IMAGE EVALUATION TEST TARGET (MT-3)

6″

Technical and Bibliographic Notes / Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming, are checked below.

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

- [ ] Coloured covers/ Couverture de couleur
- [ ] Covers damaged/ Couverture endommagée
- [ ] Covers restored and/or laminated/ Couverture restaurée et/ou pelliculée
- [ ] Cover title missing/ Le titre de couverture manque
- [ ] Coloured maps/ Cartes géographiques en couleur
- [ ] Coloured ink (i.e. other than blue or black)/ Encre de couleur (i.e. autre que bleue ou noire)
- [ ] Coloured plates and/or illustrations/ Planches et/ou illustrations en couleur
- [x] Bound with other material/ Relié avec d'autres documents
- [x] Tight binding may cause shadows or distortion along interior margin/ La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure
- [ ] Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/ Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.

- [ ] Coloured pages/ Pages de couleur
- [ ] Pages damaged/ Pages endommagées
- [ ] Pages restored and/or laminated/ Pages restaurées et/ou pelliculées
- [x] Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées
- [ ] Pages detached/ Pages détachées
- [x] Showthrough/ Transparence
- [ ] Quality of print varies/ Qualité inégale de l'impression
- [ ] Continuous pagination/ Pagination continue
- [ ] Includes index(es)/ Comprend un (des) index

Title on header taken from:/ Le titre de l'en-tête provient:

- [ ] Title page of issue/ Page de titre de la livraison
- [ ] Caption of issue/ Titre de départ de la livraison
- [ ] Masthead/ Générique (périodiques) de la livraison

- [ ] Additional comments:/ Commentaires supplémentaires:

This item is filmed at the reduction ratio checked below/
Ce document est filmé au taux de réduction indiqué ci-dessous.

10X 14X 18X 22X 26X 30X

12X 16X 20X 24X [x] 28X 32X

The c
to th
Unive
Vanco
The i
possi
of th
filmi
Origi
begin
the la
sion,
other
first p
sion,
or illu
The la
shall
TINU
which
Maps
differ
entire
begin
right
requir
meth

The copy filmed here has been reproduced thanks to the generosity of:

University of British Columbia Library
Vancouver

The images appearing here are the best quality possible considering the condition and legibility of the original copy and in keeping with the filming contract specifications.

Original copies in printed paper covers are filmed beginning with the front cover and ending on the last page with a printed or illustrated impression, or the back cover when appropriate. All other original copies are filmed beginning on the first page with a printed or illustrated impression, and ending on the last page with a printed or illustrated impression.

The last recorded frame on each microfiche shall contain the symbol ⟶ (meaning "CONTINUED"), or the symbol ▽ (meaning "END"), whichever applies.

Maps, plates, charts, etc., may be filmed at different reduction ratios. Those too large to be entirely included in one exposure are filmed beginning in the upper left hand corner, left to right and top to bottom, as many frames as required. The following diagrams illustrate the method:

L'exemplaire filmé fut reproduit grâce à la générosité de:

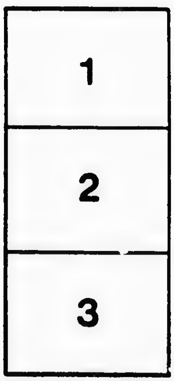
University of British Columbia Library
Vancouver

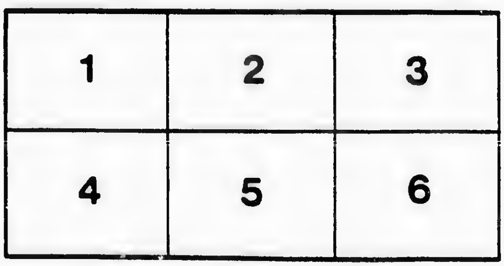
Les images suivantes ont été reproduites avec le plus grand soin, compte tenu de la condition et de la netteté de l'exemplaire filmé, et en conformité avec les conditions du contrat de filmage.

Les exemplaires originaux dont la couverture en papier est imprimée sont filmés en commençant par le premier plat et en terminant soit par la dernière page qui comporte une empreinte d'impression ou d'illustration, soit par le second plat, selon le cas. Tous les autres exemplaires originaux sont filmés en commençant par la première page qui comporte une empreinte d'impression ou d'illustration et en terminant par la dernière page qui comporte une telle empreinte.

Un des symboles suivants apparaîtra sur la dernière image de chaque microfiche, selon le cas: le symbole ⟶ signifie "A SUIVRE", le symbole ▽ signifie "FIN".

Les cartes, planches, tableaux, etc., peuvent être filmés à des taux de réduction différents. Lorsque le document est trop grand pour être reproduit en un seul cliché, il est filmé à partir de l'angle supérieur gauche, de gauche à droite, et de haut en bas, en prenant le nombre d'images nécessaire. Les diagrammes suivants illustrent la méthode.





DEPARTMENT OF AGRICULTURE

CENTRAL EXPERIMENTAL FARM
OTTAWA, CANADA

BARN-YARD MANURE

ITS

NATURE, FUNCTIONS, COMPOSITION, FERMENTATION
PRESERVATION AND APPLICATION

BY

FRANK T. SHUTT, M.A.
Chemist, Dominion Experimental Farms

BULLETIN No. 31

DECEMBER, 1898

PUBLISHED BY DIRECTION OF THE HON. SYDNEY A. FISHER MINISTER OF AGRICULTURE

To the
T.

Sir,
Experi
prepare
Farms,

The
method
often th
ling of
loss.

The
tion, pr
cing pro
hoped th
tice, so
and stor
about as

Ottawa,

To the Honourable
The Minister of Agriculture.

SIR,—I herewith submit for your approval Bulletin No. 31 of the Experimental Farm series, on Barn-yard Manure, which has been prepared under my direction by the Chemist of the Experimental Farms, Mr. Frank T. Shutt.

The proper care of barn-yard manure and the most economical methods of using it, are subjects of great importance to farmers. Too often there is more or less carelessness in connection with the handling of this valuable fertilizer, which invariably results in considerable loss.

The facts presented in this bulletin regarding the nature, composition, preservation and application of barn-yard manure offer convincing proof of the necessity of close attention to this matter, and it is hoped that, by thus bringing prominently forward the errors in practice, so common among some Canadian farmers in regard to the care and storing of this useful fertilizer such reformation may be brought about as will result in much benefit.

