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Fertilisers as an Aid to Profitable Farming.

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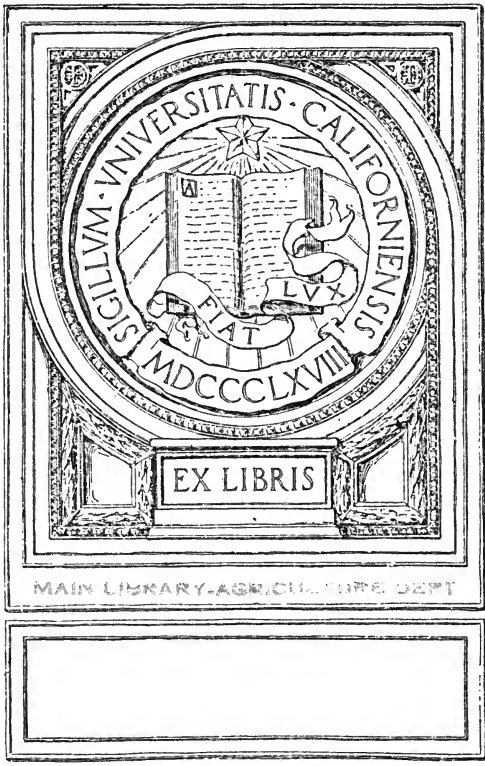


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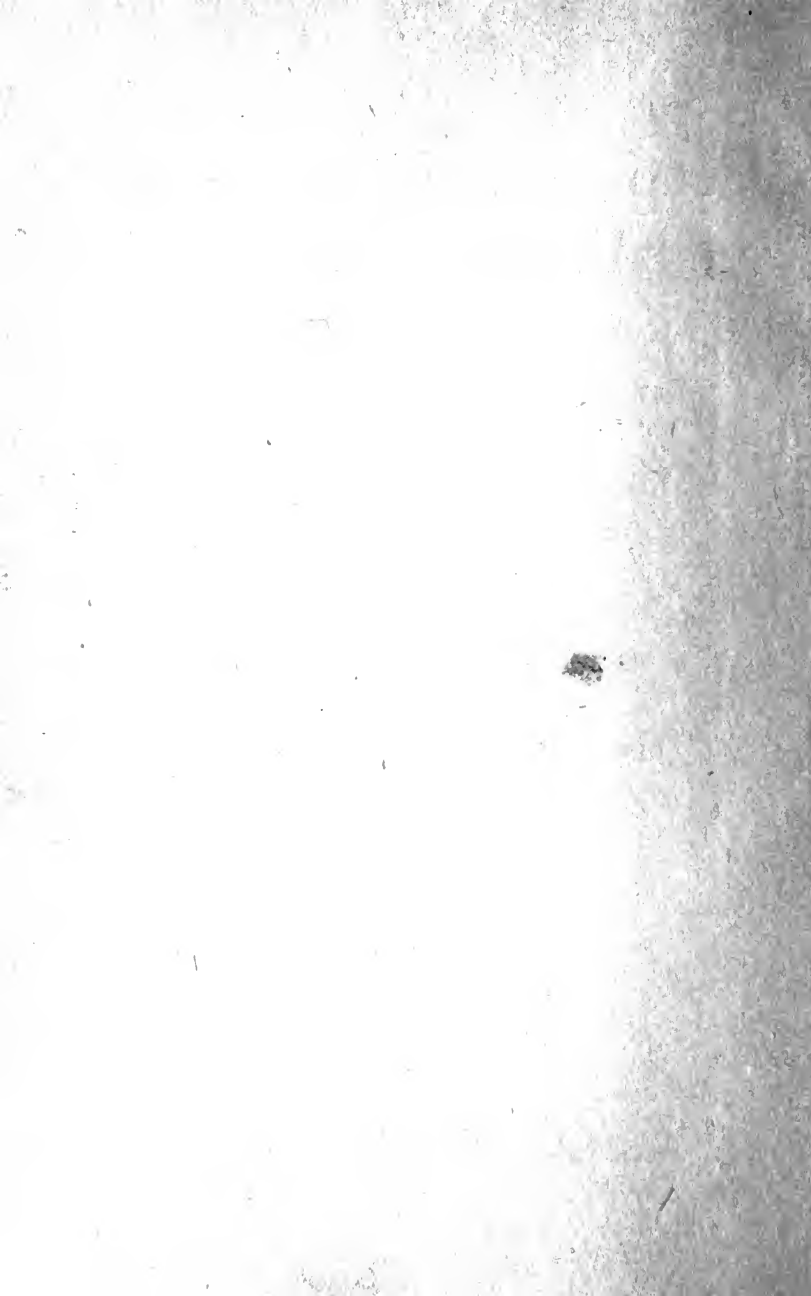




