Farm Manures

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Abstract
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FARM MANURES

By P. E. Brown

More than 2,000 years ago it was known that the application of farm manures to soils increased the yields of various crops. Since then the need of putting back into the land in this way some of the fertility taken out by crops has become more and more evident. It was not, however, until the middle of the last century that much of the mystery as to why the action of manures was beneficial was cleared up by the brilliant researches of Liebig.

The conclusions arrived at by Liebig and which, somewhat modified by later experiments, are still the essential principles of modern agriculture were:

1. "A soil can be termed fertile only when it contains all the materials requisite for the nutrition of plants, in the required quantity and in the proper form."

2. "With every crop a portion of these ingredients is removed. A part of this portion is again added from the inexhaustible store of the atmosphere, another part, however, is lost forever if not replaced by man."

3. "The fertility of the soil remains unchanged if all the ingredients of a crop are given back to the land. Such a restitution is effected by manure."

4. "The manure produced in the course of husbandry is not sufficient to permanently maintain the fertility of a farm; it lacks the constituents which are annually exported in the shape of grain, hay, milk and live stock."

Certain elements must be present in the soil for the growth of plants. They are called plant food constituents. Many of these are present in such large amounts that ordinary crop production can not exhaust them. Other elements, namely,—nitrogen, phosphorus and potassium, are often lacking and consequently these materials must be added to maintain the fertility of the soil. If the produce of the farm, such as milk, grain, hay, etc., is sold, then these essential plant foods will be removed from the soil in amounts varying with the kind and quantity of the produce sold. If there is no return of these elements, the soils will become poor and finally refuse to grow crops.

A manure has been defined as a material which furnishes any of these essential plant food constituents. Farm manures, consisting of the excreta of farm animals mixed with litter, and other refuse, contain plant food constituents derived from the vegetable food that the animals eat.

If farm produce is fed to animals on the farm where it is grown and
their manure is returned to the soil, then loss due to cropping is decreased and the fertility of the soil is maintained for a longer time. Furthermore, as has been said, "if the business of stock feeding is carried to the point where feed is purchased in addition to that grown on the farm, a considerable addition may in this way be made to the fertility of the farm at an almost nominal cost since it is assured that feed will not be bought unless its feeding value will at least pay the cost."

This statement is not absolutely true for all circumstances, however. Even though farm manure contains more or less of all the essential constituents in the food, if it is stored for any length of time, even under the best possible conditions, some loss is certain to occur. If the manure is not well cared for and properly stored, only a very small portion of the plant food taken out of the soil by the crops will be returned. The farmer who is content to keep his manure unprotected, perhaps on a hillside on the banks of a stream, is allowing his soil to become depleted very rapidly in crop producing power. Furthermore, if feed is purchased and the manure obtained is applied to the soil to increase the fertility of one farm, some other farm will be depleted in fertility to just that extent. Farm manures, therefore, play an important, even though not all sufficient, part in the maintenance of soil fertility.

COMPOSITION OF FARM MANURES

It is natural that the composition of farm manures should vary greatly. The manure may contain the excreta of several different kinds of animals or of only one kind; it may contain various materials which have been used for litter, and still other factors may vary. It is, therefore, almost impossible to state the actual plant food content of farm manure. However, a study of all the facts bearing on the subject has led to this statement of the average composition of farm manure:

One ton of farm manure contains: 10 lbs. of potash (8.3 lbs. K.), 5 lbs. of phosphoric acid (2.2 lbs. P.), 10 lbs. of nitrogen.

The factors which influence the composition of farm manure may be grouped into three classes. First, those which relate to the excrement produced by the animals; second, those which refer to the litter employed, and third, those which deal with methods of treatment of the manure after it is produced.

ANIMAL EXCREMENT

The excrement of all animals is made up of two portions, solid and liquid. The solid excrement is composed mainly of the undigested portion of the food. It contains the original constituents in a moist, softened condition and hence may be more easily decomposed than when in the food before it was eaten. The liquid portion is mostly water but contains also the digested portions of the food and the waste product from the digestive action.