I have the honour to be,
Your obedient servant,

WM. SAUNDERS,
Director Experimental Farms.

OTTAWA, 1st December, 1898.

S

T

E

P
L
T

Th
Th
Th

CONTENTS

BARN-YARD MANURE

ITS NATURE, FUNCTIONS, COMPOSITION, FERMENTATION, PRESERVATION AND APPLICATION

BY

FRANK T. SHUTT, M.A., F.I.C., F.C.S.,

Chemist, Dominion Experimental Farms.

There is certainly no subject in connection with farming of greater interest and importance than that of barn-yard manure. In this necessary and natural bye-product of every farm, the agriculturist should recognize his home supply of plant food, the chief means by which he may maintain and increase the fertility of his soils. That this truth is not fully realized is evident from the wasteful neglect so frequently to be seen in the care of manure upon our farms throughout the country. Through carelessness or ignorance, or both, the most valuable part of the manure—because the richest in available plant food—is allowed to drain away, finding its way finally to the creek or river, or, to the danger of the health of the household or stock, into the well. We believe, therefore, that the dissemination of knowledge regarding the composition and nature of farm manures and the care they should receive will be timely and lead to greater economy in the management of those stores of fertility annually produced upon the farms of Canada.

SOIL FERTILITY.

The Factors Necessary for Plant Growth.—Since the object in applying barn-yard manure—or, indeed, any manure—is to increase a soil's fertility, it is important to have a clear understanding at the outset as to what constitutes this quality or condition. A soil's fertility, or crop-producing power, is dependent upon various factors, chief among which undoubtedly is the presence of an abundance of assimilable—that is, more or less immediately soluble—plant food. There are, however, other factors or conditions that tend toward soil-productiveness, and since barn-yard manure, besides supplying the elements for the nourishment of crops, affects directly or indirectly these conditions, it will be well to consider them, if only briefly.

Light and Air.—In the absence of light and air, plants cannot thrive, for while the latter supplies the greater portion of their nourishment, the former serves to convert such within the plant into vegetable substances. Since, however, light and air are abundantly provided by nature, it will not be necessary here to dwell at any length upon their agricultural functions.

It is, however, important to point out that roots, as well as leaves, require air. Water-logged, badly drained soils and heavy, plastic clays exclude the air, and consequently have a low degree of fertility. Barn-yard manure and all organic manures do signal service for such soils by rendering them more porous and permeable to air.

Respecting the value of light, it will only be necessary to state that the full effect of manure is not obtained when crops are too thickly sown. An excellent illustration of this is afforded by the Indian corn crop. Carefully conducted experiments have shown that the amount of real cattle food furnished by, say, an acre of corn sown broadcast is very much less than that obtained from a similar area planted in rows or hills.

Warmth and Moisture.—With these also the control of the farmer is only indirect. It is, nevertheless, well to remember that judicious culture may vastly increase and also regulate a soil's warmth (so necessary, especially in seed germination and the younger stages of growth), as well as affect beneficially its capacity for holding moisture. Between 80 per cent and 90 per cent of growing plants is water. All of this, and much more which is transpired through the leaves during the life of the plant, is drawn by the roots from the soil. The presence of organic matter, as furnished, for instance, by barn-yard manure, is instrumental in controlling a right degree of soil moisture during seasons of drought, and by its fermentation raises the soil's temperature.

Good Tilth.—For want of another term to denote that suitable and favourable physical or mechanical condition of soil which is the result of judicious culture and the application of manures, the writer has been obliged to use the expression "good tilth." This, we acknowledge, is a somewhat new application of the word tilth, but it is one which we believe, though comprehensive, will be well understood. A heavy, plastic clay that bakes into hard masses, a light and too porous sand that neither holds moisture nor affords a firm root-hold to plants, a peaty or swamp soil practically destitute of clay and sand—none of these can be said to be in good tilth. A soil, however, composed of these elements in right proportions and intimately mixed and so cultivated that air is present between the soil particles, that possesses a good absorptive capacity for moisture, freedom for root extension and yet withal a certain firmness, such a soil may be said to be in good tilth. Draining, ploughing, harrowing, cultivating and the like have for their object the improvement of the mechanical condition of the soil, and indirectly the liberation of soil plant food; hence these operations are essential for soil betterment. It is nevertheless true, however, that the presence of humus from the decay of farm manures or other organic matter, is a necessary factor towards the same end. It is evident, therefore, that the structure or texture of a soil must be studied, as well as its supply of plant food; in other words, the physical and chemical condition of a soil must both receive attention, for both, viewed from the standpoint of fertility, are intimately, we may say, inseparably connected.

The Composition of Soils.—All fertile soils contain two classes of constituents, known as organic and inorganic or mineral. The organic portion of a soil is that which has been formed by the decay of plants; the inorganic, that which has been the result of the disintegration and partial decomposition of the original rock masses.

Organic Constituents.—As the decay of vegetable matter proceeds in the soil there results a black or brownish-black substance destitute of organic structure, which is known as humus.

Humus has been called "the soil's storehouse of nitrogen." This element (nitrogen) is one of the essential forms of plant food, and when bought in commercial fertilizers is the most costly. It should here be pointed out that the nitrogen in humus (which may be termed organic nitrogen) is not directly available to crops, but is rendered so by nitrification, a process resulting from the activity of certain microscopic plants or microbes within the soil which live upon and decompose the organic matter there present. Recent research has shown that soil fertility is largely dependent upon the presence of these microbes. Warmth, moisture, and air are primarily necessary for the development and reproduction of these micro-organisms; in other words, for the nitrification of the humus. Certain bases also, such as lime and potash, must be present in the soil, so that as a result of this process *nitrates* may be formed—inorganic compounds which crops absorb by their rootlets for their supply of nitrogen. Barn-yard manure introduces into the soil those microscopic organisms in large quantities, a quality not possessed by chemical fertilizers.

Analysis has shown that the amounts of humus and nitrogen are, generally speaking, closely related, and that the former is a measure of the latter. A soil poor in humus is likely to be deficient in nitrogen. Fertile soils in temperate zones are always characterized by richness in humus and nitrogen. The colour of a soil frequently indicates its quality in this respect, dark brown and black soils possessing large percentages of these constituents. There are, however, exceptions to this, as the presence of much red oxide of iron, (as in some sandy soils) may mask the colour of the humus.

