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The Economic Value of Farm Manure as a Fertilizer on Iowa Soils

AGRICULTURAL EXPERIMENT STATION
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SOILS SECTION

Ames, Iowa

THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON IOWA SOILS

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Farmers quite generally recognize that by applying farm manure to their land, they will secure increased crop yields. Few, however, have a very definite idea of the actual amount of the increases secured. Nor do they realize that every ton of manure produced on their farms has a real money value which may be determined by calculating the value of the crop increases secured from its use.

The purpose of this bulletin is to show quite definitely the value of a ton of manure on various soil types in Iowa. The data presented have been secured on 43 of the cooperative soil experiment fields of the Soils Section, located on 16 of the more extensive soil types in the state.

While considerable variations have been noted in the effects of manure on the different soil types and even on different fields of the same type, the average value for all fields and all types, which has been secured, $1.97 per ton of manure on the basis of an application once in four years, represents rather accurately the returns which may be expected on average Iowa land from the use of manure on general farm crops.

IMPORTANT TO KNOW THE VALUE OF MANURE

It is important to know the value of farm manure in order that more care may be exercised in conserving and applying it to the land. Too often it is regarded as a waste material to be disposed of in the easiest way possible. Frequently no care is taken to prevent losses before it is applied and on many farms fields at some distance from the barns and feed yards are sometimes not manured at all.

The manure produced on a farm is an extremely important fertilizer and has a large money value. It pays to take all reasonable precautions to prevent losses in the storage of the manure and to apply it to the land in a way which will bring the most profitable returns.

FARM MANURE PRODUCED IN IOWA

The total excrement of farm animals in Iowa, calculated from the livestock statistics given in the Iowa Yearbook of Agricul-

ture for 1922, amounts to about 79,000,000 tons annually. This does not include the litter, which of course makes up a large part of the tonnage of manure produced. Taking this into account, the total amount of manure produced in the state may be figured at about 95 million tons each year.

Altho a large part of the manure produced is dropped by the animals on the pastures, an enormous amount of natural fertilizer is available for use on the soils of the state. If it were all applied to cultivated land, the total value for the state as a whole would amount to many million dollars each year.

LOSSES FROM MANURE CONSIDERABLE

The losses which manure may sustain from improper care in storing and application are extremely variable but data show definitely that the losses are very large. If the manure is kept in a loose pile exposed to the weather, and the liquid portion is allowed to wash away, perhaps down a slope to a stream, 75 to 80 percent of the fertilizing value of the manure may be lost. Not only is the liquid excreta, the most valuable part of the manure, carried away, but the alternate wetting and drying brings about undesirable fermentations in the manure which lead to further losses of plant food and of valuable organic matter.

Even where ordinary care is taken of the manure, the losses may amount to 40 or 50 percent of its real value. Under the best conditions of storage the loss may be cut down to 10 or 15 percent. Thus proper precautions to prevent losses from manure may increase its value by 50 or 60 percent or even 60 to 70 percent. If all the manure produced in the state were applied without losses, or with the least possible loss, the value to the state would amount to many million dollars annually. It is certainly a paying proposition for farmers to exercise care in keeping the manure on their farms from deterioration and to get it on their land with the least possible loss.

HOW TO PREVENT LOSSES FROM MANURE

Many different methods may be followed to prevent losses from manure and no one method can be recommended for use under all conditions. In general any method which keeps the manure moist, compact, and protected from the weather will cut down the losses to a minimum.

The proper use of litter is one of the most important means of conserving manure, as it holds the liquid portion and reduces the losses from leaching. Water-tight floors and gutters in stables also lessen the loss of the liquid excreta.

Special methods of storage are often employed and probably

one of the most successful of these methods is the open concrete pit. Sometimes an uncovered basin made of concrete, 3 to 4 feet high, and of any convenient length is employed. Covered sheds or covered feed yards, especially if provided with water-tight floors, prove very effective. With the open pit or basin the manure is kept wet from the additions and the rainfall but is not very well compacted. In the covered shed or yard, the animals compact the manure and it is kept fairly moist. In both cases some losses may take place, but they are not serious.

Composting is sometimes practiced, using soil, peat or muck or well-rotted manure in layers with the fresh manure. The piles are kept moist and covered and the losses from the manure are small.

The use of various chemicals has been suggested to conserve manure, but while some of these materials, especially gypsum, give considerable effect in reducing the losses, the mechanical methods of caring for the manure are considered more desirable at the present time.

If the manure can be spread on the land as rapidly as it is produced, it undergoes practically no loss and there is no storage problem. Where such a method of handling the manure is at all practicable, it is generally most desirable. On land subject to flooding or on hillsides, however, manure should not be applied as produced owing to the danger of its washing away. Then, too, on land which is to be fall plowed, losses may occur from the manure, if it is allowed to remain on the surface of the ground during hot, dry weather. In general, spreading manure as produced is the best way to prevent losses and to secure the largest effect on crop growth.

The data given in the following pages show the returns which may be secured from the application of a normal amount of manure (8 tons) as handled on the average Iowa farm. Greater care of the manure would certainly give greater effects and less care than the average or none at all may certainly be expected to lead to less beneficial effects from the manure.

IOWA EXPERIMENTS ON THE VALUE OF MANURE

Experiments have been under way on cooperative fields in various parts of Iowa during the past six or more years to determine the value of certain fertilizers on the soil types represented. These fields are located in counties in which soil surveys have been completed and have been carefully placed so that the soil will be representative of the type, the needs of which are to be studied. Care is taken that the topography of the area be typical and that the plots be located on land which has not been

treated in any abnormal way or utilized for any other purpose than normal cropping.

The plots are laid out with accurate measurements and permanently located by placing stakes 8 to 10 inches below the surface. Each plot is 28 feet by 155 feet 7 inches, or one-tenth of an acre in size. There are 7-foot strips between all plots and permanent borders around the entire series of plots.

Definite rotations are practiced in all cases. These vary on different fields but unless seasonal conditions or the failure of a crop have necessitated changes, some good rotation is followed.

Applications to the plots are made by the Soils Section field men and the harvesting is also handled by these men, the entire plots being harvested and the weights secured in the case of the corn and hay crops while with the small grains, samples are shipped to Ames to be threshed.

One plot on each of these series received only manure, eight tons being applied once in a four-year rotation. The yields obtained on these manured plots compared with the average yields on the three check plots 1, 7, and 13 of the usual series, supply the data given in this bulletin. The average of the three checks is used except where four checks are available as noted in the tables.

The increases are calculated for the manure treatment and the value of these increases is estimated by using the 10-year average prices (1913-1922) for the various crops as given in the Iowa Yearbook of Agriculture for 1922. Average prices for soybeans are not given in the yearbooks and this crop is estimated at $1.50 per bushel. The figures employed are as follows:

Corn	$ 0.73	
Oats	$ 0.44	
Wheat	$ 1.34	
Barley	$ 0.62	
Rye	$ 1.02	
Hay	$13.11	
Alfalfa	$16.97	(9-year average)
Soybeans	$ 1.50	(estimated)

It should be noted that the ten-year average includes the high prices of the war period but it also takes in the very low prices of the period following the war, hence the figures are felt to be reasonably accurate.

The total value of the increases on all crops is determined and then the value of each ton of manure per four-year rotation is calculated and the final figures given are on this basis. The cost of applying the manure and the cost of handling increased crops

are not figured. Such figures would be arbitrary and of little value.

Perhaps the amount of manure used in these tests is a little larger than the amount actually applied on the average farm, which may be nearer 6 tons than 8 tons, but the figures secured may be considered conservative, if looked at in this way. It is quite probable that the increases per ton of manure would be greater in most cases, if 6 tons of manure had been employed. This is a point which merits further study. No data are available along this line. Indeed the results would probably be different on various soil types.