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Fertilisers as an Aid to Profitable Farming

Part I

(p. 3)

Elements of Plant Food:
Their Functions and Effects

Part II

(p. 32)

The Value of Experiments

Account, 2009 W



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Fertilisers as an Aid to Profitable Farming

“The more you give to a field the more it returns to you.”

—*Old Roman Maxim.*

PART I.

THE object of these pages is, by a simple statement of facts, to assist those engaged in Agriculture in the selection of suitable methods of manuring so that they may obtain the most profitable returns from their land.

It is not always the largest crops that are the most profitable. The cost of the manures employed may, through injudicious selection, be greater than the extra yield is worth. Artificial Manures, now popularly known as “Fertilisers,” must be used intelligently to secure the most economical results.

**Largest
crops not
always most
profitable.**

During recent years numerous recommendations have been published, indicating that successful farming can only be carried on by the use of certain incomplete fertilisers ; for example, by nitrogen in the form of nitrate of soda, sulphate of ammonia, or the newer forms derived from the air, by phosphates from basic slag, and so forth. Such statements only con-

fuse farmers, and have caused a widespread distrust of all fertilisers, a state of affairs which greater knowledge of the facts as demonstrated by scientific and reliable experiments can remedy with benefit to all concerned.

A large number of such experiments have been conducted during late years all over the United Kingdom under the careful supervision of well-known agricultural authorities, and these have confirmed, in a most conclusive manner, earlier trials made both here and abroad, the small variations being due principally to differences in soil, climate, and situation.

**Large profits
from use of
Fertilisers.**

These demonstrations have proved that crops can be vastly increased by the judicious use of fertilisers, and that this increase means a very large profit on the outlay. In fact, nothing pays the farmer so well as his manure bill!

All plants depend on certain substances for their proper growth. Many of these are nearly always present in the soil. There are others, however, which are always more or less deficient

**Necessary
Plant Foods.**

in an available form, and these plant foods, as they are called, are absolutely indispensable for perfect growth. These are known as Phosphoric Acid (which is the active principle in Phosphates), Nitrogen, Potash, and sometimes Lime. These must *all* be present in sufficient quantities for *all* crops. Should one or more be deficient, the amount of the crop will be limited by the essential element of plant food which is present

in the least abundance. No excess in the supply of any of the other plant food can possibly compensate for this deficiency. Thus, no excess of phosphates can atone for a deficiency in nitrogen, nor can an excess of nitrogen take the place of a lack of phosphates.

How to Supply these Plant Foods

Farm-yard manure, dung, or yard manure is a complete natural manure, containing nitrogen, phosphates, and potash, which are present in varying proportions according to the feeding and age of the animals producing it, as well as other conditions, the principal one being the care that has been taken of it.

**Farm-yard
Manure.**

But, though a complete manure, it is not a well-balanced one, as it is invariably richer in both nitrogen and potash than it is in phosphate, the latter substance being retained by the animals for the production of their bones, muscles, milk, &c. Farm-yard manure is comparatively poor in phosphates.

**Dung de-
ficient in
Phosphates.**

Moreover, it is a slow-acting manure; its effects are spread over a number of years. At the Rothamsted Experiment Station this is to be seen on the grass-land where farm-yard manure was applied regularly for some years, but for upwards of forty years afterwards, although it has received no farm-yard or any other manure, the effects are still visible.

