

H. D. HUGHES

BULLETIN 1

OCTOBER, 1907

IOWA STATE COLLEGE  
OF AGRICULTURE AND THE MECHANIC ARTS

EXTENSION DEPARTMENT

SOILS DIVISION

FARM MANURES

AMES, IOWA

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# FARM MANURES

By A. H. SNYDER

## *Introduction*

In 1905 the State of Iowa produced 346,000,000 bushels of corn, 146,000,000 bushels of oats and 6,000,000 bushels of wheat. This amount of produce removed from the soil approximately 656,000,000 pounds of nitrogen, 10,000,000 pounds of phosphorus and 347,000,000 pounds of potassium, which, if purchased in the form of commercial fertilizer at current prices, would cost \$131,000,000, or about the value of the corn crop of the state. The question is, how much of this vast amount of valuable fertility finds its way back to the soil and how much of it is either sold off the farm or wasted by careless methods? Statistics show that something like one-fourth is sold from the farm. That leaves about \$98,000,000 worth of fertility removed annually by the corn, oats and wheat crops, an amount that can for the most part be returned to the soil, or wasted, according to the methods employed.

### FERTILITY OF THE SOIL DEMANDS ATTENTION.

A great many of the best farmers of Iowa already realize the importance of giving careful attention to soil problems. They are carefully noting the effect of various treatments upon their soils with the result that less waste is allowed to occur. If anyone has the least doubt as to the necessity of adopting proper methods in the treatment of his soil, he need only consider the history of the older states a little farther east. He will see that the march of commercial fertilizers has advanced westward until they now have a strong foothold in Illinois, one of our nearest neighbors, and are, even now, knocking at the door of our own state. It is high time for the land owner of Iowa to decide whether he will adopt such methods of farming as will permit of returning to the soil a large percentage of the plant food removed by crops, or whether he, like his brother farther east, will rob his soil by wasteful and haphazard methods, until it is no longer a question of maintaining, but rather a question of acquiring or building up fertility.

### MANURE IS WASTED.

One of the most valuable assets of a farm is the manure produced upon it, for upon the care exercised in preservation and application of manure depends to a considerable extent the maintenance of a permanent fertility. No substitute at present known is capable of completely filling the place of farm manure. Notwithstanding its great value, there is probably no material on the farms of Iowa in which so great an unnecessary waste occurs. While it may not be destroyed intentionally, as in former years, when the virgin soil was apparently overburdened with fertility, it is a common sight in almost any section of the state to see stables and feed lots situated upon the bank of a stream or ditch, where the most valuable portion of the manure will pass into the stream naturally, or be pushed in by the stock.

There is no soil so fertile that its producing power cannot be eventually decreased by continued, haphazard cropping which constantly takes away from the soil, but returns nothing. It must be understood that every crop of corn, every crop of oats, or any crop, whatever it may be, removes from the soil a certain amount of plant food which must be returned in some manner. If it is not returned, the soil is rendered less fertile, and, while the amount of plant food removed by one crop may be small, the amount removed in the course of several years is considerable and must necessarily result in soil ruin.

### PLANT FOOD NECESSARY.

The scientist tells us that ten elements are necessary for the growth of plants. They are carbon, hydrogen, oxygen, calcium, magnesium, iron, sulphur, nitrogen, phosphorus and potassium. From 90 to 95 per cent of all plants is composed of carbon, hydrogen and oxygen, and the plant obtains these elements from air and water, both of which can usually be obtained in unlimited quantities in humid regions. The next four elements, calcium, magnesium, iron and sulphur, are only required in very minute amounts, and are present in practically all soils in abundant quantities. But the three elements, nitrogen, phosphorus and potassium, are required by plants in considerable amounts, and one or two, or possibly all three, are frequently found deficient in the soil. They are never entirely absent, small amounts being found in even the most worn-out soils, but if any one of these elements is present in too small an amount to meet the demands of the plant, the growth of the plant will be correspondingly limited. It is evident, therefore, that a soil, in order to be fertile and produce large crops,

must contain ample amounts of nitrogen, phosphorus and potassium, and furthermore, they must be in such a form that plants can use them. One of the important functions of farm manure is to convey back to the soil, in a readily available form, the majority of the plant food removed from it by crops.