No attempt has been made to differentiate between the immediate and the residual effects of the applications of manure. Obviously the increases secured on the second-year corn, the oats and the clover of the regular four-year rotation are due to residual effects. But there may be benefits from the manure (and this is ordinarily the case) for a longer period. Thus the effects of the second application of manure will include not only the benefits from that addition but the residual effects from the previous application. How long these residual effects will be apparent is not known. It is certain, however, that in the experimental data given in this bulletin, all the benefits from the manure applied have not yet been shown. Data for additional years will of course show more complete effects. The results given are therefore conservative and the effects of the manure would be increased rather than decreased by further data.

The years in which the results were secured are not given in the tables as this is not considered necessary. In a few instances results were not secured for various reasons. No mention is made of the fact in the tables and the results are calculated for the years when yields were secured. When no increases were obtained, the data are figured over the entire period including those years.

The data are taken from 43 of the cooperative soil experiment fields, located on 16 soil types and include all the fields for which yields are reported in Bulletin 221 of the Iowa Agricultural Experiment Station and in all cases the check yields are the average of the results on all check plots in the series. The yields for 1924 on all the fields are also used in the calculation as well as the data given in Bulletin 221. The results will be considered on the individual fields and these will be grouped by soil types.

THE RESULTS ON CARRINGTON LOAM

The data secured on eight series on four fields located on the Carrington loam are given in table I. These fields are located

TABLE I. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON CARRINGTON LOAM — IOWA EXPERIMENT FIELDS

I Eldora Field — Series 100 — Hardin County

	Corn bu.	Oats bu.	Clover tons	Corn bu.	Corn bu.	Oats bu.	Clover tons	Corn bu.	Corn bu.	Oats bu.
Check	37.2	35.8	1.28	53.8	34.7	41.7	1.71	63.6	38.2	56.7
Manure	38.5	50.0	1.36	55.8	52.5	49.6	1.65	67.2	40.0	69.1
Increase	1.3	14.2	0.08	2.0	17.8	7.9	...	3.6	1.8	12.4

Value of increase, $35.56; value per ton of manure per 4-yr. rotation, $1.77.

II Eldora Field — Series 200 — Hardin County

	Oats bu.	Clover tons	Corn bu.	Corn bu.	Oats bu.	Clover tons	Corn bu.	Corn bu.
Check	60.7	0.45	49.1	50.4	30.7	1.57	37.0	19.9
Manure	66.4	0.90	50.0	62.5	38.0	1.38	37.6	30.3
Increase	5.7	0.45	0.9	12.1	7.3	...	0.6	10.4

Value of increase, $29.13; value per ton of manure per 4-yr. rotation, $1.82

III Jesup Field — Black Hawk County

	Oats bu.	Clover tons	Clover & timothy tons	Corn bu.	Corn bu.	Oats bu.	Clover tons
Check	66.8	1.25	0.54	57.6	53.5	33.2	0.89
Manure	71.6	2.08	0.85	72.8	65.6	29.4	1.06
Increase	4.8	0.83	0.31	15.2	12.1	...	0.17

Value of increase, $39.20; value per ton of manure per 4-yr. rotation, $2.80.

IV Truesdale Field — Series 100 — Buena Vista County

	Corn bu.	Corn bu.	Oats bu.	Clover tons	Corn bu.	Oats bu.	Corn bu.
Check	41.6	59.5	56.7	1.90	49.5	49.2	24.2
Manure	44.3	57.1	57.9	1.20	61.6	57.7	24.2
Increase	2.7	...	1.2	...	12.1	8.5	...

Value of increase, $15.06; value per ton of manure per 4-yr. rotation, $1.07

V Truesdale Field — Series 200 — Buena Vista County

	Oats bu.	Corn bu.	Corn bu.	Oats bu.	Clover tons	Corn bu.
Check	80.0	55.1	34.6	23.5	1.89	40.1
Manure	94.2	57.0	39.7	24.6	1.90	52.7
Increase	14.2	1.9	5.1	1.1	0.01	12.6

Value of increase, $21.16; value per ton of manure per 4-yr. rotation, $1.76

VI Waverly Field No. 1 — Bremer County

	Oats bu.	Clover tons	Corn bu.	Oats bu.	Corn bu.	Oats bu.	Clover tons
Check	48.6	1.48	84.4	35.0	58.4	32.8	1.19
Manure	57.2	1.84	89.0	38.9	57.6	31.7	1.27
Increase	8.6	0.36	4.6	3.9	...	...	0.08

Value of increase, $14.61; value per ton of manure per 4-yr. rotation, $1.04

VII Waverly Field No. 2 — Series 1 — Bremer County

	Oats bu.	Clover tons	Corn bu.	Oats bu.	Clover tons	Corn bu.
Check	59.2	1.53	39.8	27.6	1.82	15.5
Manure	61.0	1.75	56.5	34.3	2.20	24.7
Increase	1.8	0.22	16.7	6.7	0.38	9.2

Value of increase, $30.50; value per ton of manure per 4-yr. rotation, $2.54

VIII Waverly Field No. 2 — Series 2 — Bremer County

	Corn bu.	Oats bu.	Clover tons	Clover & timothy tons	Corn bu.	Corn bu.	Oats bu.
Check	40.2	36.0	0.54	1.02	39.9	34.1	41.0
Manure	54.0	49.3	0.67	1.30	55.7	40.2	49.7
Increase	13.8	13.3	0.13	0.28	15.8	6.1	8.7

Value of increase, $41.11; value per ton of manure per 4-yr. rotation, $2.93

in Hardin, Black Hawk, Buena Vista, and Bremer Counties. The Carrington loam is a dark brown to black loam underlaid by a yellow clay loam. It is an extensive soil type in northern central Iowa and of glacial origin.

On the Eldora field, series 100, results have been secured for 10 years and only in one instance did the manure fail to bring about a crop increase. The corn increases ranged from 1.3 to 17.8 bushels per acre, the oats from 7.9 to 14.2 bushels while only small gains were noted with the clover. It will be noted throughout the discussion that clover shows generally the smallest effect from the manure, a result that would be expected. The range of increases in the corn is interesting and serves to indicate how variable the effects of the manure may be in different seasons. Only over a period of years, is it possible to determine with any accuracy the value of any fertilizer. The value per ton of manure on this field was found to be $1.77 per four-year rotation.

On series 200 on the same field, yields have been secured for eight years. Here the corn yields were even more variable, no increase at all being secured in 1923, while the greatest increase noted was 12.1 bushels. The oats increases were small but definite and again with clover only small increases or none at all were secured. The average value for the manure was about the same as on the other series, being $1.82 per ton.

The results secured on the Jesup field in Black Hawk County were obtained over a period of seven years. Large increases in corn were obtained while again with the oats, a small increase or none at all was secured. The clover and clover and timothy showed small increases. The average value per ton of manure was much higher here than on the two series on the Eldora field, due to the large corn increases obtained. The figure given was $2.80 per ton.

On the Truesdale field, series 100, in Buena Vista County, the results were extremely variable. Corn was not increased in two cases while in the other years when this crop was grown the increases were 2.7 and 12.1 bushels. Oats increases ranged 1.2 to 8.5 bushels. Clover showed no increase. The average value of the manure on this field amounted to $1.07 per ton.

On the second series on the same field, yields were secured for

six crops and increases were obtained in all cases. The corn increases were small except in 1924 when an increase of 12.6 bushels was secured. The effect on the oats varied widely, from 1.1 to 14.2 bushels. Clover was increased slightly. The average value of the manure was higher than in series 100, and amounted to $1.76 per ton.