The great value of farm-yard manure consists in its improvement of the texture or tilth of soils and in promoting their water-holding power, which enables crops to withstand drought much longer. In ordinary mixed farming it is best used on the roots, especially potatoes and mangels, in conjunction with suitable fertilisers, any that is left over being used on the young seeds in preference, or as a dressing every three or four years of the meadows, particularly those on light soil. If used more often it tends to encourage the coarser and less nutritious grasses.

Dung, beneficial effects.

Farm-yard manure should always form the basis of successful farm practice because it supplies humus or organic matter which is usually needed, but heavy dressings alone are not economical, though they may be all very well if manuring for a future generation. They neither yield such a large quantity nor as good quality of produce as when a medium dressing of farm-yard manure is supplemented with suitable fertilisers.

Nitrogen

This element stimulates growth, promoting the formation of leaves and stems. If an excess is present in the soil, that is when not balanced by sufficient phosphates and potash, it causes a late growth, thus retarding maturity and ripening, besides which it renders

Effects of Nitrogen on Plant growth.

the crop more susceptible to fungoid attacks and diseases of all kinds, as, for example, the disease of potatoes and rust in grain. It also favours the growth of straw, quite out of proportion to that of grain, so that lodging is induced.

Nitrogen is contained in nitrate of soda, sulphate of ammonia, and in the new forms derived from the air, by electrical processes; these are readily soluble in water. It is also contained, in organic form, in dried blood, meat meal, guanos, bones, rape, and other seed meals.

In nitrate of soda, the nitrogen being very soluble and quickly available, it acts almost at once, but as it is very soluble in water and held very loosely by the soil, especially light sandy ones, there is apt to be a considerable loss in wet seasons by drainage. It is advisable never to use it until the plants have their roots developed, so that they can assimilate it without delay. As a top dressing in the spring it is of great value.

**Nitrate of
Soda.**

Sulphate of ammonia is not so rapid in its action as nitrate of soda, as it has partly to undergo a change in the soil, which is known as nitrification, before it can be entirely assimilated by the roots, to which end the presence of carbonate of lime in the soil is absolutely necessary. Pending this change, which is a gradual one, sulphate of ammonia has the advantage of not being readily washed out of the soil and lost in the drainage water.

**Sulphate of
Ammonia.**

The continued use of either of these manures

in large quantities is liable to have an injurious effect on the texture of the soil. Nitrate of soda in large quantities causes heavy land to be wet and sticky, the only remedy against which is the application of acid fertilisers. Sulphate of ammonia causes a loss of carbonate of lime, which must be replaced, otherwise the land becomes acid in course of time.

**Injurious
effect on Soil
texture.**

There seems to be good reason to believe, from the careful experiments which are in progress, that the two new nitrogenous fertilisers obtained from the air, and known as Nitrolim and Nitrate of Lime, will prove to be valuable sources of nitrogen. It is to be hoped that, when they are manufactured in sufficient quantities, and further experiments have demonstrated their value, their production will steady the cost of nitrogen, which has always been liable to sudden and considerable fluctuations, nitrate of soda especially.

**Nitrogen
from the
Atmosphere.**

**Price fluc-
tuations.**

Nitrogen in organic form, contained in the substances already enumerated (dried blood, etc.), is more readily available than in dung, and, in fact, acts almost as quickly as in sulphate of ammonia. Organic nitrogen possesses unique and distinct advantages ; it adds humus and is held by the soil and assimilated by the plants as required ; there is no danger of its being washed away in the drainage water, which is a matter of

**Organic
Nitrogen.**

great importance should the season turn out wet, as nitrogen is the most expensive of the plant foods. Of still greater importance, however, is the manner in which organic nitrogen improves soil texture, instead of injuring it, the danger of which has already been indicated in the case of nitrate of soda and sulphate of ammonia.