The sources of humus in cultivated soils are practically three, the decaying roots of crops, barn-yard manure, and "green crops," such as clover, turned under. This last has of recent years become recognized as an economical method for enrichment of the soil in humus and nitrogen.

In addition to nitrogen, humus contains certain small quantities of inorganic plant food, such as lime, potash and phosphoric acid. These are liberated by the decay of the humus in forms most useful to plant nutrition.

The mechanical benefits to be derived from humus, we have already referred to. It is only necessary here to emphasize the value of barn-yard manure—a material rich in nitrogenous organic matter—in this connection. In comparing farm manures with commercial fertilizers, this is a point frequently overlooked.

Inorganic Constituents.—In furnishing or replacing in the soil mineral or inorganic plant food, practice has shown that as a rule it suffices to supply three elements—potash, phosphoric acid and lime. Others are used by crops, but the amounts so used are so small that the soil's store of them is not seriously diminished by cultivation. Potash, phosphoric acid and nitrogen are known as the essential elements of plant food, from the fact that it is continually necessary to return them in available forms if soil fertility is to be maintained and increased. For many soils, lime must be added to this list.

The mineral constituents come originally, as already stated, from the rocks that form the base of the soil. They are being constantly removed by cropping. Thus, a four years' rotation of wheat, barley, potatoes and hay will remove per acre approximately, in addition to nitrogen, 222 pounds of potash and 80 pounds of phosphoric acid, and a rotation of wheat, oats, mangels and hay, 342 pounds of potash and 83 pounds of phosphoric acid.

The potash, phosphoric acid and lime in barn-yard manure have once been present in the soil. Absorbed by plants, and the product used for the nourishment of animals, these elements are to be found in the excreta, minus small abstractions for the formation of bone, &c. It is obvious, therefore, that they can be replaced in the soil by applying the solid and liquid manure of the farm.

Without losing sight of the many secondary advantages to be derived from barn-yard manure—advantages, as we have seen, both chemical and mechanical in their nature—the value of this source of plant food must be recognized primarily as depending on the amounts of nitrogen, phosphoric acid and potash it contains and supplies, and it is from this standpoint principally that we shall now consider it. It may, however, be well to repeat in concise form that the various useful and important functions of barn-yard manure within the soil are (1) in supplying plant food, (2) in liberating inert or unavailable plant food, (3) in the improvement of tilth and thereby regulating the soil's absorptive capacity for moisture and warmth, and (4) in furnishing food for and fostering the development of certain useful microscopic plants, known as microbes.

Barn-yard Manure: its Nature and Composition.

The word manure is derived from the French *manœuvrer*, to work with the hand. The significance is worth noting, since it points to the benefit—chiefly in the liberation of assimilable plant food—to be derived from tillage operations generally. Cultivation, any mechanical process that increase soil fertility, would by this derivation be called manuring. This old meaning, however, has passed away, and the use of the term manure is now restricted to materials containing one or more of the essential elements, nitrogen, phosphoric acid and potash, and which are employed to furnish crops with the food they require. In quite recent times, the term "fertilizer" has been used, more or less exclusively, for chemical and mineral substances supplying plant food, such as nitrate of soda, superphosphate, kainit, &c., and the word "manure" has become practically synonymous with "Barn-yard Manure."

By barn-yard manure we understand a mixture of the solid and liquid excreta of farm animals together with the straw or other litter **used in their bedding.**

The agricultural value of any sample of manure will depend primarily and chiefly upon the amounts of nitrogen, phosphoric acid and potash it contains, and, secondarily, upon the solubility or availability of these fertilizing constituents and the amount of organic matter (which will form humus in the soil) it possesses.

The solid excreta (dung) consists of the undigested portion of the food; the liquid excreta (urine) contains products resulting from the digestion of the food, in fact, that portion of the digested food that has done its work in the animal, but is not retained in the production of flesh, milk, wool, &c.

Urine, weight for weight, has a greater manurial value than solid excrement, not only by reason of its larger percentages of plant food constituents (more especially nitrogen and potash), but also from the fact that these constituents are soluble, that is, are practically immediately available for the nutrition of crops. The nitrogen of urine (present as urea) is quickly converted into a valuable form of plant food, whereas the nitrogen of the undigested food in the solid excrement is but slowly changed into such compounds.

In speaking of the relative values of solid and liquid excrement, it may be pointed out that "one-half, and frequently more" of the total nitrogen excreted by the animal is to be found in the urine. More than 90 per cent of the total potash is also present in the liquid excrement. The phosphoric acid and lime, save in the case of the horse, on the other hand, are practically all in the dung. The composition and digestibility of the food will have much to do with the relative proportion of the fertilizing constituents in solid and liquid excreta. On this point Warington speaks as follows:—"If the food is nitrogenous, and easily digested, the nitrogen in the urine will greatly preponderate; if, on the other hand, the food is one imperfectly digested, the nitrogen in the solid excrement may form the larger quantity. When poor hay is given to horses, the nitrogen in the solid excrement will somewhat exceed that contained in the urine. On the other hand, corn and cake yield a large excess of nitrogen in the urine."

The composition of barn-yard manure, in other words, its value as a direct supplier of plant nutrition, will, therefore, depend not only upon the relative proportions of solid and liquid excreta and litter making up the whole, but also upon certain factors affecting the two former, which we may now consider.

Solid and Liquid Excreta.

The composition of the excreta will depend upon (1) the kind, (2) the food, (3) the age, and (4) the condition and function of the animal producing it.

Kind.—Considering the farm stock, horses, sows, pigs and sheep, we find that, other things being equal, the analysis of the fresh solid excreta of these animals presents us with the following data, which, however, we must point out, should only be regarded as approximate. The food of the animal, as we shall presently see, has the greatest effect upon the composition of the resulting manure.

PERCENTAGES OF NITROGEN, PHOSPHORIC ACID AND POTASH IN THE FRESH SOLID EXCREMENT (DUNG).

—	Water.	Nitrogen.	Phosphoric Acid.	Alkalies, Potash and Soda.
Horses	76	·5	·35	·3
Cows	84	·3	·25	·1
Pigs	80	·6	·45	·5
Sheep	58	·75	·60	·3

This places the dungs of the animals in the following order of value: Sheep, pigs, horses, cows.