Results were obtained on the Waverly field No. 1 in Bremer County for seven years. No increase was secured with corn in one case and an increase of 4.6 bushels was noted the only other year corn was grown. The oats increases ranged from 0 to 8.6 bushels. The clover showed small increases. The value of the manure on this field was $1.04 per ton, about the same as that shown on one series on the Truesdale field but less than the value on all the other fields on the same type.

On Waverly field No. 2, series 1, in the same county, six crops were secured. Here corn showed large increases, 9.2 and 16.7 bushels, the oat crop was definitely increased while clover showed one-fifth to one-third of a ton increase. The value of the manure was $2.54 per ton.

On series 2 on this field, results were obtained for seven years. Again corn showed large increases, 6.1 to 15.8 bushels. Oats were increased to a greater extent than on the other series on this field, 8.7 to 13.3 bushels, while clover was affected less on the average. The value of the manure was greater than in the other series, $2.93 per ton; in fact this was the largest value shown on any of the fields on Carrington loam.

The average value of the manure on Carrington loam may be calculated from these figures at $1.96 per ton. The range of value was from $1.04 to $2.93, which may indicate the range to be expected on this type.

Apparently manure may greatly increase crop yields on this soil, the effects being especially evident on corn. Less influence may appear on the oats and clover is not usually increased to any considerable extent. It is of interest to note that the average value of manure on this type was practically the same as the figure secured for all the fields on the 16 types.

THE RESULTS ON GRUNDY SILT LOAM

In table II will be found the results secured on seven series of plots on six fields in Wapello, Lee, and Henry Counties. The Grundy silt loam is an extensive upland type in southern Iowa. It is of loessial origin and is a dark brown or dark grayish-brown to almost black soil underlaid by a heavy, plastic clay subsoil, drab in color and mottled with brown, yellowish-brown and gray.

TABLE II. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON GRUNDY SILT LOAM — IOWA EXPERIMENT FIELDS

I Agency Field — Wapello County

	Corn bu.	Oats bu.	Wheat bu.	Clover & timothy tons	Timothy tons	Corn bu.	Corn bu.
Check	58.4	50.4	22.7	1.76	2.23	68.7	44.1
Manure	64.5	62.2	31.5	2.09	2.20	71.8	51.9
Increase	6.1	11.8	8.8	0.33	...	3.1	7.8

Value of increase, $33.71; value per ton of manure per 4-yr. rotation, $2.40

II Denmark Field — Lee County

	Wheat bu.	Clover tons	Timothy* tons	Corn bu.	Corn bu.	Wheat bu.
Check	24.0	1.45	4.02	54.6	59.3	20.8
Manure	31.7	1.45	5.60	61.6	70.7	19.1
Increase	7.7	...	...	7.0	11.4	...

Value of increase, $23.74; value per ton of manure per 4-yr. rotation, $1.97

* High in moisture — not calculated.

III Farson Field — Wapello County

	Oats bu.	Wheat bu.	Clover tons	Corn bu.	Oats bu.	Corn bu.	Corn bu.
Check	70.0	13.7	1.27	67.3	22.5	60.5	32.3
Manure	72.2	11.7	1.19	80.4	21.8	55.8	36.6
Increase	2.2	...	...	13.1	...	...	4.3

Value of increase, $13.66; value per ton of manure per 4-yr. rotation, $0.97

IV Mt. Pleasant Field — Series 100 — Henry County

	Corn bu.	Corn bu.	Oats bu.	Clover tons	Corn bu.	Corn bu.	Oats bu.	Corn bu.
Check	32.1	48.1	73.7	4.15	48.3	58.0	44.7	51.5
Manure	22.2	37.5	75.1	3.79	57.0	56.7	39.8	54.0
Increase	...	...	1.4	...	8.7	...	...	2.5

Value of increase, $8.78; value per ton of manure per 4-yr. rotation, $0.54

V Mt. Pleasant Field — Series 200 — Henry County

	Corn bu.	Corn bu.	Oats bu.	Clover tons	Corn bu.	Corn bu.
Check	57.3	58.7	33.9	1.80	59.9	44.3
Manure	66.3	51.2	46.9	1.90	77.3	58.0
Increase	9.0	...	13.0	0.10	17.4	13.7

Value of increase, $36.30; value per ton of manure per 4-yr. rotation, $3.02

VI Sawyer Field — Lee County

	Corn bu.	Corn bu.	Rye bu.	Clover tons	Timothy tons
Check	49.9	48.9	12.5	2.15	1.00
Manure	58.0	58.7	13.9	2.50	1.28
Increase	8.1	9.8	1.4	0.35	0.28

Value of increase, $22.73; value per ton of manure per 4-yr. rotation, $2.27

VII West Point Field No. 1 — Lee County

	Corn bu.	Oats bu.	Clover & timothy tons	Corn bu.	Corn bu.	Oats bu.	Clover tons
Check	57.0	43.0	2.21	61.9	80.2	52.1	0.30
Manure	59.7	41.5	1.87	68.3	93.3	57.5	0.42
Increase	2.7	...	...	6.4	13.1	5.4	0.12

Value of increase, $20.14; value per ton of manure per 4-yr. rotation, $1.43

On the Agency field in Wapello County, yields were secured for seven years. Corn showed small increases, 3.1 to 7.8 bushels, while with oats and wheat, increases of 11.8 and 8.8 bushels were secured from the use of the manure. Clover and timothy showed an increase of 0.33 ton while timothy alone was not increased at all. The value of the manure on this field amounted to $2.40 per ton.

On the Denmark field in Lee County the wheat increases varied from 0 to 7.7 bushels. Corn showed increases from 7.0 to 11.4 bushels and clover gave no increase. The timothy crop was not included in the calculation as dry weights were not taken. The average value for the manure was less than that on the Agency field, $1.97 per ton.

On the Farson field in Wapello County, the results were very irregular. Crop yields were secured for seven years and in four cases no increases were secured from the manure applied. In the other years the corn increases were 4.3 and 13.1 bushels and oats were increased 2.2 bushels. The value of the manure amounted to $0.97 per ton, a much lower value than that found on the two preceding fields on this type.

On series 100 on the Mt. Pleasant field in Henry County, eight years results were secured. In three cases only were increases secured from the manure. The corn increases were 2.5 and 8.7 bushels while one increase for oats amounted to 1.4 bushels. The average value of the manure was only $0.59 per ton, a very low figure for this type, much lower than the value secured on any of the other fields on this soil, probably due to some abnormality in the manured plot.

The results on series 200 on the same field are quite different on the average than those on series 100. Corn was increased in all cases but one. These increases ranged from 9.1 to 17.4 bushels. Oats showed an increase of 13.0 bushels and with clover a small gain was secured. The average value of the manure was five times as great as that on the other series, $3.02 per ton. This certainly indicates that the value of manure on this soil may vary considerably depending on the local and seasonal conditions. (Seasonal effects are different on different crops.)

On the Sawyer field in Lee County, very definite increases in corn were secured from the use of manure, 8.8 and 9.7 bushels. Rye showed a small increase and clover and timothy were increased 0.35 and 0.28 tons, respectively. The average value of the manure amounted to $2.27 per ton.

The results on the West Point field No. 1 in Lee County showed increases for corn ranging from 2.7 to 13.1 bushels. Oats

were increased to a slight extent and clover alone and clover and timothy showed slight or no effects. The value of the manure amounted to $1.43 per ton.

The average value per ton of manure on the Grundy silt loam was $1.80 and the range on the various fields was from $0.59 to $3.02. The Grundy silt loam varies in certain characteristics in different areas and this variation is reflected in the response secured from the use of manure. Undoubtedly, however, the average value may be considered to represent quite accurately the results which may be expected on this soil. Note how close the average value is to the average value for all fields on various soil types. The importance of manuring this soil is clearly shown and as in the case of the Carrington loam, corn showed the greatest increase from the manure. Wheat was also increased in some cases to a large extent. Oats were sometimes benefited materially and the hay crops showed but little effect from the manure.