**Organic
Nitrogen
improves
tilth.**

Mr. A. D. Hall, the talented director until recently of the renowned Rothamsted Experiment Station, states in his book, "Fertilisers and Manures" :— "The importance of this factor of tilth will be more realised when we remember that nearly the whole of the farmers' labour in spring is directed towards obtaining a fine seed-bed for such crops as barley and roots. Furthermore, if the weather conditions are adverse to the start of the crop, the eventual yield will depend more upon the condition of the seed-bed than upon any other factor. The potent effect of organic manures in promoting a good tilth is very clearly shown by the Rothamsted experiments upon Mangolds," and he goes on to say that "only in favourable seasons is what a farmer would call a good plant obtained on the nitrate and the ammonia plots, whereas the organic nitrogen plot starts regularly enough."

At Woburn Experimental Farm of the Royal Agricultural Society of England experiments extending over more than thirty years confirm these statements and have proved the marked advantages of organic nitrogen during a series of years on other crops as well.

The great value of organic nitrogen has not hitherto received at the hands of our agricultural authorities the appreciation due to it, or that it has received in other countries, where farmers use much larger quantities, drawing supplies from the United Kingdom, for which they are always willing to pay a higher price per unit than for either nitrate of soda or sulphate of ammonia. No doubt this want of appreciation is in part due to the demonstrations now being conducted all over this country, in which the nitrogen is invariably obtained in one or other of the soluble forms, usually sulphate of ammonia or nitrate of soda, mainly because of its uniform quality; whilst the equally valuable organic nitrogen is entirely neglected, though many practical farmers have long recognised its value, from their own experience.

**Unique value
of Organic
Nitrogen not
appreciated.**

It will thus be seen that, in our variable climate, it is never advisable to rely on one source alone for the nitrogen which crops require, but that it is much safer and more profitable in the long run to obtain it in forms of varying degrees of availability so that all through the periods of growth the plant receives a continuous supply of this element.

**Various
sources of
Nitrogen
advisable.**

Potash

Whilst all crops need potash, the systems of manuring practised here, by which the straw and

farm-yard manure are returned to the land, both of which contain appreciable quantities of this constituent, have to a large extent prevented such loss of potash as has occurred in other countries, so that heavy applications are generally neither necessary nor profitable. The most striking effect of potash manures is in increasing the production of starch and sugar, so that they are mainly of importance to potatoes and mangolds. Almost as important is their effect on grassland, where they encourage the leguminous plants (clover, &c.,) and sweeten the herbage of pastures.

**Effects of
Potash.**

On light soils, sandy and gravelly, also on chalk and peat, an application of potash will almost invariably do good. Strong clay soils are usually naturally rich in potash, and, though not always in an available form, this potash can to a large extent be set free by a moderate dressing of lime.

**Where
Potash is
most bene-
ficial.**

The forms in which potash is usually obtainable are sulphate and muriate of potash, the commercial grades of which contain about 50 per cent. of potash, and kainit, which contains about 12 per cent. of potash, together with about 30 to 35 per cent. of salt. It should be noted that these make a considerable demand upon the carbonate of lime present in the soil, more especially kainit and muriate of potash.

**Sources of
Potash.**

Phosphates

Phosphates are indispensable for successful farming. They are a necessity for the healthy development of all plants and animals. Phosphates are constantly being removed from the land in the grain and seeds, the bones, muscle and milk, therefore they must be replaced liberally if the crops and animals are not to suffer.

The effect of phosphate, the active principle of which is phosphoric acid, is the very opposite to that of nitrogen, an excess of which delays the maturing of crops. On the other hand, phosphate not only appreciably hastens ripening, which is of such vital importance, especially in wet seasons, but in the case of cereals it increases the yield and proportion of grain, and promotes a stiffer straw, so that the crops are less liable to lodge.

Furthermore, phosphates play a most important part in the early development and root growth of young plants. Observant farmers well know how superphosphate, or similar dissolved phosphates, give a good start to all crops, especially the shallow-rooted ones, and promote strong, healthy plants. The late Dr. Augustus Voelcker drew attention to the fact that the seeds of plants contain much phosphoric acid, whilst soils usually

**Phosphoric
Acid.**

of crops.