Similar data respecting urine may be tabulated as follows:—

PERCENTAGES OF NITROGEN, PHOSPHORIC ACID AND POTASH IN THE FLUID EXCREMENT (URINE).

—	Water.	Nitrogen.	Phosphoric Acid.	Alkalies, Potash and Soda.
Horses	89·0	1·2	......	1·5
Cows	92·0	·8	......	1·4
Pigs	97·5	·3	·12	·2
Sheep	86·5	1·4	·05	2·0

The urine of the sheep is seen to be the most valuable, containing the largest amount of nitrogen and potash. That of the horse ranks next, with cow's and pig's following in the order named.

It will be noticed that the urine of animals is much richer in nitrogen and potash than the solid excrements, but it is practically destitute of phosphoric acid.

COMPOSITION OF THE MIXED EXCREMENTS (BOUSSINGAULT).

	Nitrogen.		Phosphoric Acid.		Potash.	
	Per cent.	Per ton.	Per cent.	Per ton.	Per cent.	Per ton.
		Lbs.		Lbs.		Lbs.
Horse, mixed excrements...	·705	14·1	·25	5·0	·134	2·68
Cow " " ..	·547	10·9	08	1·6	·304	6·08
Sheep " " ..	·71	14·2	·25	5·0	·87	17·4
Pig " " ...	·37	7·4	·28	5·6	...	....

A study of this table will show horse manure and sheep manure to be very similar in the amounts of nitrogen and phosphoric acid they contain, being richer in these elements than those from cows and pigs, with the exception of phosphoric acid in the case of the latter. It is also worthy of note that cow and horse manure supplement one another, the former being rich in potash, the latter in nitrogen and phosphoric acid. Together they form a complete manure, furnishing in good proportions the three essential constituents of plant food.

The following table, compiled by Heiden, a celebrated German authority, gives the averages of a very large number of analyses.

COMPOSITION OF MIXED EXCREMENTS (HEIDEN).

	Nitrogen.		Phosphoric Acid.		Potash.	
	Per cent.	Per ton.	Per cent.	Per ton.	Per cent.	Per ton.
		Lbs.		Lbs.		Lbs.
Horse, mixed excrements...	·6	12·0	·3	6·0	·5	10·0
Cow " " ...	·34 to ·44	6·8 to 8·8	·1	2·0	·8	16·0
Sheep " " ...	9	18·0	·5	10·0	1 0	20 0
Pig " " ...	·5 to ·6	10·0-12·0	·1	2 0	·5	10·0

From these averages it is also seen that the composition of farmyard manure is materially affected by the proportion of cow to horse manure it contains.

Factors Influencing the Composition of the Excreta.

Food.—This is by far the most important factor in determining the fertilizing value of both the dung and the urine. The quality of the manure is *chiefly* dependent upon the quality of the food consumed. The richer the food in albuminoids or flesh-formers, the richer will the manure be in nitrogen. The same statement will hold good regarding phosphoric acid and potash. Again, the digestibility of the diet has much to do with the quality of both the solid and liquid excrement. In this connection, we would refer to the quotation from Warington's "Chemistry of the Farm," already given on page 12.

As showing this effect of diet upon quality and quantity of manure produced, we may insert the subjoined table containing results obtained at Rothamsted by Lawes and Gilbert. The figures are from an experiment with cows fed with mangels (a poor food), and lucerne or alfalfa hay (a feeding stuff rich in fertilizing elements):

Fresh Manure per day.	Mangels.		Lucerne Hay.	
	Solid Excrement, 42 lbs.	Urine, 88 lbs.	Solid Excrement, 48 lbs.	Urine, 14 lbs.
	Per cent.	Per cent.	Per cent.	Per cent.
Water	83·0	95·94	79·70	88·23
Nitrogen	·33	·124	·34	1·54
Phosphoric acid	·24	·011	·16	·006
Potash	·14	·597	·23	1·690

The above data afford a striking illustration of the great influence of food. We may safely infer that manure from cattle wintered upon straw will not only be scanty as regards quantity, but also very poor in plant food. A liberal diet of nourishing food not only gives the best results as regards the stock, but also produces the richest manure.

As the quality and quantity of the solid food affect the amount and composition of the excrements, so does the amount of water drunk. The more water that the animal takes, the poorer or more dilute will be the urine, but the inferior quality will be "largely compensated for by the increased quantity voided."

Age.—Young and growing animals absorb a much larger percentage of the fertilizing constituents of their food than do those that are mature or full grown. Stated approximately, we may say that from 50 to 75 per cent of the nitrogen, phosphoric acid and potash of the food of the former will be found in the manure, from 90 to 95 per cent in that of the latter.

Condition or Function of the Animal.—From the foregoing paragraph it might be inferred that according to the wants or requirements of the animal, so is the quality of the resulting manure. Such is found to be the case. The production of milk, flesh and wool makes a heavy demand upon the food, so that the manure of animals manufacturing these is poorer than similar animals that are not performing these functions. Mature animals at rest return practically all the fertilizing constituents of their food in their excrements. Cows in milk utilize about 25 per cent of the plant food elements in their diet, and their manure is consequently less rich than that from fattening steers, which do not retain more than 10 per cent of such constituents.

General Conclusions.—A consideration of the foregoing statements permits us to make the following summary:—

1. That the manures, both solid and liquid, of the various farm animals differ in value, that is, in the proportions of nitrogen, phosphoric acid and potash they contain.

2. That food is the most important factor in determining the value of the resulting manure; the richer the food, the richer the manure. The quantity voided also is largely dependent upon the amount of food consumed and water drunk.

3. That the manure of mature animals, other things being equal, is richer than that of young and growing stock.

4. That animals producing milk, wool, &c., make a greater draft upon their food than fattening stock or those which are mature and at rest or working. The manure of the former will not, consequently, be as rich as that of the latter.

We have also learnt that of the nitrogen, phosphoric acid and potash in the food supplied, by far the greater part (probably, as a rule, about 80 per cent) is returned in the excrement. Further, that both in nitrogen and potash, urine is much richer than the solid excrement, but the latter contains practically all the phosphoric acid excreted. The greater value of the urine, by reason of the solubility of its plant food, has also been observed. This fact points to the advisability of using a sufficiency of litter or absorbents in the stable, &c., so that the solid and liquid excreta may be applied together to the soil, for the best results are undoubtedly obtained by such a method.

