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FARM MANURE

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Michigan farm animals produce more than 27,000,000 tons of manure annually. If it were possible to save all of this manure and use it effectively in crop production, it could produce an annual increase in crop yields worth over $80,000,000. This would be the equivalent of more than $400 for each farm in the state. The plant food in this quantity of manure, if purchased in the form of commercial fertilizers, would cost about 10 times as much as Michigan farmers spent for fertilizers in 1942.

Manure not only increases crop yields but it also improves the quality and the nutritive value of the crops produced. The organic matter contained in this manure, if it could all be returned to the soil, would do much to restore the humus that is lost from our soils each year through cultivation. Unfortunately not all of the manure voided by Michigan livestock can be saved, for probably one-half of it is dropped on pastures where its full value is not realized because of improper distribution. Also, a rather large amount is dropped on roads, lanes, and other non-tillable areas such as in woods, swamps, and on waste land. It is regrettable that the manure dropped in barns and lots, and which could be largely saved, suffers enormous losses through failure to save the liquid portion, through loss of nitrogen by fermentation and drying, and through leaching by rain. Inefficient practices in the field application of manure account for additional losses. It is therefore probably safe to assume that much less than 50 percent of the potential value of manure is now realized on harvested crops. It has been conclusively demonstrated, both practically and experimentally, that it is economically feasible to prevent much of this loss.

Field tests measuring the value of manure in terms of increased crop yields have been conducted by many state agricultural experiment stations. The results of these experiments forcefully illustrate the importance of returning manure to soils if the future productivity of the land is to be insured. The Michigan Agricultural Experiment Station has found that a 5-ton application of manure preceding corn in a 3-year rotation of corn, barley, and wheat on a Hillsdale sandy loam soil has produced significant increases in yields of all

crops. During the past 9 years this application of manure has produced annual increases in yields of 11 bushels of corn, 6 bushels of barley, and over 2½ bushels of wheat. The 10- and 15-ton per acre applications of manure gave greater total increases in yields than the 5-ton application but the increases per ton of manure were less (see Table 4 and Fig. 5).

The value of manure is recognized by most farmers but, in general, they do not understand the true nature of manure, its perishable characteristics, or the direct monetary losses occurring from its improper handling. Wasteful and inefficient methods of handling manure, obvious in all sections of the state, may be taken as evidence of these facts.

The purpose of this bulletin is to bring about a better understanding and appreciation of the value of manure and to present some facts regarding the production, losses, care, field management, and returns from the use of manure from a practical point of view.

QUALITY AND COMPOSITION OF FARM MANURE

Farm manure has reference to the excrements with bedding materials from all animals of the farm including that from poultry. Most of the manure in Michigan is produced by cattle, followed in order by horses, hogs, sheep and poultry. Approximately 75 percent of all the manure produced in Michigan is excreted by cattle and that voided by both cattle and horses makes up about 90 percent of the total.

Wide variations are often found in the chemical composition of manure from different types of livestock, even of a given class of animals. Many factors influence its composition, such as the kind and age of animal, the kind and the amount of feed consumed, condition of the animal and milk produced. Because the composition of manure is so variable, data such as given in Table 1 can only be approximate. It is generally assumed that one ton of average farm manure contains about 10 to 12 pounds of nitrogen (N), 3 to 5 pounds of phosphoric acid (P_2O_5), and 10 to 12 pounds of potash (K_2O). This assumption is based on the fact that most of the manure produced on Michigan farms comes from cattle and horses.

1. Is manure worth saving?

On the average, considering all animals under all conditions, approximately 80 percent of the nitrogen and phosphoric acid and 90 percent of the potash contained in the feed consumed are voided. It is evident, therefore, that if the manure is not utilized the loss in

plant food would be tremendous. Thus, farm manure offers most farmers their chief opportunity for returning to the soil a considerable portion of the plant nutrient elements removed in crops.

2. How much farm manure is produced by different types of animals?

The amount of manure that may be produced per year by the different classes of livestock is indicated in Table 1. The amount of manure which a farmer is able to collect will be determined largely by the amount of time the animals are confined in barns or yards and the efficiency in the methods of caring for the manure that is excreted. The data in Table 1 show that the tons of manure which may be excreted by various animals, per 1,000 pounds live weight per year, vary from over 4 for poultry to over 15 for hogs.

3. How does the composition of manure from different types of livestock vary?

Water is one of the most variable constituents in manure (Table 1); varying from about 55 percent in poultry manure to over 85 percent in cow and hog manure. On a tonnage basis, poultry and sheep manures contain much greater quantities of plant food than the other manures and to a large extent this is because of their lower content of water. The various manures, on a wet basis, contain from about 22 pounds of plant food per ton in cow manure to over 40 pounds in sheep and poultry manure. The nitrogen content of a ton of fresh manure varies from about 7.5 pounds in the case