The liquid excreta is much richer than the solid portion. It contains \( \frac{3}{5} \) of the total nitrogen and \( \frac{4}{5} \) of the total potassium of the feces. On the
other hand, practically all of the phosphorus excreted is in the dung. Not only does the urine contain more of the valuable constituents but they are in an available, soluble form. The losses which occur in manure due to improper storing, etc., fall upon the liquid, and therefore most valuable, portion of the manure and all schemes to prevent such loss deal with saving the liquid portion.

The relative amounts of dung and urine produced by different animals will vary with the kind of animals and the food consumed. For cows usually the total weight of the urine is twice the weight of the dung. In the case of horses and sheep the amounts of solid and liquid are about equal. With hogs, the urine is usually very abundant but the variations are so great that exact relations between the amounts of solid and liquid cannot be stated.

FACTORS INFLUENCING THE EXCRETA

Several factors exert important influences on the character of animal excreta. These are the age, treatment and condition of the animal, the kind of animal and the quality and quantity of food.

Age, Treatment and Condition. As they feed, young animals keep much greater amounts of fertilizing constituents in their bodies than mature animals which are neither gaining nor losing in weight. Nitrogen, phosphorus and potassium are used by the young growing animals in building up new bones, muscles and other tissues and hence fail to appear in any considerable quantity in the manure. The manure from mature animals which have their growth will contain much more of these valuable constituents. It has been estimated that nearly all of the fertilizer constituents (90 to 95%) of the food may appear in the excreta of mature animals. Young animals, on the other hand, may retain as much as 50% of their food in their bodies. The excreta of milk cows contains only about 75% of the fertilizer constituents in their food, and the excreta of sheep contains a similar amount.

The condition of the animal also determines the character of the excreta. If it is in poor condition, it will take up a very large portion of the valuable matter from its food but if it is in a healthy state and mature and is merely getting fat, very little loss of fertilizer constituents from the food is noticed. Fat contains none of the valuable constituents and hence they are not removed from the food by fattening animals but pass on into the excreta.

The Kind of Animal. The variation in the composition and in the amount of manure produced by different farm animals is very great. In general it may be said that animals producing the smaller amounts of manure yield a richer product. For instance, sheep produce the smallest amount of excreta per 1,000 lbs. live weight but their manure is of the greatest value. On the other hand, cows produce the largest amount of manure but it is of the poorest quality. In the case of hogs, however, we find that they produce a large amount of manure which is equal in value to that of sheep.
These variations are due largely to the feeding habits of the animals, especially with regard to water.

Horse manure contains less water than the others and is therefore known as a "hot" manure because the decomposition processes going on in it are very vigorous and create a high temperature. There is danger of loss of valuable constituents from horse manure if it is not kept moist. This is particularly true of ammonia, the odor of which may often be noticed in the air of stables in which the manure has been allowed to dry out.

Cow manure, on the other hand contains a large amount of water and hence is called a "cold" manure as the air is largely excluded by the moisture and decomposition processes are very slow. The danger here of a loss of volatile constituents is not nearly so great as in the case of the horse manure.

Sheep manure is one of the most valuable of farm manures. It is drier and richer in nitrogen than cow manure, but not so dry as horse manure. The decomposition processes, therefore, proceed less rapidly than in the case of the latter material but more rapidly than in the case of the former.

Hog manure is also valuable but it is exceedingly variable in composition. There is a large amount of water present in this manure and decomposition processes hence are somewhat slow.

Poultry manure is the richest manure produced on the farm. It contains very little water but is rich in nitrogen. It decomposes very quickly therefore and the danger of loss of its volatile constituents is very great.

