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Fertilizers---Commercial and Domestic.

B. B. ROSS.

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FERTILIZERS—COMMERCIAL AND DOMESTIC.

The extremely low prices of agricultural products almost everywhere prevalent, at present, and particularly the unprecedentedly low figures which the chief Southern staple brings on the market, have, of necessity, attracted attention to the importance of the practice of greater economy in all of the departments connected with the conduct of the farm.

In no single department of the farm economy is there a greater tendency to make retrenchment or to curtail expenditures than in the direction of the reduction of the amounts heretofore paid out for the purchase of commercial manures or other fertilizing materials, and it is to be hoped that this tendency will at least lead to a more thorough utilization of the valuable domestic manurial resources which have been to a great extent, heretofore, either neglected or else disregarded.

These crude supplies of fertilizing materials which are within easy reach of almost every farmer, can, if intelligently and properly utilized, be made to supplement quite advantageously the supplies of artificial fertilizers which are employed as ingredients of the best domestic mixed manures.

The rational system of fertilization of the soil demands that the chief essential fertilizing constituents removed by any crops shall be replaced by returning to the soil an equivalent amount of these constituents for the use of subsequent crops, and it is, in part, to a lack of observance of this important principle, that the exhausted condition of many of our soils is due.

At the same time, it is also true that a very large proportion of our soils have been impoverished in a most marked degree by a washing away of the surface soil with its supplies of plant food and vegetable matter, while many of our

exposed soils lose by oxidation and decomposition a large proportion of their organic constituents.

To make good the losses occasioned under the several conditions above enumerated, there is a constant demand for fresh supplies of fertilizing materials for the purpose of returning to the soil the elements of plant food which have been removed, and these elements may be returned, in part, either in the form of some portion of the crop which has been produced, or by the application of supplies of manures derived from the feeding of the crops in question to farm animals.

It is the design of this bulletin, therefore, to furnish some practical information with regard to the methods of utilizing to the best advantage crude domestic manures, in conjunction with appropriate kinds and quantities of commercial fertilizers.

It is consequently not strictly within the province or scope of this pamphlet to treat of the methods of preventing or avoiding the other forms of soil exhaustion above referred to (viz: by washing and exposure), but the employment of better systems of drainage and the protection of the land by keeping it covered as continuously as possible with some vegetable growth, even if that growth be only grass, will be found to prove valuable aids in the diminution of the losses due to these sources.

Of the dozen or more elements which the soil supplies under ordinary conditions for the development and maintenance of plant life, all except three are commonly present in soils in sufficient quantities to meet the requirements of plant growth. These three important constituents of plant food are nitrogen, potash and phosphoric acid, and it is these three substances which both artificial fertilizers and domestic manures are designed to supply to the soil.

Manures are commonly divided into two classes — viz: *stimulant* and *nutritive* manures.

STIMULANT MANURES.

Stimulant manures are those whose addition to the soil does not supply directly any plant food of value, but whose presence there brings about the decomposition of other forms of plant nutriment not otherwise available for plant use. Among the more important and more commonly employed manures of this class are lime and gypsum (land plaster), and in some countries, salt also finds some employment as an auxiliary stimulant manure.

Lime is, itself, an important mineral ingredient of plant life, and some scientists and investigators (notably Ville) have classed it along with the three essential constituents of complete manures above alluded to. It so happens, however, that lime is present in sufficient quantities in almost all soils to meet the actual requirements of the plant itself for this particular element, and when it or its compounds are supplied to the soil it is almost invariably with a view to the fulfilment of its functions as a stimulant manure. One of the most important offices performed by the lime consists in the decomposition or breaking up of certain mineral forms of potash, whereby the latter becomes readily soluble and available for plant food, while in its original state of combination it was practically of no nutritive value.

Lime also corrects the acidity of so-called "sour soils" and checks in a marked degree the tendency of "running to weed" commonly exhibited by cotton and other crops grown on such soils.

The more important uses and effects of lime upon soils are very appropriately given by Dr. Hilgard in one of the Tenth Census Reports on Cotton Production, and his conclusions are reproduced herewith:

(a.) "A more rapid transformation of the vegetable matter into active humus.

(b.) The retention of such humus against the oxidizing influences of hot climates.

(c.) It renders adequate for more profitable culture per

centages of phosphoric acid and potash so small that in the case of the absence or deficiency of lime, the soil is practically sterile.

(d.) It tends to secure the proper conditions of nitrification whereby the inert nitrogen of the soil is rendered available.

(e.) It exerts a most important influence upon the flocculation and therefore upon the tillability of the soil."

For many purposes, gypsum is employed instead of lime, itself, and many of the functions performed by the latter can be quite effectively accomplished by the substitution of the gypsum (or land plaster), while for certain other purposes, gypsum can be used to better advantage than the lime.

On account of the tendency which gypsum (sulphate of lime) in a moist condition, has to fix certain volatile ammonia compounds, it is highly esteemed for use in covering compost and manure heaps, and effects a saving of considerable proportions of valuable plant food, which would otherwise be lost.

The continuous employment of stimulant manures to the exclusion of nutritive fertilizers, however, is one of the surest and quickest means of impoverishing the soil, since nothing of value is added to the stores of plant food, and the pre-existing supplies of nutritive materials are all the more readily removed by virtue of the presence of the lime or kindred stimulants.

NUTRITIVE MANURES.

