOR COST OF HAULING MANURE

On the farms studied the average amount of man labor required in hauling and spreading one load of manure was 1.05 hours (this does not include the labor of cleaning the barn). The time consumed varied from month to month, and tended to be highest in the months when the least amount of manure was hauled and lowest in the months when the most manure was hauled. Fig. 3 shows graphically the relation between the number of loads of manure hauled during the different months and the amounts of man and horse labor used per load. The total man and horse labor used each month and the variation in the time per load is shown in Table 10. These are average figures, and since many farms with varying amounts of labor per load were involved it is unsafe to conclude from these data alone that there is a relationship between the amount of manure hauled and the labor used per load. When, however, the records were grouped on the basis of the relative amount of labor used per load during the months in which the greatest and the least amounts of manure were hauled, the conclusion was shown to be justified. It was found that on 76 percent of the 130 farms on which manure was hauled during both August and May, less labor per load was required during May than during August. Similar comparisons of April and July, April and August, April and September, and May and September showed that on 66, 72, 64, and 64 percent of the farms, respectively, the labor requirement per load was least during the spring, when the greatest amount of manure was hauled.

TABLE 10.—MAN AND HORSE LABOR USED IN HAULING 62,884 LOADS OF MANURE ON 224 DAIRY FARMS

Month	Loads of manure	MAN LABOR			HORSE LABOR		
		Total hours	Percent of total	Hours per load	Total hours	Percent of total	Hours per load
Jan.	4 778	5 170.75	7.8	1.08	10 447.75	7.6	2.19
Feb.	5 520	6 050.75	9.1	1.10	11 788.50	8.6	2.14
Mar.	8 295	8 469.75	12.8	1.02	17 630.00	12.8	2.13
Apr.	11 580	10 599.50	16.0	.92	22 985.75	16.7	1.98
May.	8 711	7 721.00	11.7	.89	16 878.25	12.2	1.94
June.	1 857	1 906.25	2.9	1.03	3 928.50	2.8	2.12
July.	2 223	2 910.25	4.4	1.31	5 878.50	4.3	2.64
Aug.	5 363	6 596.00	10.0	1.23	14 039.25	10.2	2.62
Sept.	2 847	3 684.75	5.5	1.29	7 431.00	5.4	2.61
Oct.	2 474	2 725.75	4.1	1.10	5 508.75	4.0	2.23
Nov.	4 245	4 870.00	7.4	1.15	10 072.50	7.3	2.37
Dec.	4 991	5 530.00	8.3	1.11	11 104.00	8.1	2.22
Total...	62 884	66 234.75	100.0	....	137 692.75	100.0	....
Average...	5 240	5 519.56	....	1.05	11 474.40	....	2.19

The smaller amount of labor used per load during the months of heaviest hauling was largely due to economy of time in harnessing and loading. Naturally, less time per load was consumed in harnessing the teams and hitching to the spreaders when the entire day was spent in hauling from manure piles which had accumulated during the winter, than was consumed when the manure was hauled daily. On many farms a saving in labor resulted from the use of two spreaders and three men, the third man helping to load.

The variation among the different farms in the amounts of man and horse labor used per load of manure is shown in Table 11. On two-thirds of the farms studied, between 0.7 and 1.3 hours of man labor were used in hauling one load of manure. The horse labor showed slightly greater variation, ranging from 1.4 to 3 hours per load on three-fourths of the farms.

These data on the labor costs of hauling manure are included in this study because to a certain extent they account for the methods