Amount and Value of Manure produced by Farm Animals.

The amount of "dry matter" contained in the solid and liquid excrements is approximately one-half of the dry matter of the food consumed. The composition of this dry matter, respecting nitrogen, phosphoric acid and po' sh, is largely dependent, as we have already seen, upon the percentages of these constituents in the food. The total quantity of manure produced depends upon the amount of food and water consumed by the animal.

Some years ago investigations were made at the Cornell (N.Y.) Experiment Station to determine the amount and value of the manure produced by various farm animals when liberally fed and given a sufficiency of bedding. The results obtained, calculated to the basis of 1,000 pounds live weight, are as follows:—

——	Amount per day.	Value per day.	Value per year.
	Lbs.	Cents.	$ cts.
Sheep	34·1	7·2	26 09
Calves	67·8	6·2	24 45
Pigs	83·6	16·7	60 88
Cows	74·1	8·0	29 27
Horses	48·8	7·6	27 74

The fertilizing constituents and value per ton of the above are given in the subjoined table.

——	Water.	Nitrogen.	Phosphoric Acid.	Potash.	Value per ton.
	Per cent.	Per cent.	Per cent.	Per cent.	$ cts.
Sheep	59·52	0·768	0·391	0·591	3 30
Calves	77·73	0·497	0·172	0·532	2 18
Pigs	74·13	0·840	0·390	0·320	3 29
Cows	75·25	0·426	0·290	0·440	2 02
Horses	48·69	0·490	0·260	0·480	2 21

In connection with the above data, it should be remembered that they have been obtained from liberally fed animals, and further, that care was taken that all the excrements, both solid and liquid, were carefully preserved by litter and absorbents. It is quite probable that on many of our farms the manure as applied to the field does not average per head more than half the above values.

Heiden, Boussignault, and others have also made careful experiments in this connection. Their results may be condensed as follows:—A well-fed horse produces from 5 to 6 tons of manure per annum, during the time he is in the stable. A steer of 1,000 pounds produces about 20 tons of manure a year. A sheep weighing 60 pounds would produce about three-fourths of a ton, and a pig from 2 to 3 tons of manure yearly. These amounts include the necessary bedding to keep the animals comfortable.

Composition of Manure in General.

Having learnt that there are many factors affecting the quality of barn-yard manure, it is not a matter of surprise to know that this fertilizer as found upon our farms is extremely variable in composition. While this in part is due to the character of the food of the animal, the writer is convinced that it is more largely due to imperfect means of absorbing and retaining the liquid portion of the manure. The fault frequently begins in the farm buildings through insufficiency of litter or absorbent, and is continued by the leaching out of the most valuable part in the barn-yard.

In speaking of the composition of barn-yard manure in general, it is consequently impossible to do more than state results that have been obtained by different workers. The following figures are from mixed horse and cow manure, and do not include results of leached or imperfectly preserved manures:—

FERTILIZING CONSTITUENTS IN BARN-YARD MANURE.

Barn-yard Manure.	Pounds per Ton.		
	Nitrogen.	Phosphoric Acid.	Potash.
Manure, fresh, average, many analyses............	7·8	3·6	9·0
" rotted " "	10·6	5·6	10·6
" rotted, C. E. F.	10·3	8·5	15·9
" rotting during fermentation, C. E. F	9·8	6·0	13·6
" well rotted, C. E. F., one year old*......	17·7	14·6	29·9
" from Rothamsted.	12·8	4·6	10·0

* Although, as seen from the figures, this manure is extremely rich, it is to be remembered that in the rotting the sample was reduced from 8,000 lbs. to 2,659 lbs. and that the results showed that under the conditions of the experiment considerable loss of fertilizing ingredients had taken place. (See Report of the Farms, 1896.)

The following table gives the average analysis of manure from the various farm animals. The manure in each case consisted of the excreta plus bedding:—(From Bulletin No. 56, Cornell Exp. Station)—

ANALYSIS AND VALUE PER TON OF VARIOUS FARM MANURES.

Kind of Manure.	Number of Experiments.	Nitrogen.	Phosphoric Acid.	Potash.	Water.	*Value per ton.
		Per cent.	Per cent.	Per cent.	Per cent.	$ cts.
Sheep	6	·7675	·391	·591	59·52	3 30
Calves	2	·497	·172	·532	77·73	2 17
Pigs..	3	·84	·39	·32	74·13	3 29
Cows..	4	·426	·29	·44	75·25	2 02
Horses	1	·49	·26	·18	48·69	2 21

*Valuing nitrogen at 15·5 cents and phosphoric acid and potash at 4·5 cents per lb.

Poultry Manure.

Though not a large asset on the ordinary farm, poultry manure is so rich that it well merits more attention than it now receives. As both the liquid and solid excreta are voided together, the result is a manure containing large percentages of nitrogen, phosphoric acid and potash.

Analysis and value per ton of poultry manure:

Water	per cent.	56·0
Nitrogen	"	·8 to 2·0
Phosphoric acid	"	·5 to 2·0
Potash	"	·8 to ·9
Value, from		$5.00 to $8.50

The composition of the manure will depend largely on the character of the food: thus, that from hens fed with green bone and a mixture of grain will be more valuable than that from those fed with Indian corn exclusively.

Hen manu.. .uickly ferments and will lose much of its nitrogen if not preserved with absorbents. Lime and wood ashes should not be used for this purpose. Dry loam or muck, moss litter from peat bogs, road dust, are all useful absorbents for the floor of the poultry house.

Litter.

The quantity and quality of the litter necessarily affects the composition of the resultant manure; we may, therefore, briefly consider the nature of those materials commonly used to furnish farm animals a comfortable bedding and to absorb and retain the liquid excrement. The following data are given by Warington:—

MANURIAL CONSTITUENTS IN 100 PARTS OF LITTER.

——	Nitrogen.	Phosphoric Acid.	Potash.
Dead leaves	0·8	0·3	0·3
Straw	0·4 to 0·6	0·2 to 0·3	0·6 to 1·6
Peat moss	0·8	Trace.	Trace.
Sawdust	0·2 to 0·7	0·3	0·7
Spent tan	0·5 to 1·0	......	......
Peat	1·0 to 2·0	......	......