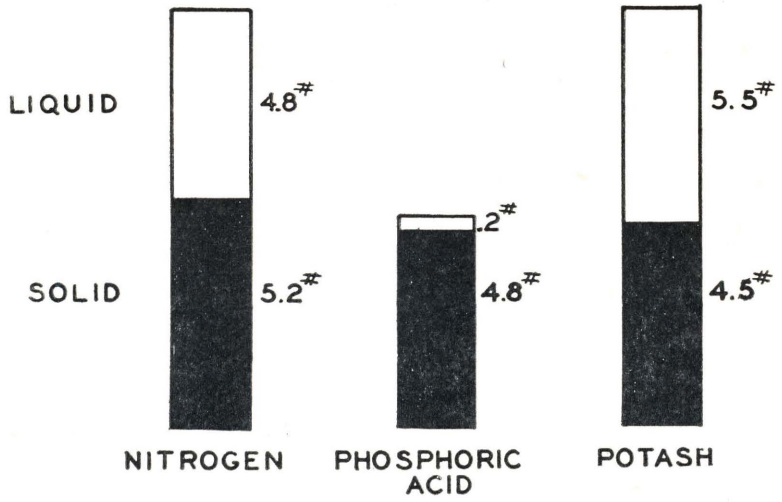

Fig. 1. Distribution of plant food between liquid and solid portions of a ton of manure.

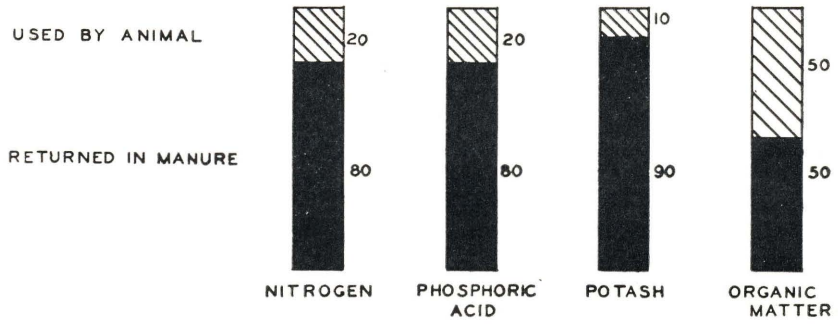

Fig. 2. Average portion of plant food in feed consumed by animals which is excreted in manure.

of hogs to about 20 pounds in the case of sheep and poultry. The phosphoric acid content varies from less than 3 pounds in cow manure to about 15 or 16 pounds in poultry manure. The potash content varies from about 8 pounds in hog and poultry manure to about 20 pounds in sheep manure.

4. How much of the plant food in manure is contained in the urine?

The urine makes up from 20 to 40 percent of the total weight of manure of animals, and yet contains approximately three-fifths of the total potash and about one-half of the nitrogen but only a very small portion of the phosphoric acid (see Fig. 1). It is evident that pound for pound the urine is more concentrated and the plant food is in a more readily available form for plant use than that in the solid fraction.

5. What percent of the plant food elements in feed consumed is retained by the animal?

On the average, farm animals retain from the feed consumed about 20 percent of the nitrogen, 20 percent of the phosphoric acid and 10 percent of the potash. About 50 percent of the total organic matter in feed disappears in passing through the animal (Fig. 2). Obviously, values may vary considerably from those given depending on the feed, kind, age and condition of the animal.

The primary object in the care and handling of farm manure is to keep the losses of plant nutrients and organic matter to a minimum. Although some loss of organic matter and nitrogen is inevitable, under practical methods such losses may be greatly reduced. Some of the more obvious ways of reducing plant-food losses in manure and means of increasing its value are indicated by the answers to the following questions.

AT THE BARN

Careless methods of handling about the barn and delayed application of manure results in loss of a large share of its value. The degree to which manure decreases in value is determined largely by the kind of manure and by the methods used in its management.

6. Is it practical to permit the accumulation of manure under the feet of certain types of livestock as a means of storage?

To permit manure to accumulate under the feet of animals in stalls, or in covered lots or feeding pens is an efficient and practical means of handling manure if plenty of bedding is used. The liquid will be absorbed and tramping by the animals will keep the manure compact, which will retard decomposition losses. This method of handling manure offers considerable flexibility in time of hauling.

TABLE 1—*Quantity and composition of fresh manure (free of bedding) excreted by 1,000 pounds live weight of various kinds of farm animals**

Animal	Estimated average weight in Michigan (pounds)	Tons excreted per year per 1000 lb. weight	Composition of manure on a tonnage basis					
			Excrement	Pounds per ton	Percentage water	Pounds nitrogen	Pounds P_2O_5	Pounds K_2O
Horses and Colts			Liquid	400		5.4	Trace	5.0
			Solid	1600		8.8	4.8	6.4
	1400	9.0	Total	2000	78	14.2	4.8	11.4
Cattle and Calves			Liquid	600		4.8	Trace	8.1
			Solid	1400		4.9	2.8	1.4
	800	13.5	Total	2000	86	9.7	2.8	9.5
Swine			Liquid	800		4.0	0.8	3.6
			Solid	1200		3.6	6.0	4.8
	170	15.3	Total	2000	87	7.6	6.8	8.4
Sheep			Liquid	660		9.9	0.3	13.8
			Solid	1340		10.7	6.7	6.0
	110	6.3	Total	2000	68	20.6	7.0	19.8
Poultry	4	4.3	Total	2000	55	20.0	16.0	8.0

*Compiled from "Fertilizers and Crop Production", Van Slyke, Orange Judd Publishing Co.