THE RESULTS ON MARSHALL SILT LOAM

The results secured on four fields on the Marshall silt loam in Pottawattamie, Montgomery, and Sioux Counties are given in table III. The Marshall silt loam is a dark-brown to black silt loam, of loessial origin, overlying a yellowish-brown silt loam subsoil. It is the chief upland soil in the Missouri loess soil area, occurring extensively thruout western Iowa.

The results secured on the Avoca field in Pottawattamie County showed little or no effect of the manure on corn but considerable increases were secured on oats, 6.5 to 7.7 bushels. Clover showed a gain of 0.64 ton but sweet clover was not increased. The average value of the manure was found to amount to $1.44 per ton.

On the Red Oak field in Montgomery County the increases in corn from the manure were very much the same in all cases and not large, ranging from 5.5 to 7.0 bushels. Oats showed an increase of 7.3 bushels and there was a wide range in effect on the wheat, from 0.3 to 20.5 bushels. Soybeans showed an increase of 2.2 bushels. The total value of the manure on this field was $3.40 per ton, a very much larger value than that secured on the Avoca field, due mainly to the one large wheat increase.

Only four crop yields were secured on the Rock Valley field in Sioux County; three crops of corn and one of oats. The corn was very definitely increased by the manure, from 4.0 to 12.0 bushels, and the oats showed a gain of 7.4 bushels. The value of the manure was $2.67 per ton.

TABLE III. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON MARSHALL SILT LOAM — IOWA EXPERIMENT FIELDS

I Avoca Field — Pottawattamie County

	Corn bu.	Oats bu.	Clover tons	Corn bu.	Oats bu.	Sweet clover tons
Check	74.8	62.5	2.06	49.7	49.0	0.77
Manure	72.1	69.0	2.70	53.6	56.7	0.63
Increase	...	6.5	0.64	3.9	7.7	...

Value of increase, $17.47; value of manure per ton per 4-yr. rotation, $1.45

II Red Oak Field — Montgomery County

	Wheat bu.	Corn bu.	Corn bu.	Oats bu.	Wheat bu.	Corn bu.	Soy-beans bu.
Check	13.6	51.4	54.6	29.6	15.2	52.3	10.2
Manure	34.1	57.2	61.6	36.9	15.5	57.8	12.4
Increase	20.5	5.8	7.0	7.3	0.3	5.5	2.2

Value of increase, $47.73; value per ton of manure per 4-yr. rotation, $3.40

III Rock Valley Field — Sioux County

	Corn bu.	Oats bu.	Corn bu.	Corn bu.
Check	46.8	39.8	40.4	12.6
Manure	55.7	47.2	52.4	16.6
Increase	8.9	7.4	12.0	4.0

Value of increase, $21.42; value per ton of manure per 4-yr. rotation, $2.67

IV Villisca Field — Montgomery County

	Clover tons	Corn bu.	Oats bu.	Clover tons	Corn bu.	Corn bu.
Check	1.40	52.3	48.9	0.78	64.1	37.4
Manure	1.20	51.0	52.1	0.88	73.9	38.8
Increase	...	...	3.2	0.10	9.8	1.4

Value of increase, $10.88; value per ton of manure per 4-yr. rotation, $0.90

On the Villisca field in Montgomery County the effects of the manure on corn varied widely, from 0 to 9.8 bushels per acre. Oats showed a small increase of 3.2 bushels and in the one case clover was increased. The average value of the manure on this field was $0.90 per ton, a much lower figure than that given on the other fields.

The average value of manure on the Marshall silt loam as determined on these four fields was $2.10 with a range from $0.90 to $3.40. This range is not unexpected on this soil owing to the fact that there are variations in topography which may lead to differences in fertilizer effects in different seasons. In general the influence of the manure was shown most definitely on the corn as was noted on the other soils previously discussed but in some cases the effect on wheat was quite large. Oats showed smaller gains and clover was only occasionally increased to an appreciable extent. The average figure showing the value per ton is slightly greater than that secured for all the fields on all the soil types.

THE RESULTS ON MUSCATINE SILT LOAM

The data secured on four fields on the Muscatine silt loam, in Scott, Clinton, and Muscatine Counties are given in table IV. The Muscatine silt loam is a dark, grayish-brown to black silt loam with a heavy brownish-gray to yellowish-brown or gray silty clay loam subsoil, usually highly mottled. It is an important upland type in eastern and eastern central Iowa.

The results secured on the Blue Grass field in Scott County show only small effects from the use of manure on the crops grown, and, in two cases, no increases at all were secured. On this field clover was increased in one instance by one-fifth of a ton, the corn increases ranged from 0.3 to 4.4 bushels, wheat showing only small effects and oats none at all. The average value of the manure was $0.81 per ton.

On the Delmar field in Clinton County corn showed a considerable increase in one case, 11.6 bushels, but in two other

TABLE IV. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON MUSCATINE SILT LOAM — IOWA EXPERIMENT FIELDS

I Blue Grass Field — Scott County

	Corn bu.	Wheat bu.	Clover tons	Corn bu.	Corn bu.	Oats bu.	Clover tons
Check	70.8	10.1	1.98	57.5	65.9	33.2	1.50
Manure	75.2	12.4	1.92	57.8	68.8	30.6	1.71
Increase	4.4	2.3	...	0.3	2.9	...	0.21

Value of increase, $11.37; value per ton of manure per 4-yr. rotation, $0.81

II Delmar Field — Clinton County

	Corn bu.	Corn bu.	Barley bu.	Wheat bu.	Corn bu.	Oats bu.	Clover tons
Check	69.5	70.0	25.6	27.5	64.0	45.8	1.03
Manure	81.1	65.8	28.1	28.4	65.1	54.3	1.08
Increase	11.6	...	2.5	0.9	1.1	8.5	0.05

Value of increase, $16.41; value per ton of manure per 4-yr. rotation, $1.17

III Eldridge Field — Scott County

	Corn bu.	Oats bu.	Barley bu.	Corn bu.	Corn bu.
Check	72.3	52.2	19.7	67.7	56.8
Manure	74.4	50.7	20.4	72.0	58.3
Increase	2.1	...	0.7	4.3	1.5

Value of increase, $6.19; value per ton of manure per 4-yr. rotation, $0.61

IV Letts Field — Muscatine County

	Corn bu.	Oats bu.	Wheat bu.	Clover & timothy tons	Corn bu.	Corn bu.
Check*	72.5	53.2	17.8	2.12	66.5	66.9
Manure	77.8	58.6	20.6	2.13	83.5	71.8
Increase	5.3	5.4	2.8	0.01	17.0	4.9

Value of increase, $26.10; value per ton of manure per 4-yr. rotation, $2.17

* Averages of 4 check plots.

instances no effect at all was secured or only a very small increase. Oats were appreciably increased, barley showed a small gain and wheat a very slight effect. The value of the manure was $1.17 per ton.

The effects of the manure were very small on the Eldridge field in Scott County. The increases for corn ranged from 1.5 to 4.3 bushels, oats showed no increase at all and there was little effect on the barley. The average value of the manure on this field was $0.59 per ton, a lower figure than those given in the two preceding cases.

On the Letts field in Muscatine County, the effect of the manure on corn showed a wide range, from 4.9 to 17.0 bushels. Wheat and oats showed small increases and clover was hardly affected at all. The average value of the manure was $2.30 per ton, considerably more than that given on the other fields on this type.

The average value of manure on this soil type as determined from the results on these four fields was $1.19, with a range from $0.59 to $2.30 per ton. The wide range in value on this soil type might be expected from the character of the soil. It is apparent that even on this soil which is naturally well supplied with organic matter and in a good state of fertility the use of manure proves profitable.