The Quality and Quantity of Food. The composition of the excreta of farm animals is influenced more by the quality and quantity of their food than by any other factor. The plant food constituents of the food eaten are found more or less completely in the feces, varying with the age, treatment and kind of animals involved. There can be no gain in valuable constituents in the change of food into manure, but they undergo a physical change in the animal body which put, them into a more usable form. If the feed is poor in plant food, the manure will be correspondingly poor. If the animals are fed on highly concentrated feeds, the excreta will be rich.

The plant food value of common animal feeds has been calculated and is exceedingly variable. It ranges from $19.80 per ton in the case of cotton seed meal to $.90 per ton for turnips. In general, then, it may be said that animals fed on concentrated feeds like cottonseed meal, linseed meal, gluten meal, etc., yield the richest manure; those fed on alfalfa hay, red clover hay, etc., the next richest; those fed on cereals (corn, oats, etc.), the next most valuable; and finally those fed on root crops like turnips yield the poorest manure.

The amount of nitrogen present in an animal's food is the most important consideration in determining the value of its manure. Nitrogen is the most important fertilizer element of the manure and the one which is most likely to be lost. The more nitrogen in the food, therefore, the greater the value of the excreta. With increasing amounts of nitrogen in the food, more urine is excreted, more litter is required, and the increased bulk of
the manure makes up for inferior quality. Very rich feeds, or large quantities, increase the value of the feces also, because such feeds are not wholly digested and used by the animal.

The amount of water drunk is likewise important in determining the value of manure. As it varies with different animals, of different ages, etc., the composition of the urine is very largely affected. The percentage of nitrogen compounds in the urine will vary with the amount of urine. The more water drunk, the poorer is the composition of the urine, but this is compensated for in the fact that the weaker the urine, the greater the quantity produced.

LITTER

Farm manures consist of mixtures of solid and liquid excreta with litter. The character and composition of the manures is therefore very largely determined by the character of the material used for litter.

The chief purpose of litter is to absorb and hold the valuable liquid excrement of animals and to keep the animals clean and comfortable. It gives value to the manure in other ways also. By increasing the quantity of the manure it helps distribution. Because of its content of plant food and other qualities it improves the physical and chemical character of the manure. Finally, litter regulates the decomposition of manure, not only by governing the admission of air, but also by actually adding bacteria.

The value of different litter materials is determined very largely by their absorbing power and their content of plant food. The prevention of the loss of the urine is a most important function of litter, for, as already noted, that is the most valuable portion of the animal excreta.

Straw is perhaps the most common material used for litter. It is a very good absorbent and possesses some manurial value. It contains 16 lbs. of nitrogen, 1.8 lbs. phosphorus and 21.6 lbs. of potassium per ton and hence increases the amount of these constituents in the manure. The straws of different grains will vary somewhat in composition and toughness but their value as litter is about the same.

Hay, both salt and fresh, may be used for litter. The former is slow to decay and the salt reduces the rate of decomposition of the manure. Neither material possesses as good absorptive power as straw and although the plant food content of fresh hay is somewhat greater than that of straw, this advantage is insufficient to warrant its use instead of straw.

Peat or peat moss are sometimes used for litter and they are very absorptive. Peat moss will absorb ten times its own weight of water while straw will absorb only three times its weight of water. They contain very little plant food and are not in very common use.

Sawdust has value as an absorbent and but little as plant food. It usually gives the manure a good mechanical condition but sometimes, as when used with horse manure, it makes the manure too open and encourages loss of valuable constituents. Sawdust is used quite frequently in city stables.

Dried leaves, soil, tanners' refuse and other materials possessing more or less absorptive power are occasionally employed, but their use can hardly be recommended either on grounds of economy or expediency.
METHOD OF TREATING MANURES

The composition of farm manures depends not only on the character of the solid and liquid excreta and the litter used but also on the way in which the manure is handled and stored after it is produced. Under certain conditions the fertilizers in the food go almost entirely into the manure. There is always some loss of valuable matter from the manure, however, if it is stored before being used. The most careful methods which it is possible to employ limit that loss to 15% of the valuable constituents. Lack of care in keeping manures will increase this loss at least to 35% and if, as is often the case, all the valuable urine is allowed to leach out of the manure pile and run away in a stream, there is a 70 to 80% loss.