The nutritive manures, in contradistinction to the stimulant, contribute directly to the plant valuable supplies of nutriment, and any excess of nutritive ingredients left unconsumed by the plant or crop, adds so much to the stores of plant food available for the use of subsequent crops. The various forms and descriptions of commercial fertilizers upon the market are designed to fulfill the office of nutri-

tive manures, and contain one, two or all three of the essential fertilizing ingredients previously referred to.

The proportions in which these ingredients are supplied, and the forms in which they occur in commercial manures exhibit considerable variations, and are largely dependent upon the manufacturerer's ideas as to the requirements of any particular crop or soil. These commercial manures are commonly divided into two classes, viz: "complete" and "partial manures," the former containing, as the term implies, all three of the chief essential fertilizing constituents of value (phosphoric acid, nitrogen and potash) while the latter contain only one or two of these ingredients.

The former are designed for general use and for direct application to soils and crops, frequently, of widely different characters; the latter are either to be employed as ingredients of home made mixed manures or composts, or else to supply some particular element, in a concentrated form, to some specific crop.

Partial manures may be advantageously considered under the following subdivisions:

(1.) Phosphoric acid manures.
(2.) Nitrogen manures.
(3.) Potash manures.
(4.) Manures containing phosphoric acid and potash.
(5.) Manures containing phosphoric acid and nitrogen.
(6.) Manures containing potash and nitrogen.

The following matter with reference to the composition, characteristics and sources of commercial manures is reproduced from the fertilizer bulletin published by the Department of Agriculture in August 1894:

(1) PHOSPHORIC ACID MANURES.

Formerly the chief source of supply of this valuable fertilizing element was bones, either raw or chemically treated, and while "bone meal" and raw bone superphosphates still have a large consumption, by far the largest proportion of phosphoric acid for artificial fertilizers, is derived from phos-

phate rock, from the fossilized remains of extinct animals, or from the soft phosphate deposits of tropical islands, and quite recently large supplies of this element have been furnished by the Thomas slag, a by-product of the Thomas-Gilchrist steel process. In this country, for the past twenty-five years, a large proportion of the phosphoric acid consumed by our agricultural economy has been furnished by the deposits of phosphate rock contiguous to Charleston, S. C., but within more recent years the supplies of South Carolina phosphate have been largely supplemented by the soft phosphates from South Florida.

The mechanical condition of fertilizers of all classes greatly affects the utility and availability of their fertilizing constituents, and in order to more readily meet the needs of the plant the crude phosphate rock is crushed to a state of impalpability, and the resulting powder so finely divided that its particles can "float" in the air, is placed upon the market under the name of "floats."

Phosphates from some of the tropical islands of the Caribbean sea and adjacent waters are also utilized to some extent as a source of phosphoric acid, though the deposits are being rapidly exhausted.

The phosphatic formations of this character owe their origin largely to the deposits of sea birds, and in rainless climates nitrogen in the form of nitrates and ammonia salts is also found, but in localities where the rainfall is at all considerable, the proportion of this element is extremely small, if it be not entirely absent. Large quantities of phosphoric acid are also supplied from the wastes of our large slaughter houses, and the fertilizers obtained from this source contain also considerable proportions of nitrogen.

Refuse bone black from the sugar refineries, after being utilized for the decolorization of sugars, is frequently treated with sulphuric acid and sold as a fertilizer under the name of "dissolved bone-black," or else is used in the preparation of many of our mixed fertilizers.

The phosphoric acid in most of our complete fertilizers is

found in three forms, viz., the soluble, reverted and insoluble forms. The first is soluble in water, the second is soluble in neutral citrate of ammonia, and is termed by the fertilizer law "citrate soluble," while the third form is insoluble both in water and citrate of ammonia, but is soluble in acids, and is therefore designated "acid soluble phosphoric acid."

In nearly all of our fertilizers the phosphoric acid is in combination with lime, and in bones, phosphate rock and the chief mineral phosphates, is in the form of what is termed "bone phosphate" or insoluble phosphate of lime. While this form of phosphoric acid is insoluble in pure water, it dissolves slowly in water containing carbonic acid (carbon dioxide) in solution, and upon many soils, especially in the presence of organic matter, and where the particles of the fertilizer are in a finely divided condition, has been employed to good advantage.

In order to reduce crude phosphates such as bones, phosphate rock, etc., to a state of fine division, and also to convert the phosphoric acid into a form soluble in water, the crude materials are treated with sulphuric acid and a product is obtained which is known as superphosphate of lime or acid phosphate, while gypsum (sulphate of lime) is also produced and remains admixed with the phosphate.

Pure superphosphate of lime is completely soluble in water, and were the precise amount of sulphuric acid required to completely convert the insoluble phosphate into the superphosphate employed, the whole of the phosphoric acid of the acid phosphate would be in a soluble condition.

In actual practice, however, the full theoretical amount of sulphuric acid is seldom employed in the manufacture of superphosphates, and a small amount of insoluble phosphoric acid is left in the product.

This insoluble phosphate, in contact with the soluble phosphate, leads to the formation of a compound intermediate between the two in composition, and this substance is the "reverted" or "reduced" phosphate.

The term "reverted" is so applied because the soluble phosphoric acid of the fertilizer "turns back" toward its original insoluble form, and a similar behavior is noticed in soils containing good proportions of iron and alumina or lime.

The "reverted" phosphate of lime is the form previously referred to as insoluble in pure water, but soluble in a neutral solution of citrate of ammonia, this solution being assumed to approximate in solvent power the soil water with which the fertilizer will be brought in contact.