#### IMPORTANCE OF HUMUS.

Both the practical experience of farmers and the results thus far obtained by the Experiment Station, point strongly to the conclusion that the maintenance of fertility in the soils of Iowa is largely dependent upon the maintenance of an ample supply of humus. It is humus which gives the dark color to our rich, black prairie soil, and the mellow, loamy texture of soil is also largely due to humus. A fertile soil must be capable of receiving and retaining a sufficient amount of water for the needs of crops; it must be warm; it must contain an ample amount of plant food in a readily available form; it must permit of a free passage of air through it; and it must furnish favorable conditions for the development of bacteria, the minute organisms which of late have been found to play so important a part in supplying nitrogen and rendering available the plant food of the soil. Humus helps to furnish all these characteristics which make a soil fertile and capable of producing profitable crops.

#### SOURCE OF HUMUS.

Now that we realize in a measure the importance of humus, let us see from what sources the soil may obtain its supply. Since humus is a more or less decomposed form of plant and animal life, it follows that the remains of plants or animals must be added to the soil. Of course, in this country it is practically all derived from the remains of plants.

There are, in general, two methods whereby plant remains are returned to the soil. First, the entire plant, or portions of it, may be left upon the land, as is the case when sod is plowed or green manuring practiced, or the corn stalks left upon the land. Second, the plant may be used as food for animals, or as bedding, and the excrement and litter returned to the soil.

#### WAYS IN WHICH MANURE IS BENEFICIAL.

The value of any particular sample of manure is difficult to estimate, owing to the fact that it may act upon the soil in so

many different ways and that its effect upon the soil almost invariably extends through a series of several years. The same manure may not be of equal value to different types of soil.

Some of the more important ways in which manure benefits the soil may be briefly stated, as follows:

- 1st. It increases the supply of humus.
- 2nd. It adds plant food.
- 3rd. It acts upon the soil in such a manner as to render the plant food of the soil more available.
- 4th. It makes the soil warmer.
- 5th. It enables the soil to receive and retain more water, and to give it up gradually to growing crops.
- 6th. It improves soil ventilation.
- 7th. It aids in the development of bacteria.
- 8th. It helps to prevent the denuding effect of washing and heavy wind storms.

#### FACTORS WHICH INFLUENCE COMPOSITION OF MANURE.

There are necessarily so many factors which influence the composition of manure that scarcely any two samples will be found to have the same composition, and hence the value of manures will vary greatly. The following four factors exert the greatest influence upon its composition and value:

- 1st. Kind and amount of absorbents used.
- 2nd. Kind and amount of food consumed.
- 3rd. Age and kind of animals.
- 4th. Methods employed in caring for manure.

#### KIND AND AMOUNT OF ABSORBENTS.

Straw is, no doubt, the substance most commonly used as bedding and as an absorbent for manure, and oat straw is more valuable for this purpose than either wheat, rye or barley straw. Peat, muck, leaves, sawdust and shavings are other substances which are sometimes used.

Professor Snyder of the Minnesota Experiment station gives the following results with regard to the relative absorbent powers of a few common materials used for bedding:

	Per cent of water absorbed.
Fine cut straw .....	30
Coarse uncut straw .....	18
Peat .....	60
Sawdust .....	43

The texture of manure is greatly influenced by the kind of bedding used. For instance, if such substances as finely cut straw, sawdust, peat, muck, etc., are used as litter, the manure will not be nearly so coarse as is the case where long wheat straw or rye straw is used. The amount of bedding present also exerts a considerable influence upon the chemical composition. Such substances as straw and sawdust contain but small amounts of plant food compared with the quantities present in the excrement of animals fed upon somewhat concentrated food. The addition of these substances to animal excrement has a diluting effect, and it will readily be seen that the greater the amount of bedding used, the more dilute becomes the manure. This must not be understood to mean that the addition of bedding material is detrimental, but, on the other hand, it must be understood that a sufficient amount of absorbent to take up all the liquid portion of the excrement is absolutely necessary to prevent great loss. Manure obtained by the use of peat as an absorbent is rendered richer in nitrogen, but peat decomposes quite slowly. It decomposes more rapidly, however, when saturated with the liquid portion of manure.