THE RESULTS ON CARRINGTON SILT LOAM

The data given in table V were secured on Carrington silt loam on five series on four fields in Clinton, Mitchell, and Linn Counties. The Carrington silt loam is a dark brown to black silt loam with a light yellowish-brown silty clay loam subsoil, grading into a brown clay loam or sandy clay, containing some gravel. It is an important upland type in north and east central Iowa.

Results have been secured for 10 years on the Calamus field in Clinton County and the effects of the manure have been very large in some cases. Corn showed increases from 5.2 to 11.2 bushels, oats from 2.2 to 20.8 bushels and clover from 0.07 to 1.02 tons. Wheat gave an increase of 6.8 bushels for the manure treatment. The large effect on the clover in one case is of special interest and indicates that manure may sometimes have a very important effect on this crop. The value of the manure on this field was large, amounting to $3.17 per ton.

On the Low Moor field in the same county, corn again showed considerable increases, from 1.8 to 11.6 bushels, due to the manure. Barley was definitely increased but the hay crops all

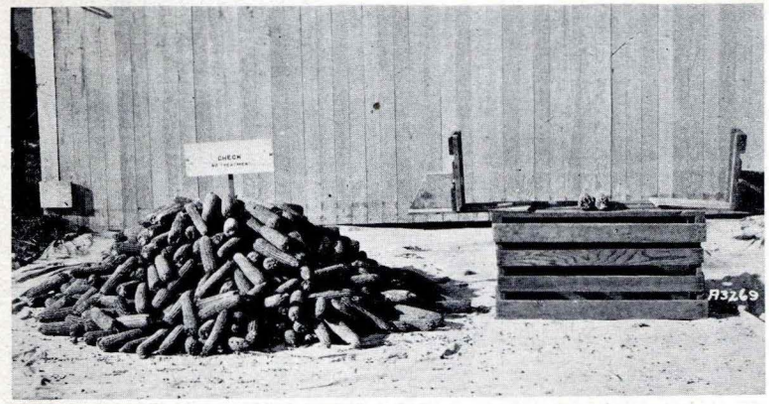

Fig 1. Yield of corn on untreated Carrington loam. — Note that little seed corn was produced.

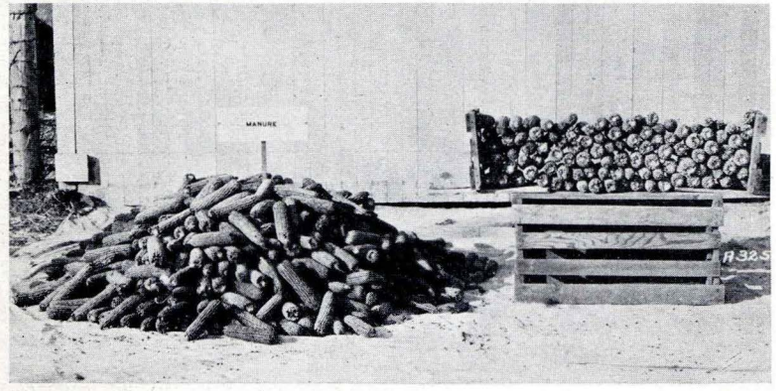

Fig. 2. Yield of corn on manured Carrington loam. — Note that crop yield was increased over that on untreated soil (above) and that more good seed corn was produced.

showed only small effects. The manure value was $1.12 per ton.

The results on the Osage field in Mitchell County also show a wide range in the effects of the manure on corn, from 0 to 14.3 bushels. Oats were increased to a considerable extent and clover showed some gain. The value of the manure was $1.89 per ton.

On series 1 on the Springville field in Linn County, the range in the effect of manure on the corn was from 10.1 to 16.8 bushels. Oats showed no gains but clover gave a half ton increase in one case. On this field the value of the manure was $3.08 per ton.

TABLE V. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON CARRINGTON SILT LOAM — IOWA EXPERIMENT FIELDS

I Calamus Field — Clinton County

	Wheat bu.	Corn bu.	Oats bu.	Clover tons	Clover tons	Corn bu.	Corn bu.	Oats bu.	Corn bu.	Oats bu.
Check*	19.3	37.3	33.4	2.02	0.67	54.5	38.3	37.7	36.1	48.2
Manure	26.1	46.7	54.2	3.04	0.74	65.2	43.5	45.4	47.3	50.4
Increase	6.8	9.4	20.8	1.02	0.07	10.7	5.2	7.7	11.2	2.2

Value of increase, $63.53; value per ton of manure per 4-yr. rotation, $3.17

* Average of 4 check plots.

II Low Moor Field — Clinton County

	Barley bu.	Clover & timothy tons	Timothy tons	Timothy tons	Corn bu.	Corn bu.	Corn bu.
Check	38.1	2.88	2.32	1.19	56.1	52.1	29.3
Manure	43.0	2.31	2.13	1.24	67.7	53.9	32.5
Increase	4.9	...	...	0.05	11.6	1.8	3.2

Value of increase, $15.79; value per ton of manure per 4-yr. rotation, $1.12

III Osage Field — Mitchell County

	Corn bu.	Corn bu.	Oats bu.	Clover tons	Corn bu.	Corn bu.	Oats bu.
Check	41.6	63.2	49.1	1.39	53.7	49.7	74.1
Manure	52.8	60.0	60.3	1.56	68.0	50.8	71.0
Increase	11.2	...	11.2	0.17	14.3	1.1	...

Value of increase, $26.55; value per ton of manure per 4-yr. rotation, $1.89

IV Springville Field — Series I — Linn County

	Clover tons	Corn bu.	Corn bu.	Oats bu.	Clover tons	Corn bu.
Check	1.90	54.7	46.5	39.2	1.41	38.7
Manure	2.47	64.8	63.3	36.4	1.47	51.2
Increase	0.57	10.1	16.8	...	0.06	12.5

Value of increase, $37.01; value per ton of manure per 4-yr. rotation, $3.08

V Springville Field — Series II — Linn County

	Corn bu.	Oats bu.	Clover tons	Corn bu.	Corn bu.
Check	59.1	48.1	1.34	63.4	35.1
Manure	66.0	46.8	1.43	76.0	40.0
Increase	6.9	...	0.09	12.6	4.9

Value of increase, $18.98; value per ton of manure per 4-yr. rotation, $1.89

In the second series on the same field the corn increases ranged from 4.9 to 12.6 bushels. Oats were increased appreciably and clover slightly. The value of the manure was less than that in series 1, $1.89 per ton, exactly the same as the value shown on the Osage field.

The average value of the manure on this soil type was higher than in the case of the types previously discussed, amounting to

$2.23 per ton. The range of value was from $1.12 up to $3.17. The effect of manure on this soil was certainly distinctly beneficial. Increases in corn yields were often very considerable. Occasionally large effects were noted on oats and wheat and clover seemed to be benefited to a large extent. The effects on the clover were much greater on this soil type than was true with most of the soils studied.

THE RESULTS ON TAMA SILT LOAM

Table VI gives the results secured on the Tama silt loam on the Hudson field in Black Hawk County. The Tama silt loam is an extensive soil type in eastern central Iowa. It is a dark brown to black silt loam with a yellowish-brown to yellow silty clay loam subsoil.

The increases in corn from the use of manure ranged from 0 to 6.7 bushels while oats were increased from 0 to 4.5 bushels. The average value of the manure was $1.12 per ton.

This soil resembles the Carrington silt loam in many ways and it is interesting to note that the value for the manure was the same as that secured on one of the fields on that type but it was much less than the average on all the Carrington silt loam fields.