"Reverted" or "citrate soluble phosphoric acid" together with the water soluble, constitute what is termed" available phosphoric acid," and though usually assigned the same value, there is considerable diversity of opinion among scientific investigators as to the relative values of these two forms of phosphoric acid.

While the soluble phosphoric acid is soluble in water only so long as its free acid remains uncombined with some such base as lime, oxide of iron, alumina, etc., and while it speedily reverts in soils containing any considerable proportions of these substances, nevertheless it is believed to have an initial diffusive property not possessed by the reverted form; that is, it is disseminated more rapidly and fertilizes more soil in a given time than the same amount of reverted would do.

While the soluble phosphoric acid is seldom found in appreciable quantities in natural phosphates, the reverted form is frequently found in small quantities along with the insoluble in phosphate rock, and in still larger quantities in some tropical phosphates, such as orchilla guano, etc.; it is also found in bones to a considerable extent, and the phosphoric acid in many of our organic fertilizers, such as cotton seed meal, is readily soluble in ammonium citrate.

The superphosphates prepared from bones are believed by many to have a higher value than those from phosphate rock; this superiority, however, if it exists, extends only so far as the availability of its insoluble phosphoric acid is

concerned, the insoluble phosphoric acid from animal sources being much more readily appropriated by the plant than the same form when of mineral origin.

The phosphoretic slag obtained by dephosphorizing pig iron in the Thomas-Gilchrist process for steel-making, has recently become an important factor in the world's supply of phosphoric acid, but has been met with but little in southern fertilizer markets.

Should the basic process of steel making be introduced in this State, an additional valuable source of phosphoric acid will be furnished to the farmers of Alabama.

The attention of this office has been called to circulars distributed by manufacturers and dealers in non-acidulated phosphates, in which a claim is advanced in favor of the natural phosphate and against the acid phosphate, to the effect that the free sulphuric acid of the latter is highly detrimental to vegetation, and therefore constitutes a valid objection to its use for fertilizing purposes.

As a matter of fact, however, the proportion of sulphuric acid used in the treatment of phosphate rock is, as stated above, very rarely sufficient to give even a slight excess of free sulphuric acid in the product and farmers need apprehend no trouble from this source.

(2.) NITROGEN MANURES.

Nitrogen is supplied in commercial fertilizers in three forms, these several forms being designated by the sources from which they are derived :

(1) Vegetable nitrogen.
(2) Animal nitrogen.
(3) Mineral nitrogen.

Among the chief forms of vegetable nitrogen may be mentioned cotton seed, cotton seed meal, and the cakes and meal resulting from the extraction of oils from various vegetable sources.

Cotton seed and its product, cotton seed meal, is the best known of any of the vegetable fertilizers to the southern

farmer, and at the same time, it is the cheapest form in which nitrogen can be obtained in the Southern States.

In addition to the seven per cent. of nitrogen which the meal contains, it also furnishes a considerable supply of phosphoric acid and potash—about three per cent. of the former and two per cent. of the latter.

While the nitrogen of cotton seed meal may not act as quickly as that of nitrates and ammonia salts, nevertheless, upon the decomposition of the meal in the soil, there are formed compounds both of nitric acid and ammonia, similar in composition to some of the mineral forms of nitrogen.

In the purchase of cotton seed meal the farmer should always guard against the admixture of hulls with the meal, the presence of the hulls being readily detected by placing the meal upon an ordinary sieve and shaking thoroughly.

The dark colored cotton seed meals, which are sometimes met with upon the market, while greatly damaged so far as their utility as feed stuffs are concerned, are uninjured as regards their fertilizing value, as has been repeatedly shown by analysis. The cotton seed meal, in addition to its direct application to the soil by the farmer, is employed as a source of nitrogen in the preparation of a large proportion of the complete fertilizers manufactured in the South.

Among the chief forms of animal nitrogen met with in the markets, may be enumerated fish scrap, dried blood, tankage and various other by products from the wastes and refuse of slaughter houses.

Several of these, as tankage, fish scrap, etc., contain in addition to the nitrogen, considerable proportions of phosphoric acid, though they are in general utilized chiefly for the nitrogen they furnish.

The dried blood is a product resulting from the evaporation of the blood from slaughter houses and the thorough drying of the residue, frequently by means of superheated steam. The color of the product varies with the temperature at which the drying is effected, and the red blood is generally considered of more value than the black. The

proportion of nitrogen varies from 9 to 15 per cent. and practical field experiments show that this element, in this form, is readily and quickly available for the use of the plant.

The chief mineral forms of nitrogen of importance are sulphate of ammonia and nitrate of soda, though nitrate of potash and muriate of ammonia are also met with occasionally in the fertilizer trade. The supplies of nitrate of soda are obtained chiefly from the nitrate beds of Chili and Peru, and the refined product has of recent years had quite a large consumption in this country. It contains 15 to 16 per cent. nitrogen in a highly available form and is employed in the preparation of high grade fertilizers, and also as a top dressing for grains, grasses, etc.

Sulphate of ammonia is largely prepared from the ammoniacal liquors of gas works, the crude liquor being neutralized with sulphuric acid and evaporated to dryness.

This substance is the most concentrated commercial form of nitrogen which is found, in general, upon the markets, and is used in the manufacture of complete fertilizers rich in nitrogen, or else is employed as a top dressing for certain crops.

For this latter purpose, however, both of the above mineral forms of nitrogen must be applied with great caution, since by virtue of their easy solubility, they are readily leached from the surface soil, especially if the subsoil is at all permeable.