7. Why is bedding used in stables?

Bedding is used primarily to furnish clean and comfortable places for animals. In relation to the value of manure, bedding is used principally: (1) to soak up the urine; (2) to make manure easier to handle; (3) to absorb plant nutrients; and (4) to increase the organic matter and plant-food content.

8. Of what value is the liquid portion?

The loss of urine through seepage or run-off is serious from the standpoint of plant-nutrient content. Of the total plant food in manure about 50 percent of the value is in the urine, and this represents the most readily available portion. The losses of nitrogen and potassium through loss of urine is especially great.

9. How may losses of liquid manure be kept to a minimum?

Most of this loss may be prevented by using sufficient bedding material to soak up all the liquid portion. This will decrease leakage through stable floors, seepage into earth floors, or drainage from manure heaps. Perhaps more than one-half the liquid portion of manure is lost on many farms.

10. Are leaching losses serious?

Leaching losses are not confined to the urine but the water soluble compounds of nitrogen, phosphorus and potassium of the solid portion are also involved. Leaching refers to removal of nutrients and other materials by water passing through the manure. Leaching losses are great when the manure is thrown in loose piles in the barnyard; and even greater losses occur when manure is piled under the eaves of the barn. Within the course of 6 months manure, which is exposed to rain, may lose more than one-half its fertilizing value. It is to be emphasized that the material which is leached out represents the most valuable portion.

11. What losses occur from manure by escape of gases?

The principal losses by this process are of nitrogen and organic matter. These losses cannot be prevented entirely but they may be greatly diminished through proper storage and good field management and to a small extent by the use of preservatives. High temperatures in manure and drying out are conducive to losses into the air. Ammonia loss may be considerable from loosely piled manure

heaps or if manure is spread and permitted to dry before plowing under. Freezing also tends to increase the loss of ammonia. No loss of phosphoric acid or potash from manure occurs in the form of gases.

12. How may losses due to scattering be reduced?

The loss suffered by manure piles (in lots) through scattering by chickens, hogs and other livestock may be prevented or reduced by protecting the manure from such mechanical scattering, or by piling it in straight-sided, compact and flat-topped piles. The avoiding of such losses is one argument for hauling manure from the stable to the field every day or so.

13. How do the different bedding materials differ in the amount of liquid they can absorb?

Ordinary straw can take up 2 or 3 times its weight of water; cut straw can take up about 5 times its weight of water; and peat may be able to absorb 10 times its weight of water. The water-absorbing ability of several types of bedding materials is given in Table 2.

14. Is sawdust bedding harmful to the soil?

Sawdust used in normal amounts as bedding is not detrimental to the soil. An excess of sawdust, as well as an excess of straw, may cause a temporary shortage of available nitrogen in the soil but no permanent injury will result.

15. Is peat of any particular value as a preservative?

It has a high liquid-absorption capacity (see Table 2) and also a preservative effect on manure. Acid peat functions as a preservative by absorbing ammonia nitrogen, by keeping the manure acid, or by the fact that little heating results when the manure is stored. A number of farmers use peat in their stables.

16. Are plant nutrients absorbed or fixed by bedding?

Ammonia and potash may be absorbed or held by certain types of bedding material which protects them against leaching loss and decreases the escape of ammonia into the atmosphere. This effect is significant with such material as peat, but little or no nutrient absorption occurs with woodshavings and sawdust (Table 2).

TABLE 2—*Characteristics of bedding materials**

Material	Bedding required to absorb 100 pounds of liquid	Ability to absorb ammonia nitrogen per ton of bedding	Plant food content per ton of air-dry material		
			Nitrogen	Phosphoric acid (P_2O_5)	Potash (K_2O)
	(Lb.)	(Lb.)	(Lb.)	(Lb.)	(Lb.)
Wheat straw	45	4.5	11	4	20
Chopped straw	20–30				
Oat straw	35	7.1	12	4	26
Cornstalks (shredded)	25–35	5.3	15	8	18
Sawdust	25	0	4	2	4
Woodshavings	25–45	0	4	2	4
Peat	10–25	30–60	16–60	2	3

*Data taken from Ohio Agricultural Experiment Station Bulletin 605.

17. Do bedding materials contribute much to the plant nutrient content of manure?

By comparing the data in Tables 2 and 3, one can observe that some of the commonly used bedding materials contain more pounds of plant food per ton than are contained in a ton of so-called average farm manure. Wheat straw, for example, contains a total of about 35 pounds of plant nutrients per ton, whereas a ton of fresh cow manure contains on the average about 22 pounds of plant food. It is to be pointed out, however, that the fertilizing elements contributed by bedding are not so readily available as are those in the manure itself.