THE RESULTS ON WEBSTER LOAM

The data secured on the Webster loam on the Lundgren field in Webster County are given in table VII. The Webster loam is an important upland soil in the Wisconsin drift soil area, in northwestern central Iowa. It is a black loam, underlaid by a black, compact, clay loam which grades into a black to drab plastic clay.

Small increases in corn were secured on this field, ranging from 2.0 to 5.4 bushels. Oats showed no gain in one case and a small increase in the others. The average value of the manure on this field was $1.00 per ton.

The value of manure on this soil, while not as large as in some other cases, is nevertheless, quite definite. Corn showed the greatest effect as would be expected. Small grains were sometimes increased, but the effects were not so large and in some cases it was found that manure caused them to lodge. Hence it should be applied as far away from the oats as possible in the rotation. The Webster loam, although high in organic matter and relatively fertile, may certainly be made more productive by the proper use of manure.

TABLE VI. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON TAMA SILT LOAM — IOWA EXPERIMENT FIELDS

Hudson Field — Black Hawk County						
	Corn bu.	Oats bu.	Corn bu.	Oats bu.	Corn bu.	Oats bu.
Check	52.4	55.6	56.1	48.6	53.0	46.5
Manure	49.3	54.7	62.8	53.1	59.6	50.6
Increase	...	...	6.7	4.5	6.6	4.1
Value of increase, $13.48; value per ton of manure per 4-yr. rotation, $1.12						

TABLE VII. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON WEBSTER LOAM — IOWA EXPERIMENT FIELDS

Lundgren Field — Webster County							
	Oats bu.	Corn bu.	Corn bu.	Oats bu.	Corn bu.	Oats bu.	Corn bu.
Check	86.4	55.7	60.4	33.5	52.1	43.5	28.5
Manure	85.0	58.3	62.4	37.8	55.5	48.8	33.9
Increase	...	2.6	2.0	4.3	3.4	5.3	5.4
Value of increase, $14.00; value per ton of manure per 4-yr. rotation, $1.00							

THE RESULTS ON WEBSTER SILTY CLAY LOAM

In table VIII appear the results obtained on the Webster silty clay loam on two fields in Buena Vista County. This soil is an important type in the Wisconsin drift soil area in northwestern central Iowa. The Webster silty clay loam is a black silty clay loam with a dark brown to black silty clay loam to silty clay subsoil, usually mottled with gray, yellowish-brown, and rusty brown.

On the Newell field, the increases in corn ranged from 0 to 7.8 bushels. Oats were increased to a small extent and clover showed a very slight effect. The value of the manure on this field was $1.37 per ton.

On the Storm Lake field the corn was not increased in two cases and the largest increase was 7.8 bushels. Oats were not increased appreciably and clover very slightly. The value of the manure was only $0.56 per ton.

The average value of the manure on this soil was $0.96 per ton, practically the same amount shown in the case of the Webster loam. These soils are very similar except that the surface soil texture of the Webster silty clay loam is heavier and manure might be expected to show much the same effect on the two types. Again it may be noted that manure showed smaller effects on these soils than in some other cases but the increases secured were quite definite.

THE RESULTS ON CLINTON SILT LOAM

The results secured on the Clinton silt loam on two fields in Scott and Muscatine Counties are given in table IX. The Clinton silt loam is a light brownish-gray to light grayish-brown or buff colored silt loam with a light brown or yellowish-brown stiff, compact silt loam subsoil with some gray mottlings. It is an important upland type in eastern Iowa and thru eastern central and southern Iowa.

On the Princeton field in Scott County the corn increases from the use of manure ranged from 5.8 to 8.7 bushels. Oats and wheat showed small gains and clover was increased 0.43 ton. The value of the manure on this field was $2.15 per ton.

On the Sherfey field the effects of the manure on the corn was more variable, ranging from 0 to 11.2 bushels. Oats showed a small increase; clover, over one-half of a ton and alfalfa, 0.63 ton. The value of the manure was $2.32 per ton.

The average value of the manure on this soil was $2.23 per ton, exactly the same value as secured on the Carrington silt loam. The crop increases were also very similar. A large effect on corn was noted in most cases and clover showed considerable gains. Oats and wheat were less affected. The large increase in alfalfa found on the Sherfey field is of particular interest, indicating the value of the use of manure on land which is to be seeded to alfalfa.

It is certainly very desirable that manure be employed on the Clinton silt loam to insure good crop yields. The type is low in organic matter and particularly in need of additions of this material.

THE RESULTS ON GRUNDY SILTY CLAY LOAM

In table X the results obtained on the Grundy silty clay loam on two series on the Mt. Union field in Henry County, are given.

TABLE VIII. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON WEBSTER SILTY CLAY LOAM — IOWA EXPERIMENT FIELDS

I Newell Field — Buena Vista County						
	Corn bu.	Corn bu.	Oats bu.	Clover tons	Corn bu.	Corn bu.
Check	63.1	57.5	58.7	0.55	67.2	58.3
Manure	70.9	49.1	64.1	0.60	70.5	65.6
Increase	7.8	...	5.4	0.05	3.3	7.3
Value of increase, $16.45; value per ton of manure per 4-yr. rotation, $1.37						

II Storm Lake Field — Buena Vista County							
	Oats bu.	Corn bu.	Corn bu.	Oats bu.	Clover tons	Corn bu.	Corn bu.
Check	74.0	64.5	60.8	41.9	0.90	52.9	26.6
Manure	73.0	54.1	57.3	42.2	1.01	60.7	27.5
Increase	...	...	...	0.3	0.11	7.8	0.9
Value of increase, $7.92; value per ton of manure per 4-yr. rotation, $0.56							

TABLE IX. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON CLINTON SILT LOAM — IOWA EXPERIMENT FIELDS

I Princeton Field — Scott County

	Wheat bu.	Corn bu.	Corn bu.	Oats bu.	Clover tons	Corn bu.	Oats bu.
Check	33.5	61.8	59.6	25.8	1.50	55.2	60.8
Manure	37.4	67.6	68.3	28.4	1.93	63.2	64.8
Increase	3.9	5.8	8.7	2.6	0.43	8.0	4.0

Value of increase, $30.17; value per ton of manure per 4-yr. rotation, $2.15

II Sherfey Field — Muscatine County

	Clover tons	Corn bu.	Corn bu.	Corn bu.	Oats bu.	Alfalfa tons
Check*	3.13	63.6	29.0	44.4	38.3	1.41
Manure	3.75	74.8	23.0	35.7	40.5	2.04
Increase	0.62	11.2	...	...	2.2	0.63

Value of increase, $27.94; value per ton of manure per 4-yr. rotation, $2.32

* Averages of 4 check plots

The Grundy silty clay loam is a black silty clay loam underlaid by a black silty clay which grades into a blue or yellowish-gray silty clay, mottled with yellow and yellowish-brown. It occurs thruout southern Iowa and southeastern Iowa on the level uplands and is an important type.

On series 1 on the Mt. Union field, the influence of the manure on corn was quite variable, the increased yields ranging from 3.5 to 26.2 bushels. Oats showed no effect and the influence on wheat was small. The value of the manure in this series was $2.34.

In the second series on the same field, the corn increases were more consistent, ranging from 7.9 to 13.6 bushels. Oats were increased to a less extent, but clover showed gains of 0.20 and 1.11 tons. The value of the manure was $3.27 per ton.