#### KIND AND AMOUNT OF FOOD CONSUMED.

The kind and amount of food consumed by the animals from which the manure is derived, exerts a marked effect upon its composition. There is only a small percentage of plant food constituents contained in feed that is permanently retained in the body of the animal, and for this reason the more plant-food there is in the food, the more there will be in the manure. A large number of experiments, notably those of Lawes and Gilbert at the Rothamsted Station, have shown that about 80 per cent of the plant-food elements in foods is returned in the manure. In the following table are given the pounds of nitrogen, phosphoric acid and potash per ton of some food materials as given by Professor Snyder:

	Nitrogen, Lbs.	Phosphoric Acid, Lbs.	Potash, Lbs.
Timothy hay .....	25	9	40
Clover hay .....	35	14	30
Wheat Straw .....	11	4	12
Oat Straw .....	12	4	18
Wheat .....	45	20	12
Oats .....	33	16	11
Barley .....	40	18	11
Rye .....	42	20	13
Flax .....	87	32	14
Corn .....	32	14	8
Wheat shorts .....	48	31	20
Wheat Bran .....	54	52	30
Linseed meal .....	100	35	25
Cottonseed meal .....	130	35	56

## AGE AND KIND OF ANIMAL.

The third factor which influences the composition of manure is the age and kind of animals, and this factor exerts its influence almost entirely upon the chemical composition of the manure.

Young and growing animals retain in their bodies more of the fertilizing elements of the food consumed by them than is the case with mature animals. Cows giving milk give poorer excrement than cows under the same conditions which are not furnishing milk. Mature animals in the process of fattening retain in their bodies only from 5 to 10 per cent of the fertility contained in their food.

There is also quite a variation in the manure produced by different kinds of animals, for example, horse manure as compared with hog manure. This difference is accounted for in a considerable measure by the difference in character of food consumed by the different kinds of animals, the hog requiring relatively a much higher percentage of concentrated food. There is, nevertheless, a variation in the digestive powers of different kinds of animals which also effects their excrement.

## METHODS OF CARING FOR MANURE.

The fourth, and, no doubt, the most important factor which influences the composition and value of farm manure, has to do with the methods employed in its collection, preservation and utilization.

In collecting manure the most importance should be placed upon the supply of a satisfactory absorbent, and in sufficient amount to prevent any loss of liquid manure. Too many people do not realize that, looked upon from the standpoint of plant food, the liquid portion of manure is more than twice as valuable as the solid excrement, when equal weights are compared.

The following table from experiments conducted by Anodyn-aud and Zacharewicz and Muetz and Girard and reported in Experiment Station Record, Vol. 5, p. 142, gives results from analyses of liquid and solid excrement:

	Nitrogen Per cent.	Phosphoric Acid Per cent.	Potash Per cent
Horse urine .....	1.52	....	.9
Horse solid excrement.....	.55	.35	.1
Cow urine .....	1.05	....	1.36
Cow solid excrement.....	.43	.12	.04

Nitrogen costs approximately three times as much per pound as either phosphoric acid or potash, and by far the largest portion of nitrogen is contained in the liquid excrement, so that the importance of carefully conserved liquid manure is readily apparent.



Furthermore, a mixture of solid and liquid excrement furnishes more nearly a balanced ration for plants, and a balanced ration is fully as important for plants as it is for animals.

### PRESERVATION.

The next question to consider is, how shall we prevent loss from manure? If manures are sheltered, no loss is sustained from leaching by the passage of rain water through them, but loss may come from other causes. Manures exposed for a time may not suffer deterioration from the rain which falls upon them, but rather be benefited, as in the case of horse manure, which tends to heat rapidly if not kept moist, causing what is familiarly known as "fire fanging." When a superabundance of water from the eaves of the barn falls upon it, or the layer or pile of manure is shallow, a single heavy shower may cause leaching.

Prof. I. P. Roberts, formerly director of the Cornell Experiment Station, gives the following results from an experiment conducted to test the loss from manures.

\*"In 1890, 4,000 pounds of manure from the horse stables, composed of 3, 319 pounds of excrement, and 681 pounds of straw, were placed out of doors in a compact pile and left exposed from April 25th to September 22d, at the end of which time the total weight had decreased to 1,730 pounds. The tabular results were as follows.

	April.	September.	Loss.
	Lbs.	Lbs.	Per Cent.
Gross weight .....	4,000	1,730	57
Nitrogen .....	19.60	7.79	60
Phosphoric acid .....	14.80	7.79	67
Potash .....	36.00	8.65	76
Per ton .....	\$2.80	\$1.06	

"The value on September 22d of an amount of manure which weighed 2,000 pounds on April 25th, was \$1.06.