18. What is the minimum desirable amount of bedding to use?

It is necessary to use sufficient bedding to absorb all the liquid. The quantity needed will depend largely upon the kind of bedding used and the type of animal to be bedded. In general, straw equal to 25 percent of the weight of excrement will suffice. The average daily requirement of unchopped straw per head of livestock is for cattle, 9 pounds; horses, 10 to 12 pounds; sheep, 1 pound; and hogs, 1½ pounds.

IN STORAGE

There is considerable evidence to show that appreciable losses occur where manure spread on the land remains unmixed with the soil and since it is often impracticable to apply manure daily during certain seasons of the year, it is necessary to resort to some storage on most farms.

19. What are the necessary provisions for good manure storage?

The manure heap should be (1) well compacted, (2) moist, (3) under shelter and (4) undisturbed (not forked over).

20. What are the requirements of a good shed for temporary manure storage?

Such a shed should have a water-tight floor, four continuous walls and a roof. Storing manure under a roof in a closed shed is perhaps the most practical means of preventing leaching losses. When it is necessary to store manure it will generally be practical to construct a special shed for the purpose.

21. If it is necessary to resort to outdoor storage how should it be done?

The manure should be placed in compact piles with straight sides and flat top. Keeping the manure moist and compact is especially important.

22. What is the most wasteful method of manure storage?

Probably the most wasteful method of storage is to place the manure in open piles in the barnlot or under the eaves of the barn.

HAULING MANURE DIRECTLY TO THE FIELD

23. Should farmers haul manure daily to the field?

Many farmers who have sufficient quantities of manure haul it to the field daily which is usually a good practice. Manure spread on the land and immediately worked into the soil is perhaps in its safest place. Obviously, it is not possible for farmers to always work manure into the soil when it is hauled out daily. Therefore, unless a relatively level piece of land is available on which to scatter manure it is generally advisable to resort to storage if good storage conditions can be provided. If good storage is not provided, it is better to have the manure on the land than to let the liquid soak into the soil of the barnyard or wash away in the drainage. Under many conditions it is advisable to haul manure once or twice a week where there isn't sufficient quantities to justify daily hauling. In winter when it may be impossible to spread manure because of snow it is better to pile it in the field, to be spread later, than to have it scattered about the barnyard.

24. Should manure be spread on hillsides where erosion occurs?

In many instances manure may decrease water erosion although much of the soluble plant foods in manure may be washed down the slope. From the viewpoint of conserving manure it is generally advisable to apply it to the more level soil areas unless it can be worked into the soil. On the other hand, it would be better to have the manure scattered on a hillside than piled under the eaves of a barn. If the hillsides are in sod or protected by a good cover crop, they may afford a desirable place to apply manure without fear of much loss due to run-off water.

25. If manure is spread on level land and not worked into the soil do appreciable losses occur?

Considerable loss of ammonia may occur owing to drying winds or freezing weather unless sufficient rain has washed the nitrogen into the soil. To decrease these losses the land should be disked after spreading if possible. In light sandy soils there may be some leaching losses which cannot be avoided, although in most soils this type of loss would be negligible especially if applied on sod or as a top dressing on small grains or other crops. The plant roots would take up a portion of the soluble plant food and prevent it from leaching.

USE OF PRESERVATIVES

A preservative is any material which is added to manure to decrease nitrogen losses. The preserving effect may be due either to the retardation of decomposition, to the conservation of volatile nitrogen compounds into non-volatile compounds, or to the absorption of ammonia. To be most effective, these preservatives should be brought into contact with manure, especially the liquid portion, as soon as it is voided.

26. Are strong acids, such as phosphoric, sulfuric and hydrochloric, effective preservatives?

They are effective preservatives, but their cost and the difficulties encountered in handling them limit their practical use.

27. Is gypsum (calcium sulfate) of any value as a preservative?

It has some value as a preservative. Gypsum, brought into intimate contact with manure, will react with the ammonia and change it into a form (ammonium sulfate) which is less volatile. So long

as the manure is kept moist, ammonia losses will be depressed, but if the manure becomes dry, ammonia will again be formed and may be lost.

28. Will the addition of superphosphate to manure decrease nitrogen losses?

The effectiveness of superphosphate as a preservative largely depends on how well it is mixed with manure. Throwing superphosphate on top of manure would be very ineffective in preserving nitrogen. The ordinary grades (18 to 20 percent) of superphosphate contain considerable quantities of gypsum and this gypsum, together with calcium phosphate in the fertilizer, react with ammonia, resulting in decreased nitrogen losses. At best the treatment saves only a portion of the nitrogen some of which may be lost later when the manure is spread on the land.

29. Is the availability of the phosphorus in superphosphate reduced when used with manure as a preservative?

The availability of phosphate is reduced. In fact, the reduction in availability of phosphate may completely offset the value of the nitrogen saved by the superphosphate.

30. Can the practice of applying superphosphate to manure in the stable be recommended?

Generally speaking, this is not an economical practice, either from the viewpoint of balancing (reinforcing) the manure or for conserving nitrogen. The addition of superphosphate to manure in the stable means that the phosphate will have to be applied broadcast. Results of many experiments show that the most efficient method of applying phosphate is to drill it in with the seed (or close beside the seed) at planting time. Where it is necessary to apply phosphate broadcast as on pastures, meadows and hay land, and manure is also to be applied, the phosphate might well be added with the manure.