(3.) POTASH MANURES.

The manures of this class which meet with the largest consumption, either for direct application to the soil or as ingredients of mixed goods, are the crude potash salts from the German salt deposits. The chief forms in which the potash is found in the crude commercial salts are the sulphate and muriate (chloride), the latter form containing the higher proportion of potassium. Kainite, another product of the German mines, consists of potassium sulphate, mag-

nesium sulphate and the chlorides of magnesium and sodium. Its average proportion of potash is about 12 per cent. and it is largely employed in the preparation of composts and in compounding mixed fertilizers designed to contain a moderate potash percentage.

The muriate of potash met with in commerce generally has a purity of only 80 to 85 per cent., giving a potash equivalent of about 50 to 53 per cent., while the high grade sulphate contains from 45 to 50 per cent. potash, and the low grade sulphate only about 30 per cent. of this ingredient. These latter goods are used almost exclusively for the preparation of complete fertilizers with a high potash content.

Cotton seed hull ashes is a southern product which is quite a valuable source of potash, though its use is largely confined to the States bordering on the Atlantic.

The hulls removed from the cotton seed, preparatory to the extraction of oil, are largely used as fuel under the boilers of the oil mills, and the ashes obtained are found to contain from 15 to 25 per cent. potash, and 7 to 10 per cent. of phosphoric acid.

In mixing hull ashes with nitrogenous organic materials, great caution is to be observed, since mixtures of this kind, if kept for any length of time, especially if allowed to become moist, are likely to ferment, with consequent loss of a considerable proportion of nitrogen.

Among the chief vegetable sources of potash may be mentioned tobacco stems, which are utilized to a great extent in the tobacco growing States, and many of the complete fertilizers manufactured along the Atlantic seaboard contain potash derived from this waste product.

(4.) MANURES CONTAINING PHOSPHORIC ACID AND NITROGEN.

Bones, whether in the original crude state or treated with sulphuric acid, contain in addition to their phosphoric acid, from 3 to 5 per cent. of nitrogen derived from the gela-

tinous matter of the bone and constitute one of the most common forms of partial manures of this class.

The boiled or de-gelatinized bone, obtained as a by-product of gelatine manufacture, is sometimes found on the market, but this, of course, contains only phosphoric acid.

Tankage, a product of the large slaughter houses, consists chiefly of a mixture of the dessicated residues of meat and bone left from the treatment of the slaughter house wastes for extraction of grease. The proportions of meat and bone in this fertilizer vary considerably, and lead to quite large differences in the nitrogen and phosphoric acid contents of different samples, the phosphoric acid generally being in excess, though its proportion is dependent largely upon the amount of bone in the material.

Fish scrap, which is simply the dry, pulverized residue from the extraction of oil from fish, contains both phosphoric acid and nitrogen, though the latter predominates and the product is chiefly used for the nitrogen which it supplies. The fertilizing value of all the materials of this class is largely enhanced by a finely divided condition of the particles, and a mechanical analysis is frequently resorted to in addition to the chemical examination.

(5.) MANURES CONTAINING PHOSPHORIC ACID AND POTASH.

Many of the acid phosphates upon the southern market have been mixed with a small proportion of kainite or some of the higher grade potash salts, and are thus better adapted for composting than the plain super-phosphates. By the simple mixture of goods of this class with cotton seed meal a complete fertilizer is obtained, and the farmer can frequently prepare advantageously, in this way, mixtures to meet the needs of his different crops.

(6.) MANURES CONTAINING NITROGEN AND POTASH.

Nitrate of potash is the only manure of importance of this class, supplying both potash and nitrogen in a very

soluble form. Its cost, however, is quite high, and its consumption is somewhat limited.

COMPLETE FERTILIZERS.

As the name implies, fertilizers of this class contain all three of the chief fertilizing constituents of value, though the proportions of these ingredients are extremely variable.

The basis of the complete fertilizer is the super-phosphate, and with this are mixed some common forms of nitrogen and potash, the proportion of these elements being largely dependent upon the manufacturer's ideas of the needs of the soil or crop. Kainite and cotton seed meal are more commonly employed than any other materials to furnish potash and nitrogen to the mixed fertilizers, and planters will, in many cases, find it a good policy to prepare their own complete manures by purchasing the materials referred to and mixing them to suit the requirements of the crop or soil of their particular section.

With these materials at hand, the farmer can prepare a fertilizer of a certain composition for his cotton and a mixture of a still different composition for his corn, the proportion of nitrogen required in the latter case being in general greater than in the former.

Of course, fertilizers prepared according to any definite formula would not be equally well adapted to all soils and sections of the State, and to those who have written to this office for information with regard to the composition of fertilizers best suited to the needs of their particular locality, the formulas furnished in reply have been largely governed by the characteristics of the soil, both as regards composition and location. For instance, on many of our hill soils which consist very largely of particles derived from micaceous and feldspathic rocks, the addition of potash is of very doubtful necessity, and in some cases, quite recently, it has been recommended that for such soils potash either be omitted entirely, or else used in very small quantities. For the same reasons, the addition of excessive quantities of

phosphates to some of our soils which are already well supplied with phosphoric acid is an extremely ill-advised procedure.

DOMESTIC MANURES.

Among the domestic manurial supplies of importance the manure of the more common farm animals first demands consideration.