"Five tons of cow manure, composed of 9,278 pounds of excrement mixed with 422 pounds of wheat straw, were exposed in a compact pile for the same period as the horse manure was, and under similar conditions, except that 300 pounds of gypsum were mixed with it."

"The outcome was as follows:

	Lbs.	Lbs.	Loss.
	At beginning	At end.	Per Cent.
Gross weight .....	10,000	5,125	49
Nitrogen .....	47	28	41
Phosphoric acid .....	32	26	19
Potash .....	48	44	8
Per ton .....	\$2.29	\$1.60	

"Manures may lose a large percentage of their valuable constituents and yet be worth more per ton than they were before the loss occurred. Consider, for instance, the five tons of cow manure which contained at the beginning 47 pounds of nitrogen, or 9.4 pounds per ton, and at the end of the investigation, 28 pounds, and note that this 28 pounds was contained in 2.56 tons, instead of in the original

\*"The Fertility of the Land. PP. 191-193"

five tons. While the total loss of nitrogen was 41 per cent in the exposed manure, the sample contained 10.9 pounds of nitrogen per ton, or 1.5 pounds per ton more than the fresh manure."

A field test of the value of covered manure as compared with manure exposed in an open yard was made from 1891 to 1893 in Utah. This experiment showed an increase in grain of 6.64 per cent in favor of the protected manure.

A similar experiment conducted by the Minnesota Experiment Station gave a yield of four bushels more potatoes and eleven bushels more wheat per acre in favor of protected manure as compared with that which was unprotected.

The system of feeding animals in box stalls and allowing the manure to accumulate tends to conserve the valuable constituents. An analysis by Biernatzki shows the difference between manure preserved after this plan and by the common heap method to be as follows:

	Moisture. Per Cent.	Total Nitrogen. Per Cent.	Phos. Acid. Per Cent.	Potash. Per Cent.
Heap method .....	83.78	.47	.26	.43
Improved method ...	76.54	.67	.31	.76

#### PRESERVATIVES SOMETIMES USED.

The fact that there is a considerable loss of nitrogen in the form of ammonia from manure in the stable or in the pile has given rise to another practice which of recent years has gained much favor. This method consists of treating manure with certain substances with a view to preserving it, or preventing the loss of some of its valuable constituents. Gypsum, kainit and superphosphate are probably the substances most extensively used for this purpose.

The experiments of J. R. Schiffer, made with barnyard manure preserved by the use of superphosphate and unpreserved manure, gave the following results:\*

	Potatoes bu.	Barley bu.
Preserved manure .....	247	42.1
Unpreserved manure .....	232	34.5
Difference .....	15	7.6

While the superphosphate undoubtedly had a marked effect in preserving the manure and preventing the loss of nitrogen, it is nevertheless highly probable that a portion of the increased yield should be attributed to the phosphoric acid added in the superphosphate. Phosphorus is the element of plant food which is found in relatively small amounts in most manures, and furthermore, it is the element, next to nitrogen, which has been found to limit the yield of crops in Illinois and Ohio. Results obtained

\*(Utah Experiment Station Fourth Annual Report, p. 160)

by the Ohio Experiment Station indicate that the addition of phosphate rock to manure serves the double purpose of conserving nitrogen and at the same time increasing the phosphorus content of the manure, so that it furnishes more nearly a balanced ration for plants. While the phosphorus contained in raw phosphate rock is considered as being largely in an unavailable form, numerous carefully conducted experiments have shown beyond reasonable doubt that its application in connection with manure renders available a much larger percentage of its phosphorus content than is the case where it is applied alone.

It is realized that the practice of using preservatives to prevent losses from manure has not been brought to the attention of the vast majority of farmers in Iowa. Nevertheless, such a practice is being employed extensively and profitably in states no farther distant than Illinois and Ohio, and the time is not far distant when it will be practiced in Iowa. As the value of manure becomes more generally and more thoroughly appreciated the methods employed in caring for it and preserving it will become more and more improved in order that the greatest benefit possible may be obtained from it.