31. If superphosphate is to be used in the stable or in the poultry house, how much should be used?

The general recommendation is from 1 to 2 pounds of 20-percent superphosphate per day per cow or horse and 2 pounds per 100 hens per day on the dropping boards or in the dropping pit.

32. Does the use of hydrated lime in stables decrease nitrogen losses from manure?

If large quantities of hydrated lime are brought into intimate contact with manure, it will partially sterilize the manure which slows up the decomposition and fermentation processes and thus retards ammonia losses temporarily. After a short time the hydrated lime loses its sterilizing effect, by reverting to calcium carbonate, and ammonia losses are encouraged by the presence of the lime. Small amounts of lime will increase nitrogen losses.

33. Should sufficient quantities of hydrated lime be used in stables to retard nitrogen losses?

It would be too costly and its effect in decreasing nitrogen losses is only temporary.

34. Does hydrated lime serve any useful purpose when used in stables?

It improves the appearance of stables, will have some germicidal effect and will tend to prevent odors but, as generally used, it will not aid in conserving nitrogen in the manure. In fact it may hasten the loss of nitrogen.

USE OF MANURE

Good management of manure should not stop at the barn or feeding pens. The method of using manure in the field, with reference to crops, kind of soil, commercial fertilizers, time and rate of application, has much to do with getting the greatest net returns out of each ton.

APPLICATION OF MANURE

35. Is prompt spreading of manure always best?

It is generally considered best if it can be applied to level land or worked into the soil very shortly. When manure is accumulated under good storage conditions, however, it is likely to lose less value than if spread on rolling ground particularly in the winter.

36. In what three ways may losses of applied manure occur?

(1) Ammonia may be lost by volatilization (escape into the air) as a result of drying or freezing; (2) surface run-off may wash away soluble nutrients; and (3) loss may occur by leaching (water draining through the soil).

37. Should manure be worked into the soil as soon as it is applied?

If it is possible to do so, it is advisable to plow it under or disk it in immediately. Manure can be more thoroughly mixed with the surface soil by disking before plowing.

38. In relation to time of seeding crops, when should manure be applied?

In general, the effectiveness of manure is decreased if it is applied a considerable time in advance of seeding the crop. In other words, manure applied to corn land in the spring is likely to give better results than an equal amount of manure applied in the fall. If the manure contains an excess of bedding such as straw, the preceding statement would not hold. Generally, it is not advisable to apply manure on sandy soils or on hilly fields much ahead of plowing time because of leaching and run-off losses.

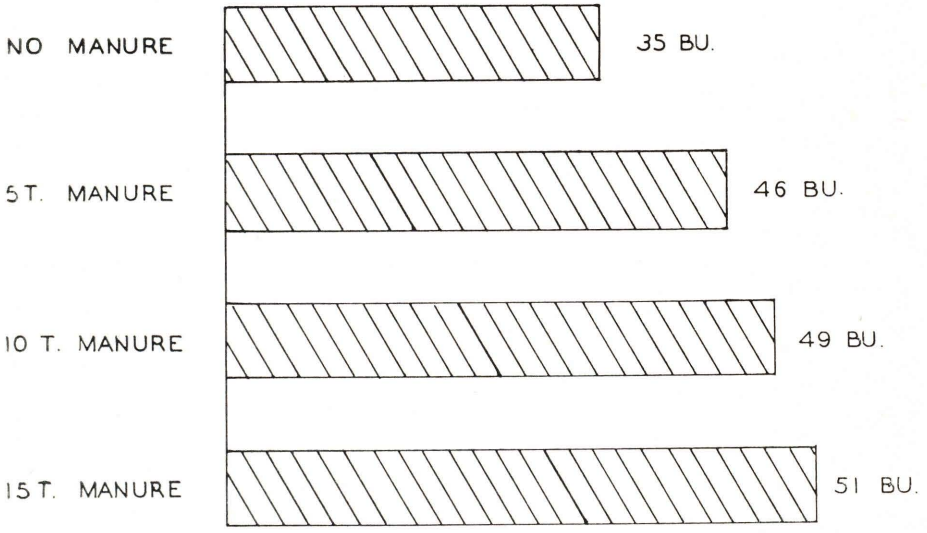

Fig. 3. Yields of corn in a three-year rotation according to rates of application of fresh manure (see Table 4).

39. How should manure be applied?

Most farmers have to apply manure broadcast because they do not have equipment for doing it any other way. There is some evidence, however, that a greater efficiency can be obtained from placing manure in the row or hill than from broadcasting it.

40. At what rate should manure be applied?

On most farms, with a limited quantity of manure, it is advisable to apply manure at the rate of from 4 to 8 tons per acre. Frequent small applications are more efficient than a single large application; the returns per ton of manure are greater. The crop response from 100 tons on 20 acres will be larger than from 100 tons on 10 acres (Fig. 3). The rate at which manure should be applied will generally depend upon the amount produced on the farm and the amount of land available on which it can be applied.