Originally they found quite general employment in the manurial economy of the farm, but since commercial fertilizers have gained such extensive use, the supplies of domestic manures have been either partially disregarded or else not intelligently applied.

The value and importance of farm manures can possibly be better appreciated and understood when it is stated that the value of the manure produced by a well fed horse per year will be from $23 to $25, calculated according to our scale of fertilizer valuations, while the value of manure per head from our average full grown cattle will probably vary from $15 to $18 per year.

The value of farm manures is largely dependent upon the kind and condition of the animal and the character and quantity of food supplied, and even under uniform conditions the composition is subject to slight variations.

Young and growing animals excrete from one-half to three-fourths of the total fertilizing ingredients in their feed and this proportion is rarely exceeded for the reason that a considerable percentage of these fertilizing constituents are being constantly utilized in the formation of fresh quantities of bone, muscle, tissues, etc., there being in consequence much smaller amounts of waste materials than is the case with full grown animals.

With milch cows the amount of fertilizing constituents excreted is relatively smaller than with other neat cattle on account of the fact that a large proportion of these valuable elements are important constituents of milk, thereby diminishing the amounts found in the excrement itself.

Full grown animals, whether fattening or working, assimilate only a very small proportion of the three chief fertilizing elements, more than nine-tenths of the total amounts of these substances taken in the food, being found in the excreta.

The manure of the horse (or mule) is weight for weight much richer than that of cattle, though a portion of this difference is due to the extremely large percentage of water contained in the manure of cattle.

Samples of barn yard manure both from the stable and cow stalls at the experiment station were subjected to analysis with the following results:

ANALYSES OF BARN-YARD MANURE.

	Water.	Phosphoric Acid.	Nitrogen.	Potash.
Manure from cow stalls (fresh)*	83.85	0 28	0.29	.....
" " " " (dry)	.....	1.75	1.81	.21
" " mule " (fresh)	76.33	0.46	0 63	0.31
" " " " (dry)	.....	1.94	2.66	1.31

* Solid excrement.

The proportion of water contained in the fresh manures of all animals is extremely high, as the analyses just given indicate, although the water percentages in these samples are below the average. The fertilizing value of such manures are made much more apparent when the percentages of the fertilizing ingredients in the dried material are given, as has been done in the case of each of the above samples, though in actual practice, it is best not to permit the manure to become even approximately dry, since "burning" or "fire-fanging" will almost always take place.

Since farm animals excrete such large proportions of the total fertilizing ingredients contained in their food, it is at once manifest that the character of the feed exerts a most important influence upon the composition and fertilizing value of the manure produced.

Indeed, the value of the manure of any given animal for fertilizing purposes is determined almost wholly by the proportions of phosphoric acid, potash and nitrogen contained in the feed stuffs, and analyses of manures resulting from the use of foods rich in the valuable elements of plant food invaribly show a marked superiority over those produced from a food less rich in those constituents.

For instance, carefully conducted feeding experiments have shown that the manure obtained where cotton seed meal and hulls were used, possessed a value more than 40 per cent. greater than that of manure resulting from the employment of an ordinary mixed feed.

In England and several continental countries, it is frequently the case that large numbers of cattle are fattened on high grade and concentrated feeds, either grown on adjacent land or imported, the manure carefully collected and preserved and in many instances returned to the very soils on which the feed stuffs have been produced, with only a very small net loss of the original fertilizing constituents removed by the crop from the soil.

The careful littering or bedding of the stalls of farm animals is of far greater importance than it is generally considered to be, and a disregard of the necessity of giving proper attention to this matter undoubtedly leads to considerable loss of valuable fertilizing ingredients. The chief function of the litter is to absorb the liquid manures which would otherwise go to waste and which it is very important to preserve and properly utilize.

The liquid manures of most farm animals contain relatively larger proportions of nitrogen and potash than do the solid excrements, and if these are not properly collected, it can be readily seen that there will be a loss of no inconsiderable amounts of the total fertilizing materials which are excreted. Among the materials ordinarily employed for litter or bedding may be mentioned straw of various kinds, leaves, saw dust, peat, muck, etc., though the first named substance is more extensively used than any other.

Experiments have demonstrated that dry straw will absorb frequently more than twice its weight of water, while dry peat and muck are almost perfect absorbents and at the same time add very greatly to the fertilizing value of the manure.

Dry straw contains only from one-half to three quarters of a per cent. of nitrogen and considerably less of potash and phosphoric acid, so that it's presence in a state of admixture with the manure does not add materially to the fertilizing value of the latter.

Straw and similar materials, however, in addition to their utility as absorbents, serve to decrease the compactness of manure, to check and regulate fermentation and in many cases promote chemical action in the manure.

The decomposed and disintegrated straw or litter will also supply humus to the soil, a not unimportant consideration in the case of many of our soils, which are almost destitute of organic matter.

The preservation of stable manures is a subject to which too much importance cannot be attached and their value is frequently much diminished by reason of the careless exposure to which they are subjected. Frequently manure heaps are left in an unprotected condition, under the eaves of barns and stables, and the leaching, which takes place with each rain fall, causes a considerable proportion of the fertilizing constituents to be washed out and lost.

Exposure to wind and variable conditions of weather also causes a loss, by reason of the escape of some of its constituents, particularly ammonia, in a gaseous form.

Carefully conducted experiments at the Cornell Experiment station have demonstrated that the reckless exposure of loose manure heaps to wind and weather may cause a loss of as much as 42 per cent. of its original fertilizing value during a period of only six months.

MUCKS.