#### APPLICATION OF MANURE.

The hauling of manure directly to the field as rapidly as it is made as compared with allowing it to accumulate around the barn or feed lot, is a question concerning which there has been considerable discussion. Some farmers are strong advocates of one method, and others may be found in the same locality who are just as strong supporters of the other. When carefully considered it is apparently true that one method will be found more economical and satisfactory under one set of conditions, and the other method equally economical and satisfactory where different conditions obtain. It seems probable, however, that from the standpoint of loss of plant food, the sooner manure is spread upon the field after it is made the less will be the loss. There are a number of conditions which enter into this question, such as the character of the soil, the system of farming practiced, the crop to which the manure is ordinarily applied, etc. It is frequently impossible to strictly adhere to the practice of hauling manure directly to the field for the reason that the land to which it is desired to apply manure is not available at all times. It cannot be applied to meadows, for example, until the hay crop is harvested.

When cattle are fed in a stable or shed, greater benefits can

usually be derived from the manure by piling it in a place where hogs will have access to it. When manure is allowed to accumulate, however, it is always important that proper precautions be taken to prevent loss by leaching and fermentation. It should never be piled under the eaves of a building, nor on a slope where surface washing will be great. When possible it should either be sheltered from rain by some sort of shed or placed in a watertight pit, so that the water which falls upon it cannot leach away the most valuable portion of the manure. Loss by fermentation is difficult to prevent, but is reduced to a minimum when the manure is kept moist and compact.

#### FRESH MANURE MAKES THE PLANT FOOD OF THE SOIL AVAILABLE.

When manure is hauled directly to the field there is usually a saving of labor, as it decreases the number of times that it must be handled. On the other hand, the fertilizing constituents of well-rotted manure are more quickly available to plants, and the manure itself is less bulky and is more easily distributed. It is equally true, however, that fresh manure mixed with the soil readily undergoes a fermentation which not only increases the availability of its own fertilizing constituents, but also assists in rendering soluble the hitherto insoluble fertilizing constituents of the soil. This is a point which deserves especial emphasis, and it should be firmly fixed in the mind that only a portion, and, it probably could truly be said, only a small portion of the beneficial results of manure is derived from the plant food actually added to the soil by them. The physical effect of manure upon the soil is of great importance, and upon some types of soil, notably clays, its greatest value results from the improvement of the physical condition of the soil. This will be further discussed later.

Professor Roberts\* has pointed out that chemical analysis shows the great majority of soils to contain quite large stores of native plant food. After giving the analyses of forty-nine samples of soil, taken from widely different areas, he makes the following comment:

"The tables reveal the fact that even the poorer soils have an abundance of plant food for several crops; while the richer soils in some cases have sufficient for two hundred to three hundred crops of wheat or maize. The average of thirty-four analyses gives to each acre of land eight inches deep 3,217 pounds of nitrogen, 3,937 pounds of phosphoric acid and 17,597 pounds of potash, and this does not include that which is contained in the stones, gravel and sand of the soil, which will not pass through meshes of  $\frac{1}{2}$  millimeter (1-50 of an inch) which, by weathering and tillage slowly give up their valuable constituents."

\*"The Fertility of the Land"

It seems evident that a great many soils which are considered poor, nevertheless contain considerable amounts of native plant food, and the fact that they are poor is largely due to the fact that the plant food present exists in such a form that it is not available for the use of plants. Therefore, the problem with such soils is a question of so treating them as to render available the native plant food which they contain, and in many cases this is a very difficult problem. In fact, there are soils known to exist in which there is sufficient plant food, but which resist tillage and other methods resorted to for rendering the plant food available, so stubbornly that the farmer finds it cheaper and more economical to purchase plant food in a readily available form and apply it to his land.

The results of numerous experiments show that one of the most important roles which manure plays is that of rendering available the native plant food of the soil. While it has been demonstrated beyond reasonable doubt that this is true, it is, nevertheless, not as thoroughly understood how it is accomplished. It is probable that fermentation products are formed by the fermenting of the manure. These may be capable of dissolving mineral compounds which are insoluble in water. Furthermore, it is known that manures contain great numbers of minute nitrifying organisms, or organisms capable of changing the nitrogen of organic matter into such a form as will make it available for the use of plants. The addition of these organisms in vast numbers may have the effect of rendering available the organic nitrogen of the soil, in addition to that of the manure itself.

#### **MANURE IMPROVES THE PHYSICAL CONDITION OF THE SOIL.**

The extent to which manure affects the physical nature of the soil depends in a large measure upon the character of the soil and the character of the manure. In general, manure has a tendency to make the soil more open in texture—to make it lighter. It is readily apparent that the extent to which this is accomplished will depend upon the coarseness or fineness of the manure.