Straw is the almost (ersal bedding material. It, however, strongly resists fermentation, and hence its fertilizing constituents are not so valuable, pound for pound, as those in the excrements. Cut straw has a greater absorbent value than long straw.

Moss litter is an excellent absorbent, holding many times its own weight of liquid. It is comparatively rich in nitrogen, and both chemical analysis and field results have shown it to produce a very valuable manure. The following table gives the composition of several samples of Canadian moss-litter as ascertained in the Farm laboratories:—

ANALYSIS OF MOSS LITTER.

Designation.	Locality.	Moisture.	Ash.	Nitrogen.	Absorptive Capacit.
Artificially dried..........	Musquash, N.B.....	23·01	1·06	0·57	623
Open air dried..	" "	19·41	1·45	0·71	905
Upper layer.........	Rusagornis, N.B....	11·28	0·81	0·51	1666
" loose..........	Point Cheval, N.B..	13·53	2·30	0·38	1834
Lower layer compact......	" " ..	14·25	7·88	0·48	1166
" "	Big Plain Bog, N.S.	15·7	1·8	·527	1395
" "	Weldon Bog, N.S...	16·20	2·05	·596	1533

Air-dried swamp muck has also a high value, both for the nitrogen it contains and its power to absorb and retain the liquid excrement. As it occurs widely throughout the Dominion, its use in and about the farm buildings should be more general than at present. It is in conjunction with straw that this material can be best employed as a litter, but it can also with advantage be mixed with the manure in the barnyard. The reports of the Chemist of the Experimental Farms during the past eight years contain the analyses of many samples of swamp muck and peat from various parts of Canada, and the data go to show that in these materials we have a vast store of plant food that might readily be made available.

The following table shows the composition of average samples of Canadian swamp muck (air-dried). The data have been taken, without any special selection, from the reports of the Chemical Division, C. E. F.:—

ANALYSIS OF SWAMP MUCK (AIR-DRIED).

Locality.	Nitrogen.	Organic Matter.	Moisture.
Victoria, B.C.	2·23	66·02	23·55
Chilliwack, B.C.	3·51	79·11	9·37
Alberni, B.C.	2·47	71·77	17·59
*Regina, N.W.T	1·66	39·22	9·90
Ompah, Ont	2·37	69·59	7·89
Phillipsville, Ont	1·87	65·22	11·72
St. Williams, Ont.	1·01	31·93	5·52
Shawville, Que.	2·27	73·92	18·59
St. Adelaide de Pabos, Que	2·30	68·58	10·03
Bishop's Crossing, Que.	1·7[illegible]	77·04	11·56
Norton Station, N.B.	1·18	78·66	4·02
Shediac, N.B	2·15	69·30	16·06
Chatham, N.B	1·65	75·15	15·01
Antigonish, N.S	2·19	80·80	9·68
Grove's Point, N.S	1·82	78·99	12·85
Waterville, N.S	1·68	75·34	7·76
Orwell, P.E.I	1·86	73·01	11·57
Aitken's Ferry, P.E.I.	2·54	67·89	11·84
Egmont Bay, P.E.I.	1·51	71·43	15·96

* From the bottom of a slough.

THE PRESERVATION AND APPLICATION OF MANURE.

The Causes, Conditions and Results of Fermentation.—Fermentation, or rotting, is brought about by the agency of certain microscopic plants known as bacteria. The extent of the fermentation, a process which necessarily means a greater or less loss of the organic matter and nitrogen of the manure, will depend chiefly upon the temperature, moisture and the amount of air throughout the heap. Rotting is not a simple process, the decomposition that takes place resulting from the development of two classes of bacteria, (1) aerobic, or those requiring the oxygen of the air for their existence, and (2) anaerobic, or those which can develop in an atmosphere destitute of oxygen. As the conditions for their development are different, so are the compounds produced by their life functions. The manure on the top and sides of the heap is freely permeated by air. It is here that the aerobic ferments set up a combustion of the organic matter, which is burnt by union with the oxygen of the air in the interstices of the manure, forming carbonic acid. Much heat in consequence of this combustion is generated. Fire-fanging is the result of excessive fermentation of this character, usually caused by lack of sufficient moisture. Lower in the heap, the heat decreases, since there the aerobic ferments cannot live for want of air. The anaerobic ferments that thrive at the bottom of the heap disengage marsh gas as well as carbonic acid, and produce but little heat. In the superficial layers the soluble carbo-hydrates (grain, sugar, &c.,) are burnt; in the lower part of the heap, the cellulose or fibre is principally decomposed.

Bacteria are present in both the solid and liquid portions of manures, but, as it has been already stated, it is more especially in the latter that they find a favourable medium for their growth. Drenching the manure heap with the drainage liquid, therefore, not only affords the necessary moisture to retain the ammonia, but also introduces ferments which act beneficially.

We have hitherto considered the action of the bacterial ferments on the non-nitrogenous compounds of manure. It now remains to be stated that the nitrogen of urine and dung may in part be liberated as free nitrogen or in part converted into ammonia and finally into nitrates by their agency. The alkaline fluid produced by the solution of the ammonia in the liquids of the dung is able to dissolve unattacked nitrogenous substances both in the litter and dung, thus preparing for assimilation much plant nourishment otherwise valueless. Rotting or fermentation results in the breaking down or destruction of organic structure in the dung and litter, humus-forming materials being produced. For this reason the mass of rotted manure is more uniform and homogeneous than fresh manure.

Fermentation always entails a loss of organic matter; it also means an escape of a part of the nitrogen. The looser the pile, the greater will be the deterioration. Fire-fanging is injurious to the quality of manure, and results, as already remarked, chiefly from an insufficiency of moisture. Liquid excrement by itself rapidly loses in value, its nitrogen escaping as carbonate of ammonia. These facts point to the great desirability of controlling fermentation, (1) by fermenting the solid and liquid excreta together (this can only be accomplished by using a sufficiency of litter or absorbent), (2) by fermenting "hot" and "cold" (horse and sheep excreta belong to the first class, that from the cow and pig are of the latter class) manures together, (3) by keeping the heap compact and moist, thus excluding excess of air. Fermentation must be regulated and controlled by these means or the losses that ensue will more than out-balance the benefits to be gained.