41. Is there danger of temporary burning or yellowing of plants as a result of using poultry manure?

Poultry manure contains at least twice as much nitrogen as average farm manure (from horses and cattle) and it decays very rapidly, liberating ammonia which may burn or injure plants. If it is thoroughly mixed with the soil, it may be used at the rate of 6 or 8 tons per acre without fear of injury. As a general rule, it is advisable to apply poultry manure at about one-half the rate at which cow and horse manure is used. If sawdust has been used on the dropping boards there is likely to be less injury from the use of poultry manure.

42. Is there any way of handling manure that will destroy the weed seeds in it?

When manure is thoroughly rotted many of the weed seeds it contains are destroyed. There is no practical way, however, to kill the weed seeds in manure as it is usually handled on the farm.

CROPS GIVING BEST RESPONSE TO MANURE

43. What crops usually give best response to manure?

All crops respond favorably to manuring, but the intertilled crops and grasses generally show the greatest stimulation. Since manure is essentially a nitrogen and potash fertilizer and since corn, potatoes, beans, sugar beets and other cultivated crops are rather heavy users of nitrogen and potash, these crops should receive a large part of the manure that is produced on the farm.

44. Should manure be applied directly for oats?

Oats have a tendency to lodge when too much nitrogen is available and generally manure should not be used directly for this crop. Satisfactory results are usually obtained with oats when the manure has been applied for a preceding cultivated crop. A light top dressing for oats on sandy or low fertility soils will usually give satisfactory results.

45. Is it a good practice to make a top dressing on wheat?

A top dressing of manure will protect the wheat over winter and stimulate spring growth and on lighter soils greatly benefit the legume seeding that may be made in the wheat. For most conditions this is an excellent practice.

46. Can manure be used to advantage in orchards?

It is especially valuable in orchards on the lighter soils where nitrogen is of much concern.

47. Should manure be used on meadows and permanent pastures?

Dressings of finely divided manure, particularly if reinforced with phosphorus, can be expected to give excellent results.

48. Can manure be advantageously applied to stands of alfalfa or clover?

An application of manure will usually increase the hay yield when applied to alfalfa or clover. However, there are several objections to using manure on these crops, some of which are: (1) If supplied with nitrogen from manure, clover and alfalfa will not take much from the air and these crops lose their soil building value. (2) Manure introduces weed seed into the hay field. (3) The nitrogen in manure stimulates the growth of grass to the disadvantage of the legume.

49. Do truck and garden crops respond favorably to manure?

Heavy applications of manure have proved desirable for these crops. It is an excellent fertilizer for intensive cropping operations.

FERTILIZING PROPERTIES OF MANURE

The benefits produced by manure on plant growth are due for the most part to its content of nitrogen, phosphorus and potassium although frequent or heavy application contributes to the humus content of the soil. However, as compared with ordinary grades of commercial fertilizer, manure is low in plant food content. Nevertheless, the large applications made compared with the pounds of commercial fertilizer usually applied, result in the addition of more plant nutrients to the acre in the manure than in the commercial fertilizer.

COMPARISON OF COMPOSITION OF FRESH AND ROTTED MANURE

Under many farm conditions it is not practical to haul manure to the field daily; it must be stored. Owing to the varying conditions under which manure is stored, a wide variety of chemical changes takes place. The more important points relative to decomposition changes in manure can be brought out best perhaps by comparing fresh with well-rotted manure. In this connection we assume that fresh manure is a normal mixture of urine and feces together with bedding and that the storage conditions for the well-rotted manure have been controlled.

50. Is rotted manure richer in plant-food constituents?

Rotted manure is richer in plant-food nutrients than fresh manure. The increase in percentage of plant nutrients is due to shrinkage in dry weight through decay of the organic matter. One ton of fresh manure may lose one-half its weight in the rotting process.

51. Does well-rotted manure have greater value per ton than fresh manure?

The increase in concentration of plant nutrients in rotted manure is obtained at the expense of large losses of organic matter and usually considerable losses of nitrogen. In general, it is believed that benefits derived by the rotting process may be more than offset by losses. Except for special uses, there is little or nothing gained by allowing manure to rot before applying it to the soil.

52. Is the nitrogen in fresh manure more largely soluble than in well-rotted manure?

A larger percentage of the total nitrogen in fresh manure is soluble or immediately available to plants. There is considerable utilization of soluble nitrogen in the formation of complex proteins during the decomposition of manure. This nitrogen will eventually become available in the soil. It is to be emphasized, however, that unless rotting conditions are carefully controlled, there is likely to be a considerable loss in total nitrogen through volatilization (escaping to the atmosphere).

53. Is the availability of phosphorus decreased by permitting the manure to rot before applying it?

The percentage of soluble phosphorus is greater in decomposed than in fresh manure. Most of the phosphorus in fresh manure is contained in the organic form of the solid portion and, as the manure decays, the phosphorus is changed to more available forms.

54. Does the total quantity of phosphorus and potassium change in the rotting process?

If no leaching or run-off occurs with manure in storage, there is no change in the total quantities of phosphorus or potassium.