The beneficial results obtained from the physical effect of manure upon a soil depend upon whether or not the soil is in such condition that it would be benefited by being rendered more porous. For this reason a heavy clay soil is usually improved to a greater extent physically by an application of manure than is a more sandy soil. Dr. W. H. Beal, of the Office of Experiment Stations, makes the following comments concerning the use of manures:

"The form in which manure should be applied (whether fresh or rotted) is determined largely by the soil on which it is to be used. If improvement of the mechanical condition is the main object sought, the best results will be obtained by applying the fresh manure to the heavy clay soils, and the well-rotted manure to the light soils. If, however, the prompt action of the fertilizing constituents of the manure is desired, light soils, in a favorable season, are likely to utilize coarse manure to better advantage than heavy soils. Decomposition takes place slowly in heavy soils and the constituents of fresh manure become available very slowly. In light soils, on the other hand, unless the season is dry, the conditions are such that the manure decomposes readily, and the fertilizing constituents are probably rendered available as fast as the plant needs them. There is also considerable danger on this class of soils that some of the soluble constituents will be carried away in the drainage, if well-rotted manure is applied. For this reason such manure should be applied to light soils only a short time before it is likely to be needed by the crop. In general, it may be said that for spring application the more readily available rotted manure is preferable to the fresh unrotted manure.

"On clay soils it often happens that manure produces no effect whatever during the first year on account of slowness of decomposition, but since the clay possesses very powerful absorptive properties the manure is not lost. The fertilizing constituents are retained in the soil and are finally utilized by the crop. There is, therefore, little or no danger on this account in applying manure to clay soils a long while in advance of the planting of the crop. During dry seasons the manure may produce little effect, but with a sufficient amount of moisture its action is likely to be considerable. The application to such soils of large quantities of manure improves their physical condition.

"Many experiments, notably those made by the Michigan and Wisconsin Stations, have shown that manure is one of the most effective means of increasing the productiveness of swamp or muck soils. This is thought to be due largely to the increase of available nitrogen brought about by the application of the manure."

Fresh manure has a forcing effect and tends to produce stems and leaves at the expense of fruit and grain. It is, therefore, better for early garden truck, grasses and forage plants than for cereals or fruits.

#### FRESH MANURE MAY BE INJURIOUS.

It should be stated, however, that an application of fresh manure may be found injurious in some cases. The physical effect of plowing under a rather heavy application of coarse, fresh manure may be considerable. During a drouth or long spell of dry weather a crop is almost entirely dependent for its water supply upon the moisture which rises from the lower strata of soil by capillarity. Professor King has shown that well-rotted manure, when thoroughly incorporated with the soil, tends to strengthen capillary rise of water. A soil so treated contains

more moisture during drouth, and crops resist drouth better upon such soil than upon unmanured soil. Upon the other hand, a considerable quantity of coarse material plowed under tends to cut off the capillary passages and prevent the moisture from rising to the root zone from the lower layers of soil.

#### METHODS OF APPLICATION.

There are three general methods of applying manure. First, it may be hauled to the field and placed in small heaps to be spread at a later date. Second, it may be spread upon the field immediately upon hauling. Third, it may be applied in the hill.

The first method is not to be recommended, owing to the fact that equal distribution is impossible. The soluble plant-food constituents are leached out of the manure and pass into the soil directly beneath the heap. These spots are excessively fertilized and the crop growing upon them is rank and frequently lodges, while the remainder of the field receives only the coarse portion of the manure, deprived of most of its fertility. Furthermore, the small heap offers very unsatisfactory conditions for fermentation and nitrification owing to the fact that it dries out quickly and cannot be kept continually moist. Last, but by no means least, may be mentioned the extra labor in handling the manure as one of the objections to this method. It necessitates handling it once more than when it is spread at the time of hauling, and it makes the use of a manure spreader impossible.

The second method, that of spreading manure as it is hauled to the field, will under most conditions be found most economical and most satisfactory, as it permits of much more even distribution and saves time and labor. This method, however, should not be practiced upon rolling land if it is desired to allow the manure to lie upon the surface of the ground, for in such a case much of the valuable constituents of the manure will be carried away by surface washing.