**Phosphates
hasten ripen-
ing, increase
Grain, stiffen
Straw.**

**Hasten early
development.**

**Strong
plants.**

contain but little. By placing available phosphates within the reach of young plants, we are simply acting on a hint given "by Nature, in the care she takes to provide young plants in their earliest periods of existence with a constituent which possesses so remarkable an effect in pushing on the young plants."

The three kinds of phosphates best known in agriculture are :

Insoluble phosphate, to which class the natural mineral phosphates belong. These are insoluble except in strong acids.

Citric soluble phosphate, which, though not soluble in water, is more or less available and assimilated by the plants in course of time. Basic slag, precipitated phosphate, steamed bone flour, undissolved bone phosphate are representative of this class.

Water-soluble phosphate, to which superphosphate, dissolved or vitriolated bones belong.

Phosphates are most advantageously supplied in the form of superphosphate, bones, either ground to powder (bone meal or steamed bone flour) or treated with acid (dissolved or vitriolated bones), and basic slag.

Basic Slag

Basic Slag is a by-product formed in the manufacture of steel from low-grade pig iron. The phosphates are in a form which, though insoluble in water, are largely soluble in a standard solu-

tion of citric acid which is presumed to represent the action of organic acids that may be present in the soil. As it is a by-product, its composition is variable, though good qualities will contain 38 per cent. or more of total phosphates, but by far the larger quantity is of lower grade. Slag is often sold as "80 per cent. soluble"; that is to say, 80 per cent. or four-fifths of the total phosphates is *soluble* in a standard solution

**Soluble
Phosphates
in Slag.**

of *citric acid*, but farmers must not be misled into thinking that this means *water-soluble* phosphate. The term

"Soluble Phosphate" has for more than half a century been understood to apply solely to the water-soluble phosphate in superphosphate and similar dissolved phosphates. "Eighty per cent. soluble" means that, presuming the basic slag contains 38 per cent. of total phosphates, only 30.40 per cent. of the phosphates would be in an available form. The efficiency of this fertiliser also depends on the "grist" or fineness of grinding, which should be such that 80 per cent. will pass through a standard sieve having 10,000 holes to the square inch.

It should be borne in mind that as basic slag is a very heavy material, its covering properties are not so great as a lighter or more bulky article.

There is a widespread notion that basic slag can be advantageously used to restore lime, and statements are habitually made that it contains 20 to 25 per cent. of caustic or free lime.

**Caustic
Lime in
Basic Slag.**

Such statements as these are misleading. Ex-

haustive investigations by such well-known agricultural chemists as Mr. John Hughes, a few years ago, and by Professor Hendrick, the chemist to the Highland and Agricultural Society, and more recently by Mr. Morison, at the Rothamsted Experiment Station, have demonstrated that the percentage of free or caustic lime in average British slags does not usually exceed 4 to 5 per cent. From this it is quite evident that whilst basic slag may be used beneficially on soils which are somewhat poor in carbonate of lime, it cannot possibly replace direct applications of lime when soils are in need of that element.

The principal value of basic slag lies in that it is an alkaline phosphate containing lime, and is most suitable for wet, sour soils rather deficient in lime. Such soils are also benefited by the application of bone meal, steamed bone flour, or precipitated phosphates.

On what
Soils to use
Slag.

Superphosphate

Superphosphate is the name applied to mineral phosphates (of which there are enormous natural deposits throughout the world) that have undergone a certain treatment with sulphuric acid, which transforms the insoluble phosphate of lime into a form which is soluble in water. According to the grade of mineral phosphate used, the resultant superphosphate ranges from 26 per cent. to as much as 38 per cent. water-

soluble phosphate ; that containing 35 per cent. soluble is about the highest grade generally used in this country. Whilst the higher grades are somewhat more costly to produce proportionately, this is generally more than compensated by the saving in carriage, cartage, and distribution, and the resulting delivered price per unit costs less than in the lower qualities.

High-Grade Superphosphate is well worth the attention of consumers. British people are generally credited with recognising the fact that it pays to buy the best quality obtainable when purchasing any article, and the same reasoning applies to the selection of fertilisers, whether superphosphate or any other kind.