Weight for weight, rotted manure is more valuable than fresh manure. The losses during fermentation are principally in the destruction of the organic matter and loss of nitrogen and do not, *under the best farm conditions*, lead to much loss of phosphoric acid and potash. It might be possible with a perfectly tight concrete floor to prevent all loss from drainage, but as the potash is extremely soluble it is impossible without such means to prevent some loss of this element. The decrease in weight that takes place, due chiefly to the combustion or burning away of the organic matter, will depend upon the extent of the fermentation. Some of the nitrogen will always escape, either in the free state or as ammonia, but under right conditions of fermentation the percentage of this element will always be found to be considerably greater in rotted than in fresh manure.

The advantages gained by rotting may be enumerated briefly as follows:—The manure becomes disintegrated and of uniform character throughout, allowing an easier and more uniform distribution in the field and a more intimate mixing with the soil; the coarse litter is decomposed and its plant food thus made more available; compounds are formed from the organic matter that more readily produce humus within the soil; the availability of the nitrogen of the solid portion of the manure is increased; the phosphates are made more assimilable; there is less weight of manure to haul to the fields; the larger number of weed seeds that may be present are destroyed.

Experiments in Rotting Manure.

A number of experiments in the rotting of manure have been made during the last three years at the Central Experimental Farm, Ottawa. The results will be found in detail in the report of the chemist for 1898, but we may insert here some of the data, as they will be of interest in this connection. The manure experimented with was composed of equal parts of horse and cow manure. Four tons of this mixed manure were placed in a weather-tight shed, and an equal amount placed exposed in outside box or bin, open to the weather, but with flooring and sides of wood in good condition and practically water-tight (see illustration). These manures were weighed and analysed monthly for the period of a year. The more important results obtained have been summarized, and are contained in the following table:—

WEIGHTS OF FERTILIZING CONSTITUENTS IN "PROTECTED" AND "EXPOSED" MANURES.

	Fresh.		At the end of 3 months.		At the end of 6 months.		At the end of 9 months.		At the end of 12 months.	
	Protected.	Exposed.	Protected.	Exposed.	Protected.	Exposed.	Protected.	Exposed.	Protected.	Exposed.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Weight of manure	8,000	8,000	2,980	3,903	2,308	4,124	2,224	4,189	2,185	3,838
Organic matter	1,938	1,938	880	791	803	652	760	648	770	607
Total nitrogen	48	48	40	34	39	33	37	29	37	31
*Total phosphoric acid	25	25	25	23	26	22	25	21	24	21
†Available phosphoric acid	15	15	20	15	19	15	21	17	19	16
*Total potash	62	62	65	48	59	44	60	41	60	40
†Available potash	51	51	62	45	52	42	56	38	55	35

* Soluble in strong hydrochloric acid. † Soluble in dilute citric acid.

The data in the above table are calculated from the percentage composition and the weight of the manures at the periods indicated. The great difficulty in obtaining thoroughly representative samples for analysis from such a large mass of wet material composed of several constituents (straw, dung, &c.) renders *absolutely exact* results practically impossible. The apparent discrepancies here noticeable are, however, so slight that the general accuracy of the work cannot be doubted. Indeed, the figures prove that the greatest care has been taken, both in the sampling, the analysis and the weighing of the manures.

From the foregoing, the subjoined data have been calculated, showing the losses of fertilizing constituents that ensue under the different systems of preservation.

LOSS OF FERTILIZING CONSTITUENTS IN THE ROTTING OF MANURE.

Fertilizing Constituents.	At the end of 3 months.		At the end of 6 months.		At the end of 9 months.		At the end of 12 months.	
	Protected.	Exposed.	Protected.	Exposed.	Protected.	Exposed.	Protected.	Exposed.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Loss of organic matter	55	60	58	65	60	67	60	69
Loss of nitrogen	17	29	19	30	23	40	23	40
Loss of phosphoric acid	None.	8	None.	12	None.	16	4	16
Loss of potash	None.	22	3	29	3	31	3	36

The most important conclusions from the above are, (1) that the chief losses take place chiefly during the first three months of rotting, (2) that about 10 per cent more organic matter is destroyed in "exposed" than in "protected" manure, (3) that nearly twice as much nitrogen escapes from the "exposed" than from the "protected" manure, (4) that while the phosphoric acid and potash remain practically constant throughout in the protected manure, the losses of these elements, especially of the potash, are very considerable from the exposed manure.

As an offset against these losses, fermentation has broken down or decomposed the litter, has converted the nitrogenous matter into substances that more readily form humus in the soil, has increased somewhat the availability of the phosphoric acid and in all probability has destroyed the greater number of the weed seeds that might be present.

In directing attention to the foregoing results we think it well to emphasize the fact that the "exposed" sample of our experiments was rotted under much better conditions and circumstances as regards protection from loss by drainage than exist ordinarily upon farms. The losses from rotting manure upon farms in general must exceed many times those recorded here.

Leaching.—This in Canada undoubtedly causes more loss than excessive fermentation. When the drainings of a manure pile exposed to rain are allowed to run off and escape there is great loss in the available, and hence more valuable, organic and mineral plant food elements. Such "washed" manure is worth but a fraction of its original value. This depreciation before the manure is carted to the fields may, and frequently does, exceed 50 per cent of its value as it came from the stable and barn. The greatest loss is in potash, nitrogen and soluble organic compounds coming next. The more active the fermentation has been, the greater will be the deterioration if the pile is afterwards subjected to leaching. Thus it is that large piles of manure by rotting and leaching in open yards and on fields subject to flooding suffer deterioration and are reduced in value. If under the most favourable circumstances losses of plant food occur during the fermentation of manure, what must be the waste upon many of our farms where from the manure pile, frequently situated upon a hillside or steep incline, streams of fertility leached out by rains and the drippings from the roofs of the farm buildings, issue forth to find their way to the creek or river.

Samples of the dark, almost black, liquid, draining from manure piles in four barn-yards yielded the following results to analysis:—

COMPOSITION OF MANURE LEACHINGS.