The third method, or the application of manure to the hill in which the crop is planted, is never practiced on large areas. It is of advantage where the supply of manure is very limited, and it is desired to get its full effect immediately. Well-rotted manure is best suited to this method of application, and the method is used to good advantage for gardening or for forcing crops.

#### CROPS BEST SUITED TO MANURING.

The crop to which the manure had best be applied will vary to a considerable extent with the conditions and the system of farming practiced. For the state of Iowa as a whole there are probably more farmers who advocate applying it as a top dressing to

grass land than to any other crop. Such a practice undoubtedly has many advantages and is to be recommended. In the first place it stimulates the growth of grass, so that there is a greater quantity of forage to plow under when the field is broken up, and in a sense there is double benefit derived from the manure. Perhaps the greatest advantage in applying the manure to grass land lies in the fact that it can be hauled upon this kind of land at almost any season of the year, or at least there are a great many times when it may be hauled upon grass land when it cannot be hauled upon plowed land, or land that has been in corn. Trouble sometimes results from the use of coarse manure and shallow spring plowing, especially when the manure has been leached before it is used, owing to the fact that leached manure does not readily ferment in the soil. Surface washing is less on land covered by sod than is the case with land which is bare, so that less loss from the manure results from this action when it is applied to grass land.

Soils of low fertility admit of manuring directly before the planting of most any crop, but more fertile soils, like many of the prairie soils of Iowa, which are in need of manure mainly for its physical action, will not admit of its use on all crops. On many soils of this state an application of manure will cause wheat or oats to lodge. It never injures corn by causing too rank a growth, and when wheat follows corn which has been manured, there is but little danger of loss from lodging.

Professor Snyder gives the following rule regarding the crop to which manure should be applied :

"When in doubt as to what crop to apply the manure, it is always safe to apply it to corn and then follow with the crop which would have been injured by its direct application. The facts that coarse, leached manure may cause trouble in a dry season, and that well-rotted manure may cause grain to lodge, are no substantial reasons why manure should be wasted, as it frequently is in western farming, by being burned, used for making roads, thrown away in streams, or used for filling up low places."

#### RATE OF APPLICATION.

The rate at which manure may be most economically applied will vary to a considerable extent with different soil and crop conditions. In general farming there can be no question but that it is much better to follow the practice of giving frequent and light dressings of manure to land, rather than to apply large amounts at long intervals. A small increase of a few bushels of grain, or a few hundred pounds increase of grass or hay per acre, steadily maintained over the whole farm, year after year, will bring much



larger returns than can be secured from heavy application at long intervals, or continuously on small portions of the farm, while the balance receives little attention. One hundred tons of manure carefully applied to ten or fifteen acres well cared for will give larger returns in general farming than when the same amount is applied to four or five acres, as is often the case.

When too much manure is applied wasteful oxidations occur give larger returns in general farming, than when the same which destroy the organic matter at once, returning it direct to the atmosphere; and this may happen when an unsuccessful effort has been made to apply a moderate amount of manure by distributing it unevenly over the surface. The use of the manure spreader has done and is doing much to overcome the uneven distribution of manure. When spread by this implement the manure is spread more evenly, thus enabling the same quantity of manure to cover a much larger area than is otherwise possible. The spreader is not only valuable because it spreads the manure more rapidly and more easily, but it also makes it possible to obtain more nearly the maximum benefit from a given quantity of manure.

#### COMPARATIVE VALUE OF MANURE AND FORAGE.

When manure is carefully conserved and no losses occur, the manure produced from a given amount of forage or grain always produces better results than if the forage or grain was applied directly to the soil. In the southern states it is a common practice to use cotton seed as a fertilizer. The same amount of cotton seed would yield larger returns if it were fed to stock and the manure placed upon the land. This is because there is so little of the fertility of feed retained in the body of the animal, and because the action of the digestive fluids upon the foods makes the fertility of the manure much more available for the use of plants than is the case with food which has not passed through any fermentation stages.

It is, therefore, better economy, when possible, to keep stock and carefully conserve the manure than to apply the forage directly to the soil.