The actual money loss due to improper storing of manure has been variously estimated. Lipman assumes a 20% loss from the manure of horses and mules. Placing the value of the manure produced by all these animals in the United States at $700,000,000 a year which is a conservative estimate, there may be a loss of $140,000,000 a year due to careless storage of manure. Others have placed the estimated loss from the manure of all farm animals at 33\(\%\) and Roberts calculated from that estimate, that the average annual loss for each farm in the United States would amount to $83.33. Many farms suffer losses to a much greater extent and others to a less degree but it is evident from these figures that all possible care should be taken to prevent losses.

Roberts says, "The new idea that the manure should be as carefully preserved from unnecessary waste as any other product of the farm, is hard to put in practice after having for 40 years stored the farmyard manure under the eaves upon a steep hillside which forms one border of a running brook."

LOSSES OF FARM MANURE

These heavy losses from farm manures may come through the escape by leaching of liquid and other valuable constituents or by the fermentation of the manure and the loss of nitrogen by volatilization, or evaporation.

Leaching of Farm Manure. Inasmuch as the liquid portion of the feces contains the greater part of the valuable constituents, particularly nitrogen, when that part escapes much of the fertilizer value of the manure is lost.

To prevent this, in the first place litter of good absorbent power should be used. Furthermore, manure should be sheltered. When, as is so often the case, manure is allowed to remain for months unprotected from sun and rain, the loss, not only of nitrogen but also of potassium and phosphorus, may be very great: It has been estimated that in six months, 60 to 70% of the plant food present may disappear in this way. In general, it is safe to say that about one-half of the plant food value of manure may be lost by such careless storing or rather lack of storing. This loss does not fall
on the liquid portion only but also upon the solid, which in the course of several months may lose one-half of the nitrogen, phosphorus and potassium which it contained.

FERMENTATION OF FARM MANURE

Every farmer has seen the changes which manures undergo on standing. They shrink in bulk, become dark in color, the temperature rises and the composition is completely altered. Some of the plant food is lost entirely by being volatilized and passing out into the surrounding air and the remainder is changed into a more available form. These changes are the result of the action of various microorganisms notably bacteria and molds.

BACTERIA IN MANURE

Containing as it does much plant food and a large amount of organic matter, it is not surprising that manure is the home of numerous bacteria. The number of such organisms will vary considerably, depending on the physical and chemical character of the manure, the method of treatment, etc. In general it may be said that manure may contain from 7,000,000 to 375,000,000 bacteria per gram (1-30 oz.). On the average farm manures probably contain about 80,000,000 organisms per gram. Most of these organisms occur in the solid excreta which has been found to contain 18 to 40 billion bacteria per gram. The urine is practically sterile and the litter usually contains comparatively small numbers.

Some idea of the bacterial matter in manure may be given by the estimate that 9 to 20% of the dry weight of cow manure consists of bacterial substance.

Furthermore there is a great multiplication of bacteria on standing and in a few weeks the number present will be much larger than at first. After a longer or shorter interval, however, depending on the physical and chemical composition of the manure, this increase in number of bacteria will cease and a decrease will occur. These facts may be easily understood when we recall that the manure at first contains a large amount of available food which causes a great multiplication of bacteria. As this available food decreases there is not enough to support the increased number of organisms and many of these therefore die.

THE CLASSES OF BACTERIA IN MANURE

The bacteria present in manure may be divided into two classes; the aerobes, which require air, and the anaerobes which require absence of air for their growth. Whether there are more bacteria of one or the other of these classes will depend very largely upon the physical condition of the manure which will vary with decomposition.