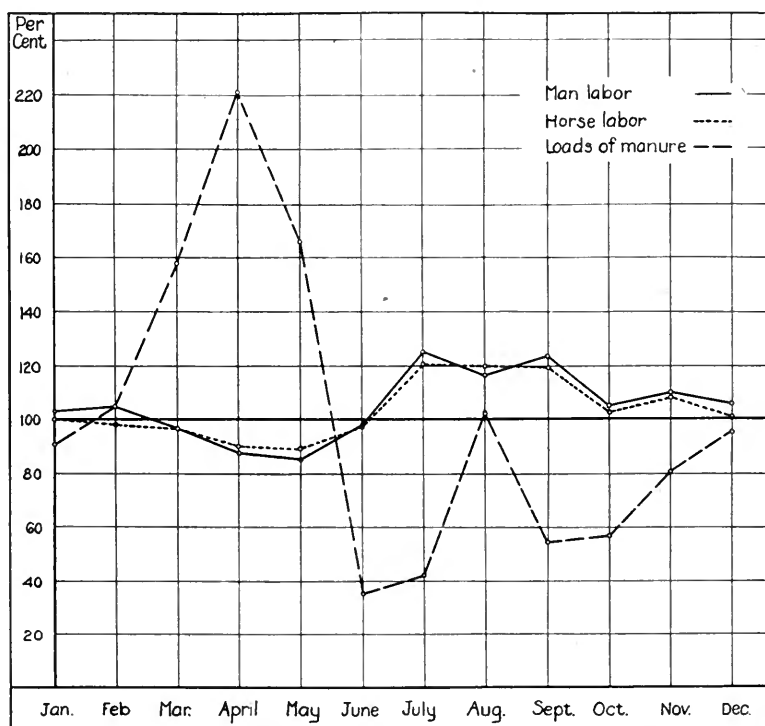


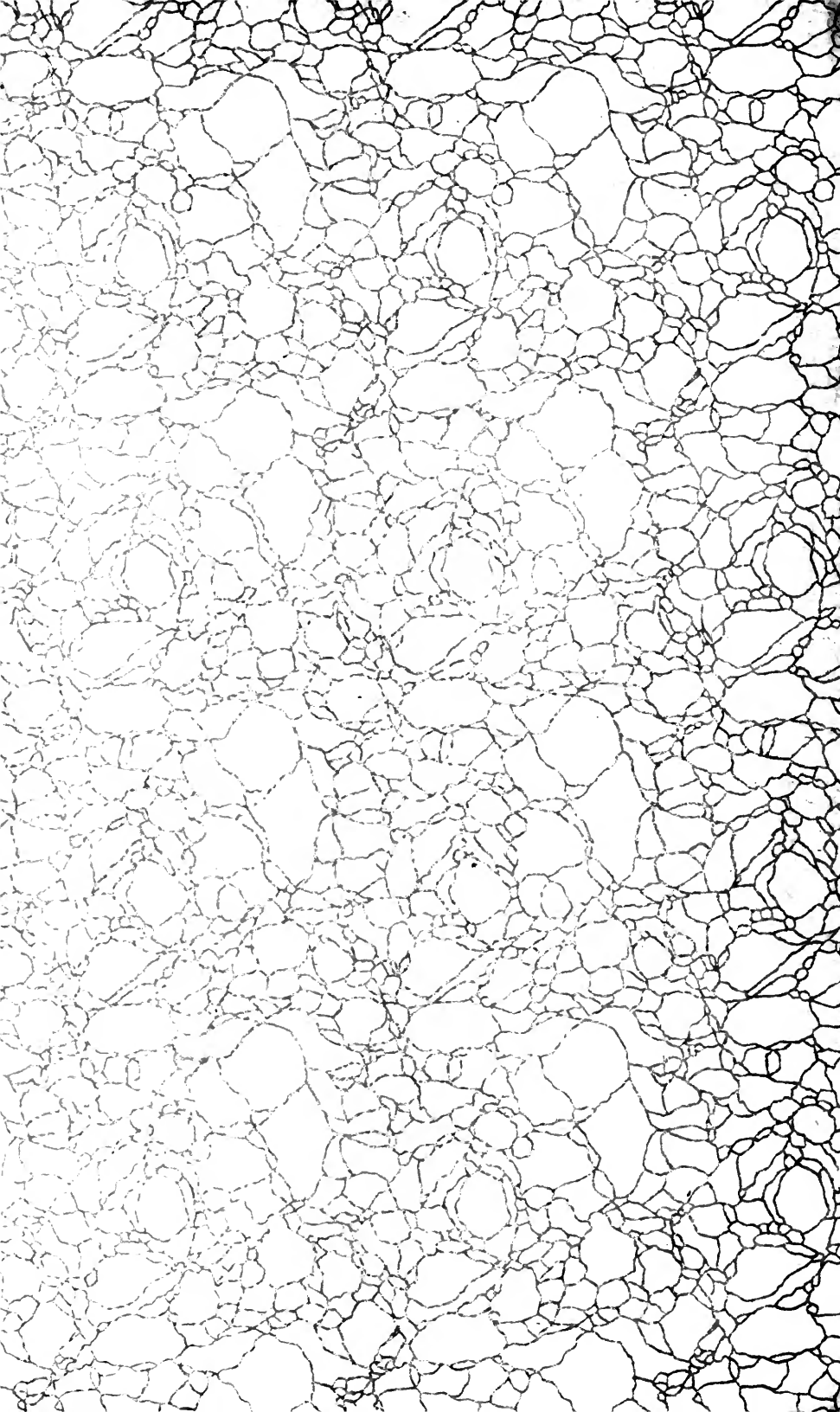
FIG. 3.—RELATION BETWEEN AMOUNT OF MANURE HAULED DURING THE DIFFERENT MONTHS, AND THE AMOUNTS OF MAN AND HORSE LABOR USED PER LOAD