In localities contiguous to swamps or low marshy bottoms where a dense vegetable growth has prevailed at some time in the past, mucks form a desirable proportion of the manurial supply of the farm, and in some sections of this country, as well as in Europe, mucks and peat form an article of commerce.

Materials of this character owe their value largely to the quantity of vegetable matter they contain, though the character of the vegetable growth from which they are derived influences very appreciably their composition.

Nitrogen is the most important fertilizing constitnent of mucks, though it is present in quite varying proportions, ranging from one half per cent. in a low grade article to 4 per cent. in mucks of extreme richness.

In addition, there are small proportions of phosphoric acid and potash, but these are of minor importance as compared with the nitrogen contained in the muck, and the large supplies of organic matter, which constitute a ready source of humus.

The thoroughly air dried muck may either be employed in composting, or is used as bedding in stables, it being especially adapted to this latter purpose on account of its great absorbent properties, readily taking up and retaining liquid manures with comparatively small loss of ammonia.

In composting, it can be used along with acid phosphates, either as a substitute for, or in conjunction with, stable manure.

The addition of moderate proportions of lime to muck composts is frequently practiced and in most cases to good advantage.

Two samples of muck from the southern part of the State have been examined in this laboratory quite recently and showed on analysis the following composition:

ANALYSES OF MUCK.

SAMPLE.	Phosphoric Acid.	Nitrogen.	Potash.
No. 1. From Baldwin county, Alabama	Trace	0.70	0.04
No. 2. From Escambia county, Alabama	0.58%	0.98	0.31

MARLS.

Throughout a very considerable area of the State, particularly in the cretaceous formations, marls are found in comparative abundance and many samples of high quality have been analyzed in this laboratory.

Marls, properly speaking, consist of carbonate of lime admixed with varying quantities of sand, clay or loam.

The carbonate of lime is ordinarily the chief constituent of value in marls, though small proportions of phosphoric acid and potash accompany the lime in many cases.

The carbonate of lime contained performs the functions of a stimulant manure, decomposing and rendering available some of the ordinarily inaccessible mineral forms of potash present in the soil, and also promoting the formation of humus and the nitrification of the otherwise inactive nitrogen of the soil. The chief difficulty in the way of the more extensive utilization of marls lies in the fact that they will not admit of transportation to any considerable distance, and the soils in the immediate vicinity of the marl deposits are in most cases quite well supplied with lime.

Light and sandy soils, however, will in most instances be benefited by the application of good quantities of well pulverized marl and such soils are sometimes found within easy reach of marl deposits.

"Green sand marls," or glauconitic marls, have been found in a number of localities in this State in sufficient quantities to prove of value for local use. They contain potash (in the form of the mineral "glauconite," in quite considerable proportions, and somewhat smaller quantities of phosphoric acid. Materials of this class act quite slowly when employed for fertilizing purposes, but as this action extends

over quite a long period, the application of green sand marls constitutes quite an important contribution to the permanent plant food supplies of the soil.

The following are the analyses of two samples of green sand marl examined in the station laboratory within the past year.

ANALYSES OF GREEN SAND MARLS.

	Phosphoric Acid.	Potash.
Green Sand Marl, No. 1. From Silas, Ala.....	2.24	3.78
" " " " 2. " " "	2.74	3.86

Marls of this high quality can be employed to quite good advantage, locally, either by direct application to the soil, or in conjunction with cotton seed and stable manure in the form of composts.

MISCELLANEOUS MANURIAL SUPPLIES.

In addition to the above described manurial supplies, there are other crude natural fertilizing materials which are incidental to certain localities in the State. Especially is this the case in North Alabama where valuable deposits of bat manure have been found in a number of caves. These deposits of bat excrement show considerable proportions of nitrogen and fairly good proportions of phosphoric acid and potash.

The following results of analysis of several samples of this material will serve to illustrate its composition and value as a fertilizer.

ANALYSES OF BAT MANURE.

SAMPLE.	Phosphoric Acid.	Nitrogen.	Potash.
Bat Manure, No. 1. From North Alabama, exact locality not known	2.79	3.20	0.85
Bat Manure, No. 2. From North Alabama, exact locality not known	5.56	8.26	2.02
Bat Manure, No. 3. From Lauderdale county	2.27	5.40	0.85

Samples No. 1 contained 65 per cent. moisture, while sample No. 2 had been air dried.

Deposits of cave earth, when employed locally, are of no small manurial value by virtue of the phosphoric acid and nitrogen contained, as the following analyses will show:

SAMPLE.	Phosphoric Acid.	Nitrogen.
Cave Earth, No. 3. From North Alabama, exact locality unknown	0.86	0.36
Cave Earth, No. 4. From North Alabama, exact locality unknown	1.63	0.29
Cave Earth, No. 5. From North Alabama, exact locality unknown	2.20	0.53
Cave Earth, No. 6. From North Alabama, exact locality unknown	3.31	0.20
Cave Earth, No. 7. From Lauderdale county, Alabama	6.84	0.94
" " " 8. " " " "	Trace	0.41
" " " 9. " " " "	3.65	

The bat manure, in a moderately dry condition, is of sufficient fertilizing value to admit of its transportation and it can be employed in mixed fertilizers as a source of nitrogen.

As a top dressing for grains, grasses, clover, etc., it can also be used to considerable advantage.

COMPOSTS.

The most advantageous form in which the crude manurial materials of the farm can be utilized, is, in general, in the compost heap.