The fermentations brought about by these two classes of bacteria are quite different, particularly with regard to the final products. Both classes of action may occur together, the aerobic bacteria working at the surface of the manure pile and the anaerobic in the inside. If the manure is loosely stored, then the aerobes are most active; if it is packed lightly
the anaerobes will be most active. In the decomposition or rotting processes brought about by these bacteria, the various constituents of the manure are attacked and changed into more available or simpler forms. Thus the proteins or complex nitrogenous compounds, are changed through various stages into ammonia. The non-nitrogenous compounds, like cellulose or other carbohydrates, are changed finally into carbon dioxide gas, hydrogen, water, etc. The complex potassium and phosphorus compounds from the food are acted upon by the acids and carbon dioxide in decomposition and rendered available.

The losses from manure brought about by bacteria fall mainly on the nitrogen, the most valuable constituent.

**Loss of Ammonia Gas**

If the aerobic bacteria are most active much ammonia gas ($\text{NH}_3$) will be formed and this will be lost into the air. This loss of ammonia gas is particularly apt to occur from the urine. The loss of ammonia in this way from urine is evidenced by and may be detected in the odor of ammonia in stables. The nitrogen compounds of the solid excreta may also be lost as ammonia gas, if plenty of air is present in the manure pile.

Loss of ammonia from the liquid manure may be checked by the use of absorbent litter which holds the liquid and prevents its decomposition. Loss from the solid portion may be prevented as will be shown later, by keeping the manure moist and protecting it from the action of sun and rain.

**Loss of Nitrogen Gas**

Nitrogen gas will also be lost from manure if aerobic bacteria are allowed to work away undisturbed. They will change ammonium compounds formed in the decomposition of proteins still further to nitrogen gas which will then pass off into the air. This general loss of nitrogen from manure loosely piled is the main cause of its decrease in value.

**Change of Available Nitrogen into Unavailable**

There is another process which should be mentioned here because it concerns a loss of soluble nitrogen in the manure through its change into insoluble nitrogen. The change is brought about by bacteria. They take up simple nitrogenous materials and store them in their bodies as complex substances. This of course does not involve a loss of nitrogen but checks the loss of nitrogen by keeping in the manure ammonia and nitrates which might otherwise be lost by passing into the air or by leaching.

**Less Loss under Anaerobic Conditions**

When manure is packed and kept moist, air is very largely kept out, the anaerobic bacteria are favored and the changes occurring are quite different. There is a much smaller production of simple compounds like ammonia. The changes in the complex materials are checked by the lack of air and while some losses occur they are very small compared with those brought about under aerobic conditions. The comparative losses in manure under aerobic and anaerobic conditions have been well shown. Careful experiments demonstrated that manure loosely stored, with abundant
air present, in twenty-one weeks lost 53% of its organic matter and 34% of its nitrogen while compacted manure lost in the same length of time only 28% of its organic matter and 15% of its nitrogen.

It is evident, therefore, that anaerobic activities are much less wasteful of the nitrogen in manure than are aerobic processes. All methods of storing of manure which tend to keep out air are beneficial in that they tend to reduce the loss of nitrogen.

**METHODS OF PREVENTING LOSSES FROM MANURE**

The losses from farm manures may be prevented or at least reduced by chemical or mechanical means.

**CHEMICAL METHODS**

The mixing of various materials with manure has been advocated from time to time to prevent the loss of valuable constituents. Among these may be mentioned land plaster or gypsum, kainit, superphosphate, phosphate rock or "floats," sulphuric acid, salt, lime, etc. While in some cases some of these substances have reduced the loss of certain constituents by chemical action or by the restriction of fermentation, the disadvantages of their use outweigh the advantages and they are not recommended for general farm purposes.

**MECHANICAL METHODS**

Mechanical means of caring for manure have received much attention and the value of various methods have been carefully compared.

In the first place the litter is one of the most important means of preventing loss and very absorbent materials should be used to hold the valuable liquids. Water tight floors and gutters in the stables also lessen the danger of loss of the liquid manure.

The loss of nitrogen into the air may be reduced by checking the fermentation processes in the manure. As has been noted already, if the manure is kept packed and moist, the aerobic bacteria are restricted and the anaerobic encouraged and the danger of loss of nitrogen becomes much less.