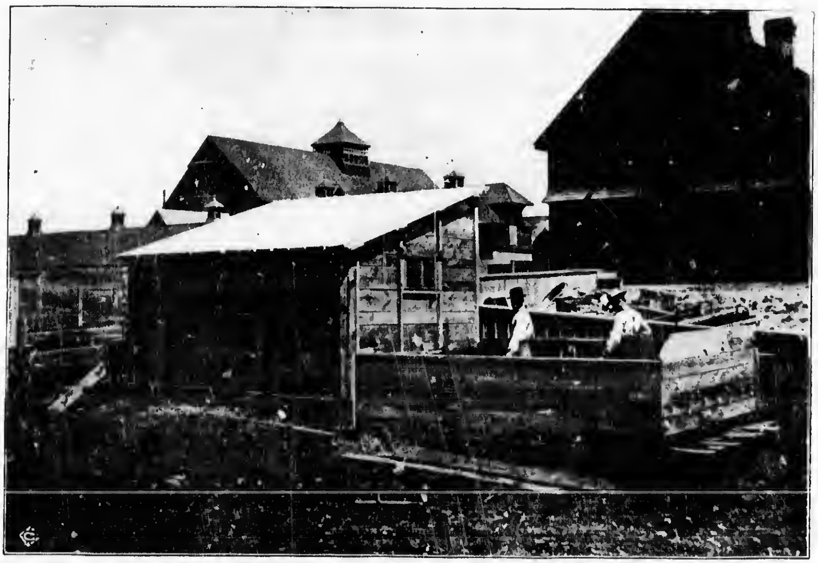
Fertilizing Constituent.	In 1,000 Parts.			
	No. 1.	No. 2.	No. 3.	No. 4.
Nitrogen	·511	1·14	1·60	·03
Phosphoric acid	·104	·038	·10	·03
Potash	2·660	1·980	4·90	1·89

l to
was
ards
rms.
eed

ex-
sed
the
ood
ori-
elds
me
and
fer-
e is
ure
ng
ost
en-
ms
or
gs
to

re

The leaching of Manure. The pond has been produced by leaching and drainage from the pile of manure upon its further side.



Building and open bin used in manure preservation experiments. Men engaged in sampling and weighing manure.

When it is remembered that all this plant food is in solution, the great value of these drainings will be apparent. Though in many instances, owing to copious showers, the drainage water from the manure pile may not be so rich as those above recorded, it is evident that there must be a very large loss, especially in potash, every year from this cause on many farms.

Losses in the Stable.—The readiness and rapidity with which urine decomposes has already been emphasized. The first loss from this cause, as well as from wasteful drainage, occurs in the stable and points to the economy of using there a tight floor and an absorbent that will fix and retain the volatile ammonia. Gypsum is such an absorbent, and used in conjunction with the bedding will be found a valuable preventive of loss of nitrogen. Dry swamp muck, an excellent absorbent, can also be recommended for the cow stable, pig pen or other places in and about the farm buildings where there is liquid manure likely to go to waste. By the use of such materials both the bulk of the manure may be increased and its quality improved. Careful experiments have shown that the loss in the stable often exceeds that in the manure pile; the use of absorbent will tend to reduce the loss in both places.

The Application of Manure.

The Relative Merits of Rotted and Fresh Manures.—The advantages of rotted over fresh manure have already been studied; it has also been seen, on the other hand, that even under a good system of preservation, rotting must be accompanied by loss of fertilizing constituents. Weight for weight, rotted manure is more valuable than fresh manure, containing larger percentages of plant food and having these elements in a more available condition, but the losses in rotting may, and frequently do, out-balance the benefits. Undoubtedly the safest storehouse for manure is the soil. Once in the soil, the only loss that can occur is through drainage away of the soluble nitrates, and this is usually very slight, indeed it is not to be compared with the loss of nitrogen in the fermenting manure heap. We, therefore, unhesitatingly say that the farmer who gets his manure while still fresh into the soil returns to it for the future use of his crops much more plant nourishment than he who allows the manure to accumulate in piles that receive little or no care, and which, therefore, must waste by excessive fermentation or leaching, or both.

With regard to the respective effects of fresh and rotted manures on different classes of soil, it may be stated that fresh manure is better for clays and heavy loams, since it does much to improve their physical condition by opening them to the air and making them more friable. On the other hand, rotted manure is better suited to light and sandy soils, tending to make them more compact and retentive of moisture.

Fresh manure may with advantage be used for crops which have a long season of growth, while rotted manure, with its more available plant food, will give better results for such as gather their food and reach maturity during a shorter period. Excess of fresh manure tends to rankness of growth and the undue development of foliage, and is frequently the cause of "lodging" in grain and too much "top" or leaves in root crops.

The Drying Out of Manure on the Field.—While considering the matter of the application of manure, we may take occasion to answer the question so frequently asked: does manure spread and allowed to dry out upon the field, lose any of its nitrogen? In 1892 we conducted some experiments which proved conclusively that the loss from volatilization of ammonia when the manure was spread in thin layers and allowed to dry out, was so very small that it could be disregarded. It appears that in manure so treated, fermentation is at once arrested. The following are the results we obtained:—

LOSS OF NITROGEN IN FARM-YARD MANURE BY DRYING OUT IN THIN LAYERS.

No.	Manure.		Per cent.	Amount per ton in lbs.	P. c. lost on exposure.	Value at 17c. per lb
						$ cts.
1	Well rotted; after fermentation.	Before exposure...	·515	10·3	......	1 75
		After " ...	·505	10·1	·01	1 72
2	Rotting; during fermentation.	Before exposure...	·490	9·8	......	1 67
		After " ...	·466	9·3	·024	1 58

The above data, of course, do not in any way contradict the statement that great losses of plant food may, and often do, occur in the field. When fertilizing material washed from the spread manure is received by the soil, it is there retained for future crop use, but if the field, by reason of its location is subject to flooding, or the ground is frozen—preventing the percolation of the leachings—much of the best and most valuable part of the manure is undoubtedly carried away and practically lost to the farmer.

The Frequency of Application.—The present opinion, as gathered from experience, is that it is better rather to feed the crop than to try to permanently improve the soil, though, of course, both are intimatly connected, and one cannot be done without in a large measure accomplishing the other. However, the principle here stated points to the advisability of light and frequent dressings rather than heavier applications at longer intervals, and there can be no doubt but that it is more profitable to dress with ten tons every second year than to apply twenty tons every fourth year.