It is an established fact that both water-soluble phosphates and those which are insoluble in water are taken up by plants, though the former are assimilated much more rapidly than the insoluble forms, which are of little value except on wet soils deficient in lime or of an acid nature. On normal soils, or soils containing a fair average amount of lime, water-soluble phosphate is alone of practical financial value.

Water-Soluble Phosphates are preferable.

When superphosphate is applied, the first rainfall, even a heavy dew or the natural moisture in the soil, dissolves the water-soluble phosphate and causes it to soak into the earth, where it is arrested in a very finely divided condition and thoroughly disseminated throughout the soil. It is in a far finer state of division

than it could ever be possible to grind it by mechanical means. Phosphates which are insoluble in water, such as slag and mineral phosphates, however finely ground, will not compare with the state of chemical division obtained by dissolving phosphates with acid. As the former are incapable of being thoroughly disseminated in the soil, and because of their insolubility, the beneficial action of these phosphates is comparatively slow.

Mr. A. D. Hall, on page 150 of his book already cited, states :—“ The essential condition that should dictate the choice of superphosphate as a fertiliser, is the presence of sufficient carbonate of lime in the soil to ensure the precipitation of the soluble phosphoric acid as a calcium compound. Experience has shown that the extra price of the unit of phosphoric acid in its soluble form in superphosphate is more than justified by its superior effectiveness, which is due to the rapidity with which it becomes disseminated in a finely divided condition in the soil, immediately near the roots of the crops.”

**Extra cost
of Soluble
Phosphate
more than
justified.**

With such a weighty pronouncement as this, it must be perfectly evident that water-soluble phosphate is vastly superior and better value than any other form. All that is needful to obtain the most profitable returns is to see that the soil is not deficient in carbonate of lime, and, if it should need it, to apply it without delay, as described later.

Whether phosphates are supplied to the soil in a water-soluble form or otherwise, they do not leach or wash away in the drainage water like nitrates, but are retained in the soil. The researches of Way, Voelcker, and, more recently, Dyer on Rothamsted soils, which had been receiving as much as $3\frac{1}{2}$ cwts. of high grade superphosphate for very many years, have proved most conclusively that the unconsumed phosphoric acid was practically all retained in the surface soil to the depth of 9 inches, and was also in such a form as could be readily assimilated by the plant roots. From this it is abundantly evident that an excess of phosphates can do no possible harm to the crops and is never wasted. Moreover, it also shows that superphosphate can be advantageously applied much earlier than is generally done; in fact, if applied in the autumn, when there is usually sufficient rain to dissolve and distribute it thoroughly, better results are likely to follow than when applied late in spring.

In addition to water-soluble phosphate, superphosphates always contain some citric soluble phosphate, approximately 1 to 2 per cent., sometimes even more, which is just as valuable as the "soluble" phosphate in basic slag. It is not generally known that this is not taken into account by the manufacturers in fixing the price of superphosphate, so that our farmers unwittingly get the benefit of it, though in other countries its value is recognised.

Lime

The use of lime as such, or as carbonate of lime (chalk, &c.), in agriculture, dates from a very early period, and its utility has been recognised in almost every country. In former times it was customary to apply very large dressings at long intervals, but this method has been found to have rather an injurious effect during the first year or more after application, and smaller dressings at shorter intervals have been proved to be far more beneficial.

Some of the benefits to be derived from the presence of carbonate of lime in the soil are :—

1. It promotes the decomposition of humus or organic matter in the soil, rendering it available as plant food.
2. It corrects sourness and improves the quality of herbage.
3. It hastens the processes of nitrification.
4. It assists the liberation of potash and other plant food from the dormant ingredients in the soil.
5. It improves the physical character of soil, rendering heavy clay soils porous, friable and drier, and making light, sandy, and gravelly ones more compact.
6. It promotes healthy growth. "Finger and toe," and other fungoid diseases, are very rarely, if ever, found on soil well supplied with carbonate of lime, and should these exist, they can be eradicated by a thorough liming.

7. Without sufficient lime in the soil, chemical fertilisers, which are the mainstay of profitable cultivation, cannot exert their full benefit.