**STORING MANURES**

There are several methods of storing manure to prevent losses due to temperature, to the weather and to leaching and among these are the use of pits, covered yards, deep stalls, and composting.

**Fits** are sometimes used to keep the solid and liquid excreta together and thus prevent loss by leaching and by aerobic bacterial activities. One difficulty is encountered here in keeping the upper part of the manure wet enough as the liquid of course collects in the bottom of the pit. In France this difficulty is overcome by allowing the liquid portion to drain into a separate pit and then pumping it over the solid mass from time to time.

**Covered yards** consist in well roofed sheds with or without sides and should have water tight floors. The manure is thus protected from rain and leaching and from the alternate wetting and drying out which leads to destructive fermentation processes. The moisture content of the manure
Corn Grown on a Plot of Ground not treated with manure

must be regulated and it must be kept compact. Frequently the animals are allowed to run in such covered yards and in that way compactness is secured and the loss is slight.

Deep stalls are much used in Europe. The method consists in allowing the litter and excreta to accumulate under the feet of the animals. It becomes very compact and very little loss can occur. The method is considered objectionable in this country for sanitary reasons, particularly with dairy animals.

Composting. Various methods of composting manure may be employed. They all consist in storing it in alternate layers with some absorbent material, keeping the pile moist and well covered and turning it over occasionally. Soil, peat or muck, or well-rotted manure may be employed as the absorbent and if proper care is taken to keep the moisture right very little loss can occur.
**THE VALUE OF FARM MANURES**

The value of farm manures has always been recognized and for many years they were the only fertilizing material of any importance.

**Chemical.** In the first place farm manures add a considerable amount of plant food to the soil, as has been shown already. Thus there is returned to the soil at least a portion of the constituents which are taken out by the crops. Furthermore when manure is properly stored they are returned in a form available for plant nourishment.

**Physical.** One ton of manure adds on the average about 425 lbs. of organic matter to the soil. This organic matter not only acts in improving the physical character of the soil with regard to waterholding power, warmth, aeration, etc., but when it decays it leads to the production of larger quantities of available plant food *from the soil itself.*

**Bacteriological.** Manure contains an enormous number of bacteria.
Consequently when it is applied to the soil the bacterial content of the soil is increased and beneficial bacterial activities are encouraged. Manured soils have shown greater production of nitrogen available for plants than have unmanured soils and this is due to the greater bacterial activities.

The value of farm manures therefore as a means of increasing crop production depends on the improved chemical, physical and bacteriological condition of the soil attendant upon its use. Furthermore the effect of applications of farm manure is not exhausted in one season but may be shown in the crop yields for many succeeding years.

It must be emphasized here again that while applications of farm manure do not restore to the soil all the fertility removed by crops which have been fed to the animals producing the manure, they do restore a large portion of the valuable constituents and prevent as rapid a depletion of the soil as would otherwise occur. Again if feeds are purchased for live stock and the manure produced is applied to the soil, the loss of fertility from the soil may be reduced to a minimum.

The value of applications of farm manures to Iowa soils cannot be doubted in the light of the results obtained at the Iowa Agricultural Experiment Station. The advantages gained by their use on the loose soils are well demonstrated by the results given in Bulletin 95 of the experiment station and the accompanying plates which are reproduced from that bulletin.

Recent, and still unpublished data secured on the experimental plots of the station at Ames, on Wisconsin drift soil, also show beyond question the increased yields of corn, oats and clover obtained when manure is applied once in the rotation.

THE USE OF FARM MANURES

Farm manures may be applied to the soil either in a fresh or a well rotted condition.

FRESH OR ROTTED MANURES

The application of fresh manure has some advantages, among which may be mentioned the smaller loss of plant food by leaching and fermentation and the utilization of all the valuable constituents present. The fermentation processes occur in the soil and consequently there is greater effect on the plant food in the soil itself. The physical effects of fresh manure may also be greater than those of rotted manure, particularly in opening up heavy soils. Fresh manure has also been shown to favor especially the growing of stems and leaves and hence may be of considerable advantage to certain crops.