#### LASTING EFFECT OF MANURE.

Some forms of chemical or commercial fertilizers exert practically no influence upon the soil beyond the period of growth of the crop to which they are applied. Such is not true with respect to manure, for usually only a comparatively small portion of its beneficial effect is realized the first season, and the influence

of a single application of manure is usually apparent for several years after it is applied. This is the common experience of almost every farmer, but is probably most clearly shown by the notable work of Lawes and Gilbert at Rothamsted. Their records show the effect of manure upon soils for a period of more than fifty years. In one experiment farm manure was used for twenty years and then discontinued for the same period. It was observed that when its use was discontinued there was a gradual decline in crop-producing power, but not so rapid as on plots where no manure had been used. The manure which had been applied for the twenty-year period made itself felt for an ensuing period of twenty years.

Manure is one of the most effective means at the disposal of the farmer to permanently improve his soil. No other fertilizer possesses to so great a degree the power of restoring worn soils to productiveness and giving them lasting fertility. It accomplishes this result, however, not only by the actual fertilizing constituents which it supplies, but also improves the physical properties of the soil, increasing the amount of humus, which is generally deficient in worn soils, improving its texture and increasing its water-absorbing and water-holding power. Its value to the soil can scarcely be measured, for no other substance has equal power in maintaining permanent fertility.

#### SUMMARY.

1. The crops of Iowa remove vast amounts of fertility from the soil annually. Much of the fertility removed by the crops is not sold off the farm, but a large percentage of that which remains upon the farm is unnecessarily wasted. The experience of older states farther east, where the land has been under cultivation for a longer period, shows the importance of adopting methods designed to conserve soil fertility.
2. One of the most valuable assets of a farm is the manure produced upon it. It represents fertility which has been drawn from the soil by crops and must be returned to it, if productiveness is to be maintained. It not only adds to the store of plant food in the soil by returning the nitrogen, phosphoric acid, and potash removed by crops, but it also renders the native plant food of the soil more available. It adds humus to the soil, improves its physical condition, makes it warmer, and enables it to receive and retain more moisture.
3. Manures vary greatly in composition and value. The four general factors which exert the greatest influence upon the composition and value of manure are, (a) Kind and amount of ab-

sorbents used, (b) Kind and amount of food consumed by the animals, (c) Age and kind of animals, and (d) Methods employed in collecting, preserving and applying the manure.

4. By far the largest percentage of the plant food contained in manure is found in the liquid portion. It is especially rich in readily available nitrogen, contains a high percentage of potash, but is deficient in phosphoric acid. The nitrogen rapidly escapes into the air if special precautions are not taken to prevent its loss. When the liquid and solid portions of manure are mixed together, the one supplies the deficiencies of the other and a more nearly balanced ration for plants is secured.

5. Mature animals, neither gaining nor losing weight, excrete practically all the fertilizing constituents consumed in the food. Growing animals and cows giving milk excrete somewhat smaller amounts.

6. The amounts of nitrogen, phosphoric acid and potash in the manure stand in direct relation to those in the food. Nitrogen is the most costly fertilizing constituent, and, therefore, exerts a greater influence on the quality of manure than any other constituent. It rapidly escapes from the manure in fermentation if measures are not taken to prevent it.

7. Manure should be hauled out and spread upon the field at short intervals whenever practicable. When thus handled, the losses of valuable constituents need not be very great, but when the manure is stored for a considerable time the difficulties of preservation are greatly increased and losses are much more likely to occur.

8. Losses in manure result from two chief causes: first, fermentation, whereby nitrogen, either as ammonia or in the gaseous state, is set free and escapes into the air. Second, by weathering or leaching, which involves a loss of the fertilizing constituents. The loss from destructive fermentation may be largely prevented by the use of proper absorbents and by keeping the manure moist and compact. Loss from leaching may be prevented by storage under cover, or in water-tight pits.

9. The best disposition to be made of the manure of the farm depends to a large extent upon the character of the manure and the nature of the soil and crop. Where improvement of the physical condition of the soil is the principal object sought, fresh manure is best adapted for this purpose to heavy soils, and well-rotted manure to light soils. Where it is desired to obtain prompt action of the fertilizing constituents, the best results will probably be attained by applying fresh manure to the light soils, although excessive applications in this case should be avoided on

account of the danger of "burning out" of the soil in dry seasons. Fresh manure has a forcing effect, and is better suited to early garden truck, grasses and forage than to crops grown for seed, such as the cereals. Manure should be spread when hauled to the field and not left in heaps to leach. The rate of application must be determined by individual circumstances. As a rule it is better to manure lightly and frequently than to apply a large amount at long intervals. The effect of manure is very lasting and is also cumulative.