When a soil contains less than 1 per cent. of carbonate of lime in the surface soil, it is getting near danger point, and will be greatly benefited by "liming."

**Soils needing
Lime**

The actual percentage is easily ascertained by a chemical analysis, which every farmer who is in doubt should have made; they are now so inexpensive as to be within the reach of all. The presence of certain plants or weeds also denotes the deficiency of lime, as, for instance, spurrey, sorrel, corn marigold, the foxglove, bracken, heather, and gorse, also the absence of leguminous herbage in the pastures.

Lime can now be readily obtained in the form of powder, either as ground freshly burnt lime, or as carbonate of lime (ground limestone or chalk), to which state burnt or caustic lime reverts in the

**Ground
Lime.**

soil. Ground lime is to be preferred on all clay soils or damp sour land, applied at the rate of 8 to 10 cwts. per acre, which will usually be found sufficient for four or five years. On

**Limestone
Chalk, Marl.**

the lighter soils, such as sands and gravels, finely ground limestone, chalk, or marl, should be used in preference, as they are milder in their action. Of the two former, double the quantity will be necessary, as they are only equivalent chemically to about half their weight of caustic lime, or about 1 ton

per acre every four or five years, but the cost of these materials per ton should be less than one-half that of ground lime. Of marl, from 2 to 5 tons per acre should be applied according to the quantity of carbonate of lime which it contains.

In whatever form lime is used, it should be applied in the autumn or early winter. As it sinks in the soil it should never be ploughed in on arable land; it will travel downward quite fast enough without the plough. It is always preferable to plough the farm-yard manure into the land first, then, after a few days, to spread the lime on the surface and harrow it in.

It has to be borne in mind that though lime has the power of rendering available the dormant plant food in the soil it is not in itself a plant nutrient. Unless the supply of phosphate, nitrogen and potash is provided by adequate manuring, the ultimate effect of applications of lime alone is to impoverish the land.

In addition to the fertilisers already mentioned, containing only one element of plant food, there are a few which combine two of them, as, for example, Nitrogen with Phosphates and Potash with Phosphates.

Nitrogen and Phosphate

In this class are to be found raw bones, in the various well-known forms of bone meal, steamed or boiled bone meal or flour, and dissolved bones, in which the bone has undergone

treatment with sulphuric acid, which fixes the nitrogen and renders water-soluble a considerable portion of the otherwise more slowly available bone phosphates. Steamed or boiled bone flour contains much less nitrogen, but considerably more phosphates than ordinary bone meal, and in a finer state of division.

On light, sandy soils and gravels the readily available neutral bone phosphates may be relied upon to give the best results, and should always form part of a complete manure for crops thereon, if the land has not been "limed" within recent years.

Potash and Phosphate

Most farmers will be familiar with the recommendations often made as to the mixing of phosphates and potash salts for certain crops and soils, coupled with the warning that the mixture should be distributed as soon as possible after being made, as otherwise it will be in an objectionable or unsowable condition. A new fertiliser has recently been placed upon the market, known as *Potassic Superphosphate*, which presents potash and phosphates combined in the form of a dry powder, and entirely avoids these objections. It should always contain at least 23 per cent. of water-soluble phosphate with 4 per cent. of potash. Owing to the intimate combination of the potash and soluble phosphate in this fertiliser, its beneficial effects are more rapid and effective than when these

elements are applied separately, and Potassic Superphosphate should always be preferred where the indications are that soils or crops will be benefited by an addition of these two elements only.

Complete Fertilisers

Complete Fertilisers is the name applied to those fertilisers which contain all three of the principal elements of plant food, viz., Nitrogen, Phosphate, and Potash, in varying proportions and degrees of availability obtained from those different sources which long experience has proved to be most suitable for the requirements of individual crops, giving due consideration to the soil, climate, and rainfall.

Experiments or demonstrations conducted year after year by our agricultural colleges, county instructors, and others all over the United Kingdom, show conclusively that the most profitable results invariably follow the use of Complete Fertilisers.

Complete Fertilisers most profitable.