There are some disadvantages, however, in the use of fresh manure which should be mentioned. When fresh manure is applied to light, sandy soils it may dry out the soil too much and prevent the best decomposition of the organic matter present and it may lessen the water holding power of the soil. Many crops may be affected injuriously by fresh manure. It
sometimes causes too rapid production of plant food and that may affect the plants. Furthermore, certain crops may be reduced by the over production of stems and leaves which fresh manure encourages.

Well rotted manure is a better balanced manure, the phosphorus and potassium being in a more available form and in a larger proportion and the nitrogen in a less available form. It possesses the advantages also of convenience in handling, more uniform action, and no danger of injury to light soils.

In general, the character of the soil and the nature of the crop to be grown will determine the relative advantages of fresh and well rotted manure for particular conditions. Fresh manure will prove of considerable advantage, for instance on heavy soils, but should be used carefully on light soils.

On Iowa soils there is a little danger from the use of fresh manure if it is applied about as it is produced during the fall and winter and thoroughly mixed with the soil before seeding. If so used there is the least danger of loss of valuable constituents, as these are leached into the soil and retained there. Moreover, the effect on the crop is not at all injurious.

THE AMOUNT TO APPLY

No fixed recommendation can be made as to how much manure to apply, but in general 5 tons per acre is a light application, 10 tons moderate, and 20 tons heavy. Moderate applications of manure will usually maintain the humus content of fertile soils while soils poor in humus will be benefited by heavy applications. The amount to apply will therefore be determined by the character of the soil and the crop to be grown.

DISTRIBUTION

Manure may be distributed in three ways, by broadcasting, by distributing in heaps and then spreading and by drilling in with the seed. Broadcasting is perhaps the most common practice and it scatters the manure uniformly over the land at the least expense. The manure spreader is generally used for this method. When manure is distributed in heaps and then spread by hand, much handling is required and if it is allowed to remain in the heaps for any length of time, the spots under the piles receive the benefit of all the leaching. Drilling the manure in with the seed is occasionally practiced for forcing some plants and has an important effect.

Fresh manure cannot be used for this purpose.

TIME OF APPLICATION

Manure may be spread on the soil as rapidly as it is produced during the fall and winter preceding spring plowing or it may be stored and spread just before plowing. If it is spread as produced there will be no loss in storing and it is put on the land at convenient times and with less handling than if it is stored. There is one disadvantage in the application of manure as produced. When it is spread on the soil the soluble portion leaches out into the soil and the insoluble is left; this decomposes much more
slowly when it is finally mixed with the soil than if it had decomposed with the soluble portion. Manure should, of course, not be spread as produced on soils subject to flooding or on hillsides, as the valuable portion will be washed away before it is mixed with the soil.

Furthermore, if manure is spread as produced on soils to be fall plowed and is allowed to lie on the surface of the ground during dry, hot weather, ammonia may be lost.

With these exceptions, however, it is undoubtedly the best plan to spread the manure on the soil as produced or at as short intervals as possible to avoid losses.

CONCLUSION

We have found that the composition of manure is exceedingly variable and is regulated by various factors such as the character of the animal excreta, the litter used and the care of the manure after production. The composition of the animal excreta has been shown to depend on the kind of animals producing it, the age, treatment, and condition of the animals, and the quality and quantity of their feed.

The extensive losses which farm manures incur by leaching and improper fermentations have been discussed and methods of storing to prevent such losses have been suggested.

The value of farm manures is too well known to need any further emphasis but experiments on Iowa soils have shown beyond doubt their value for increasing crops.

Finally the use of farm manures with regard to time of application, amount to apply, etc., has been briefly discussed and some suggestions offered.

If the soils of Iowa are to be maintained in a fertile condition, the farm manures must be carefully collected and preserved and the valuable constituents which they contain returned to the soil.