The average value for the manure on this soil was $2.80 per ton. It is rather surprising to note this large value on a soil type which is black in color and apparently well supplied with

TABLE X. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON GRUNDY SILTY CLAY LOAM — IOWA EXPERIMENT FIELDS

I Mt. Union Field — Series I — Henry County

	Corn bu.	Wheat bu.	Corn bu.	Oats bu.	Wheat bu.	Corn bu.	Corn bu.
Check	57.8	9.9	46.0	32.3	21.5	38.8	22.7
Manure	61.3	11.8	52.0	27.7	22.0	65.0	27.5
Increase	3.5	1.9	6.0	...	0.5	26.2	4.8

Value of increase, $32.77; value per ton of manure per 4-yr. rotation, $2.34

II Mt. Union Field — Series II — Henry County

	Oats bu.	Clover tons	Corn bu.	Corn bu.	Oats bu.	Clover tons	Corn bu.
Check	64.4	2.11	83.4	62.4	60.2	1.59	40.5
Manure	72.1	3.22	91.3	76.0	67.2	1.79	49.9
Increase	7.7	1.11	7.9	13.6	7.0	0.20	9.4

Value of increase, $46.18; value per ton of manure per 4-yr. rotation, $3.27

organic matter. The effects on corn were considerable and clover showed large increases. Oats, too, were sometimes increased to a large extent. Probably in this case the value of the manure may be attributed to its effect on the physical condition of the soil or to the addition of bacteria which stimulate the production of available plant food. Whatever the reason, however, it is apparent that this soil will respond in a large way to the proper application of manure.

THE RESULTS ON GRUNDY CLAY LOAM

The results secured on Grundy clay loam on the Stockport field in Van Buren County are shown in table XI. This soil is a dark brown to black clay loam underlaid by a dark grayish-brown compact silty clay which grades into a light-drab or grayish-drab sticky clay or heavy silty clay, mottled with yellow or rusty yellow. It occurs in considerable areas in southeastern and southern Iowa. It is very similar to the Grundy silty clay loam.

Corn increases brought about by the manure were quite variable, ranging from 3.1 to 10.6 bushels. Oats and clover showed only small gains. The average value of the manure was $2.08 per ton.

The effects of the manure were quite definite on this soil and while the increases were not quite as large as in the case of the silty clay loam on the Mt. Union field in Henry County, they were considerable. The value of the manure here was about that given for all the fields on all the soils tested. Again corn showed the largest effects while oats and clover were influenced to a lesser extent.

THE RESULTS ON MARION SILT LOAM

Data secured on the Marion silt loam on the West Point field No. 2 in Lee County are given in table XII. The Marion silt loam is an important type in southern Iowa. It is a light brownish-gray to light gray silt loam underlaid by a layer of silty flourlike, grayish or whitish material. The subsoil is a heavy, compact silty clay, gray or grayish-brown in color, mottled with grayish-brown and rusty brown.

The effects of the manure were very evident on the corn in this field, giving increases of 14.4 and 15.2 bushels. Oats were not affected in one case but in another season showed increased yields of 15.6 bushels. A large increase in clover and timothy was secured in one case while in another instance no gain was secured. The average value of the manure was $3.84 per ton.

This soil showed the largest value of manure of any of the types tested. It is certainly low in organic matter and in need

TABLE XI. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON GRUNDY CLAY LOAM — IOWA EXPERIMENT FIELDS

Stockport Field — Van Buren County						
	Corn bu.	Corn bu.	Oats bu.	Clover tons	Corn bu.	Corn bu.
Check	54.1	52.2	34.9	1.62	68.4	57.6
Manure	62.9	55.3	41.7	1.65	75.5	68.2
Increase	8.8	3.1	6.8	0.03	7.1	10.6

Value of increase, $24.98; value per ton of manure per 4-yr. rotation, $2.08

TABLE XII. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON MARION SILT LOAM — IOWA EXPERIMENT FIELDS

West Point Field No. 2 — Lee County							
	Oats bu.	Clover tons	Corn bu.	Oats bu.	Clover & timothy tons	Corn bu.	Oats bu.
Check	39.6	1.57	27.8	29.2	1.73	48.2	38.1
Manure	55.2	1.59	43.0	28.7	2.70	62.6	66.4
Increase	15.6	0.02	15.2	...	0.97	14.4	28.3

Value of increase, $53.88; value per ton of manure per 4-yr. rotation, $3.84

of additions. It would seem from these results that manure may bring about considerable increases in corn and in some seasons give large effects also on oats and hay crops.

THE RESULTS ON WAUKESHA SILT LOAM

The results secured on the Waukesha silt loam in two series on the Clarinda field in Page County are given in table XIII. This is an important soil type in Iowa, occurring on the terraces or second bottoms along many of the streams. It is a dark brown to black silt loam underlaid by a light brown or yellowish-brown silt loam to silty clay loam.

In series 100 there were small increases in corn from the use of manure. These increases ranged from 0 to 6.3 bushels. Oats showed from 2.2 to 7.2 bushels. Soybeans were increased by 2.0 bushels and clover gave a small increase. The average value of the manure was $1.07 per ton.

On the second series the corn increases were larger and more variable, ranging from 0.8 to 16.4 bushels. Oats again showed small increases or none at all. The value of the manure was $2.09 per ton.

The average value of the manure on this soil was $1.58 per ton, the results on the two series, one for nine years and the other for eight, being quite different. Corn showed the greatest effects from the manure as has been noted on the upland types while other crops showed very small gains. While the value of the manure was not as large as was the case on some of the upland soils, it was quite definite.

TABLE XIII. THE ECONOMIC VALUE OF FARM MANURE AS A FERTLIZER ON WAUKESHA SILT LOAM — IOWA EXPERIMENT FIELDS

I Clarinda Field — Series 100 — Page County									
	Corn bu.	Oats bu.	Clover tons	Corn bu.	Oats bu.	Soy-beans bu.	Corn bu.	Corn bu.	Oats bu.
Check	49.9	52.1	1.30	56.2	45.1	23.3	83.5	67.4	48.6
Manure	49.9	54.4	1.36	58.7	52.3	25.3	87.4	73.7	53.4
Increase	...	2.3	0.06	2.5	7.2	2.0	3.9	6.3	4.8

Value of increase, $19.34; value per ton of manure per 4-yr. rotation, $1.07

II Clarinda Field — Series 200 — Page County								
	Corn bu.	Oats bu.	Clover tons	Corn bu.	Corn bu.	Oats bu.	Corn bu.	Corn bu.
Check	74.8	75.3	1.75	55.2	51.3	47.0	70.6	25.4
Manure	77.1	83.0	1.35	56.0	64.4	32.6	79.3	41.8
Increase	2.3	7.7	...	0.8	13.1	...	8.7	16.4

Value of increase, $33.52; value per ton of manure per 4-yr. rotation, $2.09

THE RESULTS ON O'NEILL LOAM

Table XIV shows the results secured on O'Neill loam on the Everly field in Clay County. This is an important terrace soil, occurring on the second bottoms along many Iowa streams. It is a dark brown to dark grayish-brown loam underlaid by a light brown to brown compact loam or light silty clay loam. The lower subsoil consists of sand and gravel in layers of varying depths.

The effects of manure on corn were quite variable on this field, ranging from 0 to 9.3 bushels. Clover gave an increase of over one-half ton while oats showed from 4.0 to 15.4 bushels gain. The value of the manure was $2.14 per ton.

This soil certainly is benefited by the use of manure which will increase its water-holding power and lessen the danger of crops suffering from drouths which are very apt to occur in dry years. Corn showed the greatest effects while oats and clover were also largely increased. This type responded to manuring much like the Carrington loam and other loams of average fertility.

THE RESULTS ON BUCKNER SILT LOAM

The results obtained on the Buckner silt loam on the Atalissa field in Muscatine County are given in table XV. The Buckner silt loam is an important terrace type, particularly in eastern Iowa. It is a dark gray to black silt loam with a dark brown to black silty clay loam subsoil, grading at the lower depths into a light brown silty clay loam.

Corn increases due to manure ranged from 0 to 6.5 bushels. Oats gave increases from 8.3 to 13.9 bushels. The average value of the manure was found to be $1.46 per ton.