SUPPLEMENTING MANURE WITH COMMERCIAL FERTILIZERS

55. Is manure a properly balanced fertilizer?

For many crops and soils it is not properly balanced. It is low in phosphorus in comparison to its nitrogen and potassium content. Stated in fertilizer terms manure, on the average, has the analysis 0.5-0.25-0.5 or a ratio of 1-½-1. The most popular fertilizer in the state has a ratio of 1-6-3. This indicates that manure is extremely deficient in phosphorus.

56. Is it always necessary to supplement manure with phosphate?

Occasionally, there are soils which contain ample quantities of phosphorus and no supplement is needed. Furthermore, when the addition of nitrogen is the chief objective in applying manure as when used in orchards or as a top dressing on some pastures, reinforcement with phosphate may be unnecessary.

57. What is the best way to supplement manure with phosphate fertilizer?

It is best applied to the succeeding crops at planting time through a drill or planter. Phosphate can be more economically utilized by applying it locally (close to the seed) than by broadcasting—which would have to be done if it is applied with manure. Where it is necessary to apply phosphate broadcast, as on pasture and hay crops, and where manure is also to be used, the phosphate may well be applied with the manure (see question 30).

58. How much phosphate should be used as a supplement to manure?

If it is to be applied broadcast with manure, use the equivalent of 40 to 50 pounds of 20-percent superphosphate per ton of manure. If the phosphate is to be applied through a drill in the row or hill at seeding time, apply superphosphate of the ordinary grades at the rate of from 200 to 300 pounds per acre.

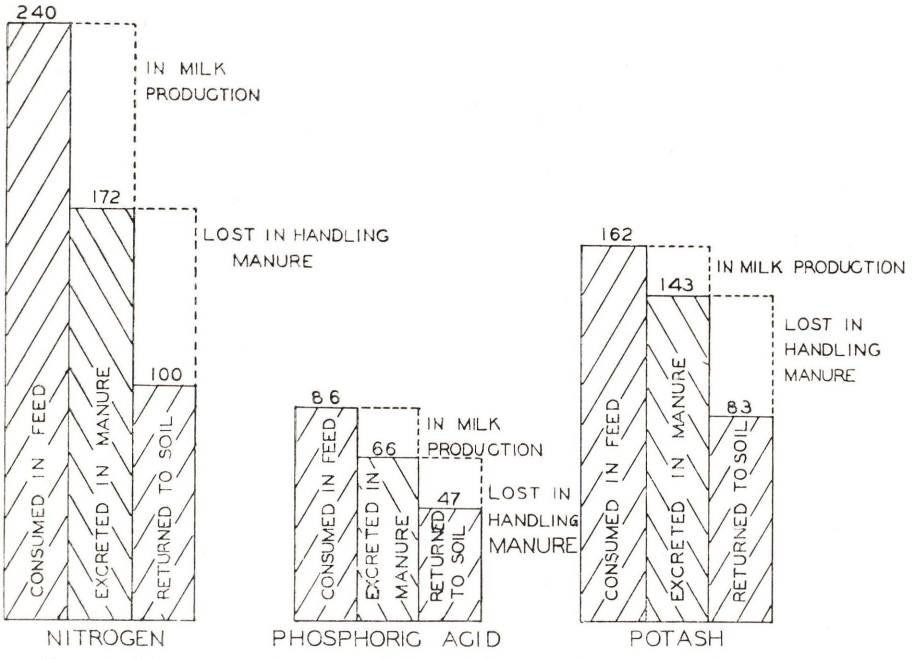

Fig. 4. Plant nutrients consumed by a dairy cow in a year and what becomes of them. It is to be noted that with a dairy system of farming only about 42 percent of the nitrogen, 55 percent of the phosphoric acid, and 51 percent of the potash in the feed consumed are returned to the land, assuming that the milk is sold.

In making these calculations, it was assumed that a liberally fed 1,000-pound mature cow was producing a daily average of 30 pounds of 5-percent milk. The feed consisted of corn, oats, alfalfa, silage, wheat bran, and linseed meal with the mixture containing approximately 14 percent protein.

59. Is manure likely to be deficient in nitrogen?

If excess bedding material, low in nitrogen, such as straw, and especially shavings, has been used, nitrogen may be deficient, or if excess losses of nitrogen from the manure have occurred a temporary nitrogen deficiency may result.

60. Will the proper care and wise use of manure alone result in the maintenance of soil fertility?

It is not possible unless a very large portion of the feed that is fed on the farm is purchased. Only a portion of the plant nutrients removed by crops is returned to the soil in manure even when all crops are fed on the farm (see Fig. 4). Commercial fertilizers and lime, as needed, must accompany the use of manure.

VALUE OF MANURE AS A FERTILIZER

61. Are the fertilizing constituents of manure readily available?

The availability of nitrogen in manure may be expected to average about 30 percent of that of mineral nitrogen fertilizers. The phosphoric acid and potash is about equal is availability to that of mineral fertilizers.

62. How does the quantity of plant nutrients added per acre in a normal rate of application of manure compare with that in an average application of commercial fertilizer?