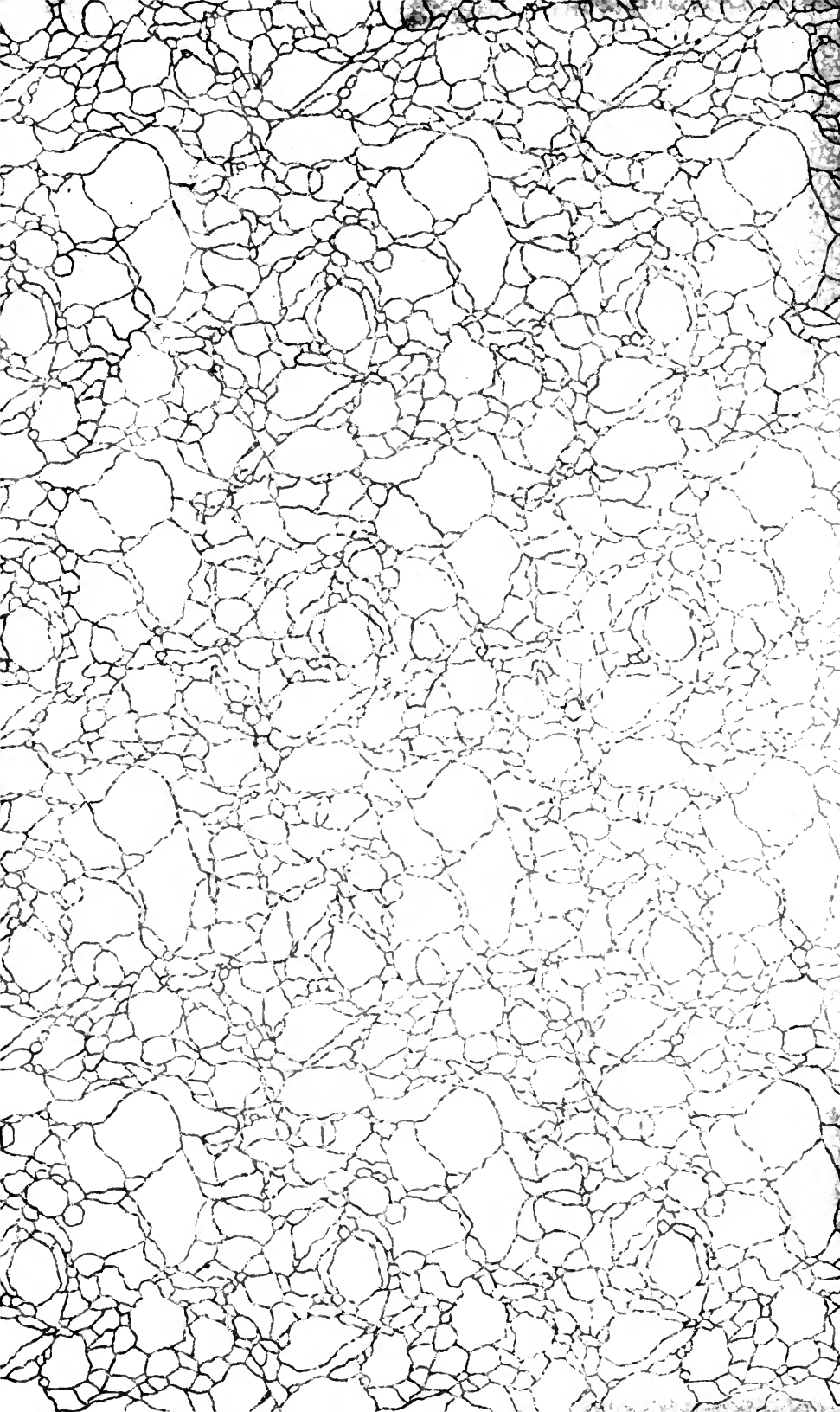
TABLE 11.—SHOWING HOW THE AMOUNTS OF MAN AND HORSE LABOR USED PER LOAD OF MANURE VARIED ON 224 DAIRY FARMS

<i>Man labor</i> per load	Number of farms	<i>Horse labor</i> per load	Number of farms
0.3 to 0.5 hours . . .	3	0.6 to 1.0 hours . . .	6
0.5 to 0.7 hours . . .	23	1.0 to 1.4 hours . . .	19
0.7 to 0.9 hours . . .	65	1.4 to 1.8 hours . . .	39
0.9 to 1.1 hours . . .	59	1.8 to 2.2 hours . . .	51
1.1 to 1.3 hours . . .	28	2.2 to 2.6 hours . . .	47
1.3 to 1.5 hours . . .	12	2.6 to 3.0 hours . . .	26
1.5 to 1.7 hours . . .	9	3.0 to 3.4 hours . . .	14
1.7 to 1.9 hours . . .	12	3.4 to 3.8 hours . . .	11
1.9 to 2.1 hours . . .	5	3.8 to 4.2 hours . . .	3
2.1 to 2.3 hours . . .	3	4.2 to 4.6 hours . . .	4
2.3 to 2.5 hours . . .	1	4.6 to 5.0 hours . . .	1
2.5 to 2.7 hours . . .	2	5.0 to 5.4 hours . . .	1
2.7 to 2.9 hours . . .	1	5.4 to 5.8 hours . . .	1
2.9 to 3.1 hours . . .	-	5.8 to 6.2 hours . . .	-
3.1 to 3.3 hours . . .	1	6.2 to 6.6 hours . . .	1

of handling manure which prevailed on the farms studied. On most of these farms so much labor was required to haul and spread a load of manure that to have hauled it daily as it was produced would have been impractical during the cropping season.







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