Among the advantages offered by composting may be mentioned the better proportioning of the fertilizing ingredients designed for use on some specific soil or crop, which the proper preparation of the compost heap permits; the rapid disintegration and decomposition of the organic materials which may be employed as litter or else as ingredients of the compost; the promotion of nitrification, which is generally believed to be facilitated by the employment of carbonate of lime or marl in the compost; the retention and preservation of ammonia, which is possible in properly managed composts, the loss of which element constitutes one of the most objectionable features of the exposure of loose heaps of stable manure.

In addition, the stable manure by admixture with the other materials in composts, ordinarily becomes less compact, the material is more easily handled, and when applied to the soil, the fertilizing constituents contained are in a condition of more ready availability for the use of the plant. The most common ingredients of composts in the South are acid phosphate, cotton seed and stable manure, though in some cases mucks, marls, ashes, lime, etc., are employed.

For cotton the following compost formula is recommended for use on the average soil:

Acid Phosphate (14 per cent. available Phosphoric Acid)	500 lbs.
Cotton seed	700 "
Stable manure	800 "
Total	2,000 lbs.

In the preparation of composts, a layer of stable manure is spread out evenly in a level place to a depth of several inches; upon this a corresponding quantity of acid phos-

phate is placed, next a layer of cotton seed, this alternation being continued until the materials are exhausted.

The cotton seed employed in the compost should be moistened thoroughly, and the heap after its completion, should be saturated with water containing 100 pounds of Kainite in solution. The heap should be covered with a layer of rich earth or vegetable mould, or better still with a thin layer of gypsum; any liquid drainings from the stable which may be at hand, can be used to advantage in moistening the heap from time to time. The bed should be protected from rains by a shelter, and the heap should be left undisturbed for a period of from three to six weeks. When ready for use, the heap is broken up and the materials are thoroughly mixed and incorporated with each other. The quantities of this compost applied to the soil should be just about double the quantities of the average complete fertilizer ordinarily used on the soil or crop in question, i. e.—from 300 to 600 pounds of the compost per acre.

The composition of such a compost would be approximately as follows :

	Available Phosphate Acid.	Potash.	Nitrogen.
500 lb Acid Phosphate	70 lb	.....	.....
700 " Cotton Seed	7 "	8 lb	21 lb
800 " Stable Manure	2.4 "	4.8 "	4.81 "
Total	79.4 lb	12.8 lb	25.81 lb

The percentage composition would be :

Available phosphoric acid 3.97%.

Nitrogen 1.29%.

Potash .64%.

The addition of the kainite will increase the potash percentage to about 1.2, and the fertilizing value of the complete mixture, calculated on a fertilizer basis, will be about $9.70.

Instead of stable manure, muck can be employed, if deposits of this material of a good quality are at hand, and straw and decaying leaves in moderate quantities, may also be used if the heap is to be allowed to stand for some time.

A compost for corn will require relatively larger proportions of nitrogen and smaller quantities of phosphoric acid, and the following formula will furnish the desired elements in fairly satisfactory proportions:

Acid Phosphate (High Grade)	300 lbs.
Cotton Seed	900 lbs.
Stable Manure	800 lbs.
Total	2,000 lbs.

Kainite to be added as before.

Mixtures adapted to corn can be used to some advantage also with sugar cane, especially where the latter is grown on light sandy lands.

FRAUDULENT FORMULAS FOR COMPOSTS.

Several times during the present season there have been forwarded to this office, formulas for the preparation of composts and home mixed fertilizers, these formulas having been sold for as much as $5 by the parties who have adopted this fraudulent means of earning a livelihood.

The character of the materials recommended, and the forms and proportions in which the several ingredients are to be supplied, show upon the face of the formulas, evidence of the fraudulent and deceptive character of the latter.

Two of these formulas are given below, in order that the sham and deception involved in the sale of such recipes may be exposed.

FORMULA NO. 1.

Ammonia	5 lbs.
Phosphoric Acid	2 "
Nitrate of Potassium	5 "
Saltpeter	10 "
Sulphur	5 "
Potash	10 "
Lime	50 "
Ashes	100 "
Dirt or lot scrapings	1800 "

FORMULA NO. 2.

Nitrate of Ammonia	4 lbs.
Soda Ash	4 "
Saltpeter	2 "
Potash	4 "
Bluestone	2 "
Lime	50 "
Salt	25 "

Mix in 10 gallons of water and add to green vegetable mold or barn yard scrapings.

It will be observed that in the first formula, commercial ammonia is recommended, although it is one of the costliest forms of ammonia and a form in which its complete loss is best assured. The amount per ton of actual ammonia thus supplied is insignificant, and were the ammonia not already in a free condition, it would soon be liberated by virtue of the presence of caustic alkalies in the mixture.

Potassium nitrate and saltpeter are one and the same substance, although they are mentioned separately in this formula.

This salt is one of the costliest and most concentrated forms of nitrogen and potash obtainable, and its use in a compost would be entirely inadvisable, when so much cheaper forms of nitrogen can be easily secured. The sul-

phur in this formula, as well as the bluestone and other substances (soda, etc.) in the other formula, is entirely superfluous and unnecessary, and supplies but another evidence of the untrustworthiness of such recipes.

The presence of caustic alkalies in the second formula, along with ammonia salts would of course lead to an almost total loss of this last ingredient, while the proportions in which it is recommended that these mixtures should be applied, would furnish extremely small quantities of the important fertilizing ingredients to the soil.