The quantity of nutrients added per acre in manure is often 5 to 10 times that normally applied as commercial fertilizer. In other words, 10 tons of manure contains about as much total plant food as is contained in 1,000 pounds of a 10-5-10 fertilizer.

63. What is the value of the plant food in a ton of manure in terms of dollars and cents?

Because of its variable nature, it is difficult to place a value on manure which shall express its worth. It is perhaps impossible to estimate its value nearer than 50 percent. Assuming that nitrogen is worth 10 cents per pound, phosphoric acid (P_2O_5) 6½ cents per pound, and potash (K_2O) 5 cents per pound, the plant nutrients in a ton of average farm manure (0.5% N, 0.25% P_2O_5, and 0.5% K_2O) would be worth $1.83. The value of sheep and poultry manure may run twice that amount (see Table 3).

TABLE 3—*The approximate composition and fertilizing value of one ton of fresh manure (without bedding) excreted by various kinds of farm animals**

Animal	Pounds nitrogen	Pounds phosphoric acid (P_2O_5)	Pounds potash (K_2O)	Total pounds plant food per ton	Value per ton**
Horse	14	5	11	30	$2.28
Cow	10	3	10	23	1.70
Swine	8	7	8	23	1.66
Sheep	21	7	20	48	3.56
Poultry	20	16	8	44	3.44

*These data were taken or calculated from Table 1.

**These calculations are based on nitrogen at 10 cents per pound, phosphoric acid (P_2O_5) at 6.5 cents per pound and potash (K_2O) at 5 cents per pound.

TABLE 4—*Yields of crops in a three-year rotation with no treatment, as compared with 5, 10, and 15 tons of manure applied before corn.**

Treatment	Corn (9-year average)		Barley (8-year average)		Wheat (7-year average)	
	Bushels per acre	Increase	Bushels per acre	Increase	Bushels per acre	Increase
5 tons per acre	45.8	11.0	18.7	5.8	24.4	2.6
10 tons per acre	49.4	14.6	22.8	9.9	27.4	5.6
15 tons per acre	51.0	16.2	26.4	13.5	28.1	6.3
No treatment	34.8	.....	12.9	.....	21.8	.....

*Manure was hauled directly from stable to the field and applied broadcast and plowed under before corn in a rotation of corn, barley, and wheat on a Hillsdale sandy loam soil.

64. Does manure tend to increase yields more than commercial fertilizers in unfavorable seasons?

Results of experiments do not indicate that manure is more effective in increasing crop yields in unfavorable seasons than is commercial fertilizer.

65. Are crop increases per pound of nutrients applied in manure greater or less than with chemical fertilizers?

As a rule they are no larger and frequently are less with manure.

66. What is the value per ton of manure based on increased crop yields?

This value depends on many factors, such as, kind of manure, method of handling, rate of application, type of farming, crops

Fig 5. Yields of crops (bushels per acre) in a 3-year rotation with no treatment as compared with 5 tons of fresh manure applied before corn (see Table 4).

grown and crop prices. The value may vary from less than $1 per ton to more than $20 per ton. Under normal conditions on a general farm this value might be expected to average about $3.

67. How long does an application of manure show a favorable influence on crop yields?

The influence on crop yields will usually be noted for several years. The beneficial effects of manure are distributed over a longer time than those of chemical fertilizers and with repeated applications the cumulative effects tend to be larger.

68. Are the growth-promoting influences of manure due only to its content of nitrogen, phosphorus and potassium?

They may be due in part to the presence of "minor" elements, such as calcium, magnesium, sulfur, iron, zinc and manganese, to the organic matter, to increased microbiological activity, or to the presence of growth-regulating substances of a vitamin-like nature.

EFFECTS OF MANURE ON SOIL TILTH

69. In what ways may manure improve the tilth or physical condition of the soil?

The humus which manure supplies improves soil granulation, the water-holding capacity, the permeability of the soil to water, and aeration. It tends to loosen heavy clay soils and holds soil particles together in light sandy soils. Manure applied as a top-dressing protects the soil from beating rains, decreases evaporation losses of water, increases the intake of water, and reduces erosion by checking run-off losses.

The benefits to soil tilth from heavy applications generally are recognized by farmers, but under most farm conditions the effect on the physical conditions of the soil are very small because of the relatively small amounts of manure applied.

CONCLUDING REMARKS

As the average fertility of our soils is continuously decreasing, the saving and efficient use of manure are of vital importance in our system of agriculture. Manuring is one of the most logical and practicable methods of aiding in the maintenance of soil productivity. Manure should not be considered just something to be disposed of but rather it should be recognized as a most valuable by-product of the farm.

The use of farm manures is not sufficient in itself to maintain soil fertility. It cannot be substituted for good cropping systems, lime, commercial fertilizers, good seed, proper drainage, or proper cultural practices. Maximum returns from manure can be had only where it is well cared for and wisely used in conjunction with the other good soil-management practices.

It is advisable that farmers recognize the value of manure, familiarize themselves with the principal ideas brought out in this bulletin and then handle the manure by the best known methods consistent with their conditions and the conveniences which they have at their disposal or are able to obtain.