The value of manure on this soil is quite definitely shown by these figures. Corn and small grains may be very largely

TABL XIV. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON O'NEILL LOAM — IOWA EXPERIMENT FIELDS

Everly Field — Series I — Clay County							
	Corn bu.	Corn bu.	Oats bu.	Clover tons	Corn bu.	Corn bu.	Oats bu.
Check	47.1	35.4	23.5	1.82	42.2	35.4	43.4
Manure	56.2	34.1	27.5	2.35	51.5	37.0	58.8
Increase	9.1	...	4.0	0.53	9.13	1.6	15.4
Value of increase, $30.07; value per ton of manure per 4-yr. rotation, $2.14							

TABLE XV. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON BUCKNER SILT LOAM — IOWA EXPERIMENT FIELDS

Atalissa Field — Muscatine County						
	Oats bu.	Corn bu.	Corn bu.	Oats bu.	Corn bu.	Corn bu.
Check*	52.2	71.2	65.6	47.1	55.5	35.4
Manure	60.5	77.7	65.6	61.0	59.7	34.4
Increase	8.3	6.5	...	13.9	4.2	...
Value of increase, $17.57; value per ton of manure per 4-yr. rotation, $1.46						

* Averages of 4 check plots.

increased and other crops would undoubtedly show similar effects.

THE RESULTS ON LAMOURE SILTY CLAY LOAM

The results obtained on the Lamoure silty clay loam on the Everly field, series II, in Clay County are shown in table XVI. The Lamoure silty clay loam is an important bottomland soil, occurring along many of the streams of Iowa. It is a very dark brown to nearly black silty clay loam with a dark drab to brownish-drab silty clay loam subsoil. Both soil and subsoil are usually high in lime.

The effects of manure on corn were large on this field, ranging from 17.2 to 21.3 bushels. Oats were definitely increased while clover was not influenced at all. The average value of the manure was $3.10.

Apparently manure is a valuable fertilizer for use on this soil. In spite of the high content of organic matter and relatively high fertility of the soil, large crop increases may be obtained.

MANURE GIVES LARGE EFFECTS ON ALL SOILS

It is evident from a consideration of all the results given in the previous pages that manure may have large effects on prac-

TABLE XVI. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON LAMOURE SILTY CLAY LOAM — IOWA EXPERIMENT FIELDS

Everly Field — Series II — Clay County					
	Clover tons	Corn bu.	Oats bu.	Clover tons	Corn bu.
Check	1.60	58.1	47.4	0.72	36.9
Manure	1.45	75.3	54.1	0.71	58.2
Increase	...	17.2	6.7	...	21.3
Value of increase, $31.04; value per ton of manure per 4-yr. rotation, $3.10					

tically any soil type. Dark colored heavy types are benefited as well as light colored and light textured soils. It is usually expected, of course, that the greatest influence will be exerted on the soils low in organic matter and coarse in texture. But this is not always the case as is apparent from the values secured from the 16 Iowa soil types used in these experiments. These values are given in table XVII.

The average of all types was $1.97 and the range among the types was from $0.96 on the Webster silty clay loam up to $3.84 on the Marion silt loam. Both Webster types show smaller effects than the other upland soils, as might be expected, but the influence of the manure on these heavy, rich soils was quite definite. The Muscatine silt loam showed less effects than the other loessial types except the Tama silt loam which was the lowest. The Marion silt loam was influenced the most of any of the soils which again might be expected from the light color and rather low productive power of the soil.

Some of the results secured are rather surprising. For example, the large effects of the manure on the Grundy silty clay loam are unexpected, very much greater increases being secured than on the Grundy silt loam. The large effects on the Lamoure silty clay loam are also not in line with the expected results. The greater beneficial effects on the Carrington silt loam than on the Carrington loam would not be anticipated but the differences here were not large enough to be very significant. The high yields secured from manure on the Marshall silt loam and the Clinton silt loam are to be expected, and greater effects on the O'Neill loam than on the Waukesha silt loam would also be anticipated.

Manure exerts beneficial effects on crop yields on various soils because of its chemical, physical, and biological effects on the soil. In most cases the addition of plant food constituents in the manure may prove of real value, adding actual fertility to the soil. The organic matter in the manure is always of value as it improves the physical conditions in soils and increases bacterial action and hence the production of available plant food. Finally the bacteria in manure may be of much value, bringing about a greater action on the mineral constituents in the soil and giving plants a better food supply.

In general manure may be of value because of all these effects on the soil but on different types some special action may be responsible for the benefits. Thus on the Grundy silty clay loam the large effects of the manure are undoubtedly due to its physical and bacteriological influence on the soil, more the physical effect probably than the biological. Indeed the effects of manure on all the heavier, richer soils are probably attributable to stimu-

TABLE XVII. THE ECONOMIC VALUE OF FARM MANURE AS A FERTILIZER ON 16 SOIL TYPES IN IOWA. RESULTS SECURED ON 43 IOWA EXPERIMENT FIELDS

SOIL TYPE	No. of Fields	Av. Value
Carrington loam	8	$1.96
Grundy silt loam	7	1.80
Marshall silt loam	4	2.10
Muscatine silt loam	4	1.19
Carrington silt loam	5	2.23
Tama silt loam	1	1.12
Webster loam	1	1.00
Webster silty clay loam	2	0.96
Clinton silt loam	2	2.23
Grundy silty clay loam	2	2.80
Grundy clay loam	1	2.08
Marion silt loam	1	3.84
Waukesha silt loam	2	1.58
O'Neill loam	1	2.14
Buckner silt loam	1	1.46
Lamoure silty clay loam	1	3.10
Average of all types	(43)	$1.97

lation in bacterial action. On the lighter soils, the chemical effects of the manure, the actual addition of plant food, may account for its value.

RESULTS INDICATE NEED OF CONSERVING MANURE

Considering the fact that the average value of manure in all these fields on 16 soil types was $1.97 per ton, there can be no question regarding the value of applying manure to these soils. Larger effects might be secured, however, and the manure might play a larger part in the permanent fertility of the soils if it were well cared for and properly applied to the soil. The differences in the results secured in the various fields indicate how the effects of the manure may vary and how large the increases may be in some cases. It is certainly evident that all the care which farmers may exercise in preventing losses from manure before it is applied and in insuring the largest possible effects from its use will pay handsomely in the increased value of the crop yields secured. Finally it may again be emphasized that manure is a very valuable fertilizer for Iowa soils.

SUMMARY

The economic value of farm manure used as a fertilizer on Iowa soils is $1.97 per ton according to results given in this bulletin.

The range in value is from about $1.00 per ton on some of the soils to over $3.00 per ton on others.

These figures are obtained by calculating the economic value of the actual crop increases secured from the use of manure on 43 cooperative soil experiment fields of the Soils Section, located in various parts of the state in surveyed counties and on 16 different soil types.

The values of the crop increases are calculated from the ten-year averages for crop prices as compiled by the State Department of Agriculture. (1913-1922.)

The results are based on an eight-ton application of manure once in four years. A lighter application (6 tons) would probably show a somewhat greater value per ton. All the residual effects of the manure used are not included in the data available. Hence the value assigned to manure here is conservative.

It is estimated that over 95 million tons of manure are produced in Iowa each year. If it were all applied to the land without loss, the total value to the state would amount to many million dollars.

Losses from manure, due to improper storage and handling amount to about one-half its value on the average — in many cases up to three-fourths of its value and under the best conditions from 10 to 15 percent. These losses reduce materially the fertilizing value of manure as measured by crop increases.

The actual money value of every ton of manure produced on Iowa farms, if used as a fertilizer for general farm crops, emphasizes the importance of proper care in the storage and application of the manure.