For instance, the commercial value of the materials in formula No. 1, would be only about $1, though one of these ingredients, phosphoric acid, is not on the market in a free state, as the formula might lead one to suppose.

The commercial value of the fertilizing constituents in formula No. 2, is even less than that in No. 1, and the mixture is as equally untrustworthy.

It is to be hoped that the sellers of these formulas have met with but little success, and that the farmers will prepare their composts or home mixed manures out of the crude materials which they have at hand, used in conjunction with acid phosphate, kainite, etc.

GREEN MANURES.

The practice of green manuring, or the plowing under of certain green crops grown especially for this purpose, is one of the oldest systems of fertilization at present in use, and has been followed in the South with advantage for many years, though only one or two particular crops have been utilized for this purpose. While it has been long known that the cow pea and many other leguminous plants possessed in a most marked degree the capacity of collecting and assimilating large quantities of the chief fertilizing constituents, and particularly, nitrogen, nothing has been definitely known as to the causes underlying their remarkable properties as nitrogen collectors until within quite recent years.

So readily does the cow pea grow upon many soils which fail to respond to the requirements of other crops, that when it is desired to convey the idea of an almost total lack of fertility in a soil, we often hear the expression—"the land is too poor to grow cow peas."

It was formerly supposed that this capacity of collecting plant food so successfully, even on very poor soils, was due to the long and deep reaching roots which were presumed to readily take up supplies of plant food beyond the reach of many other crops. The amounts of nitrogen assimilated by the pea and similar plants on rather unfertile soils were frequently so out of proportion to the available supplies of nitrogen in these soils, that investigators have for years sought to determine whether or not these plants possessed the power of assimilating the free nitrogen of the atmosphere. The researches and experiments of a number of German investigators, extending over a long period of years, have at last shown that leguminous plants are capable of taking up and assimilating the nitrogen of the atmosphere, and this property is known to be dependent upon the presence of bacteria or minute microscopic forms of life, which are found in the tubercles or excrescences which occur quite profusely upon the roots of thrifty and vigorous plants of this character.

Certain particular bacteria are found to be peculiar to certain specific plants, and plants grown in a soil destitute of the organism peculiar to them, are observed to have few if any root tubercles.

By adding to the soil in question small amounts of soil from land on which similar plants are observed to develop root tubercles, it will be found that the plants grown on the former soil will also soon have tubercles formed upon their roots, and at the same time, the growth of the plants becomes vigorous and rapid. The presence of these bacteria in the tubercles of the roots of leguminous plants, in connection with the functions which the bacteria perform, constitutes an example of what is termed by scientists "*symbiosis*" (*life together*), the plant, itself, and these micro-organ-

isms being mutually dependent upon each other. Since nitrogen is the costliest form of plant food obtainable, and since many of the commercial forms of nitrogen are either inaccessible to, or beyond the means of, many of the farmers, it will be readily seen that this system of green manuring, which provides a means for the collection of this valuable element from the atmosphere and a medium through which it can be stored up for the use of subsequent crops, is of the highest importance and utility to the farmer. Experiments conducted at this station several years since, showed that a crop of pea vines, grown on a sandy loam, of only moderate fertility, contained the following amounts of phosphoric acid, potash and nitrogen (calculated from actual analyses) per acre.

	In vines.	In roots.	Total.	Value.
Phosphoric Acid	39.05 lb	6.90	45.95	$ 2 30
Potash	88.79 "	13.12	101.91	1 02
Nitrogen	115.54 "	7.70	123.24	21 56

The values are calculated according to our scale of fertilizer valuations, and it will be seen that the value of the nitrogen alone, exceeds that of a ton of ordinary complete fertilizer, while the nitrogen is equivalent in amount to that contained in 1750 pounds of cotton seed meal, though this crop was considerably above the average yield.

In addition to the advantages derived from turning under a crop which has a peculiar adaptability to securing plant food from the air, and from the soil and soil water, such a crop supplies an immense mass of organic matter to the soil.

This vegetable matter on oxidation and decomposition, gives off large amounts of gaseous matter of which carbonic acid forms the chief proportion, and this last substance is highly instrumental, especially when in a state of solution, in the breaking up and dissolving the chief constituents of the soil.

The organic matter is also the source of supply for large amounts of humus which is so essential to soils in promoting the absorption and retention of moisture, and in the improvement of the mechanical condition and physical characteristics of the soil.

Humus is a material of somewhat complex composition and is the result of the partial decomposition of organic matter (whether vegetable or animal) in the soil.

Its color varies from brown to black, owing to the stage of decomposition it has reached, and the dark color of our most fertile soils is due to the presence of considerable proportions of this substance.

Very light, quickly drained soils, to which the term "thirsty" is often applied, are especially benefited by the addition of large quantities of humus forming material, which enable the soil by its increased absorptive and retentive capacity to withstand drought much more readily.

It also improves to a marked degree the texture of stiff, difficulty tillable soils, enabling them to be worked more easily, at the same time that it permits of more thorough aeration by virtue of their increased porosity.

Gases, such as carbonic acid, are more readily retained, and in conjunction with the water with which they are brought in contact, render the solution of certain forms of plant food comparatively easy.

It is also a most important agent in effecting the decomposition and disintegration of the mineral constituents of the soil, and in supplying some of the conditions most essential to nitrification.

In addition to the cow pea, which is the favorite crop for plowing under in the South, the clovers and alfalfa (or lucerne) rank very high as crops adapted to green manuring.