It is, however, claimed that the cost of mixed Complete Fertilisers is usually excessive, and that farmers would save money and consult their best interests by buying the separate materials and mixing them together on the farm.

Alleged Excessive Cost of Complete Fertilisers.

From a purely theoretical standpoint it is a

very simple matter to take as a basis one of the price lists to be found in the agricultural journals, and calculate therefrom the cost at which certain mixtures could be made, employing the cheapest materials. One fact appears to be overlooked: the figures so obtained merely show the cost of the amounts of nitrogen, soluble or other phosphate and potash when purchased in the form of unmixed raw materials at one or other of our largest seaports or trade centres. The expense incurred for railway or other carriage, crushing or grinding and mixing the material, loss in weight, is left entirely out of consideration in the comparison, though it has to be paid for whether at the farm or factory.

It has already been shown that the elements of plant food are present in different ingredients, in varying forms of availability, and that it is not good policy in every case to rely on one single source. Nitrogen, in some sources, is very soluble in water, and quick acting, whilst in others it is not so; the same applies to phosphates, whilst potash in some combinations is far inferior to others on certain crops.

Every practical agriculturist will agree that a combination of different forms is far more likely to produce the most profitable results, especially as it is impossible to forecast the probable weather during the growing season. In agriculture one must always prepare for eventualities.

But having decided to adopt the recommenda-

tion as to mixing a fertiliser on the farm, and procured the materials in proper proportions, now comes the actual process. From the usual instructions it appears such a simple matter.

**Mixing
Fertilisers
on Farm.**

Empty out the materials from the bags, turn them over thoroughly three or four times, crush any (?) lumps, mix, put through a *half-inch mesh* sieve or screen, and, after all this labour—for it is labour, and we speak from actual experience—what is the result? A coarse-grained, unsatisfactory mixture, which spreads badly, giving too much nitrogen in one place, and too little in another, and the same with both phosphates and potash, the resulting crop being irregular and patchy. A properly manufactured complete fertiliser has many more times the covering power, because it is in a fine-grained homogeneous powder, the result of the grinding it gets by the powerful machinery of the factory, so that it may pass through a sieve of *one-eighth inch mesh*, not one of *one-half inch mesh*. Of a large number of samples of compound fertilisers selected at random from factories all over the United Kingdom, 95.50 per cent. of the material passed through a one-eighth inch mesh sieve.

**Greater
covering
power.
Regular
Crops.**

Just consider what this means in grains of fertiliser per acre when a half-inch mesh equals 5,184 holes per square yard, whereas one-eighth inch mesh equals no less than 82,944 holes per

square yard! Five cwt. of fertiliser per acre only amounts to about *one grain* of fertiliser to every *pound* of soil to the depth of nine inches.

The great importance of "good mechanical condition for equal distribution" is pointed out in leaflet No. 80 of the Board of Agriculture and Fisheries, where it is described as of "hardly less importance than the selection of manure."

**Good
condition
essential.**

This is borne out by a manurial trial conducted at the farm of the Harper-Adams Agricultural College in Shropshire, during the four years 1909 to 1912 inclusive, when factory-made potassic superphosphate compared with equal quantities of phosphate and potash applied in the form of superphosphate and kainit, showed a consistent yearly increase of hay averaging three cwt. per acre in favour of the factory-prepared fertiliser, which much more than repaid its slightly higher cost.

Items of expense which are incurred, but which are not usually considered, are the labour involved in mixing and crushing the lumps, the wear and tear of implements, and the loss in weight arising from material which is absorbed by, or clings to, the sacks, no matter how well cleaned, and the loss by the chemical action induced. It would be an object lesson and an unwelcome surprise to any one who mixes four or five tons of bagged materials, and then has the resultant mixture very carefully weighed after the operation, to realise what is the extent of this loss.

**Is money
really saved?**

Again, in practically all of these crudely made farm mixtures a certain amount of chemical action is set up, hence the prescription usually states that the mixture must be "applied immediately," or certain ingredients "must not be mixed." In chemically compounded, factory-made fertilisers all this chemical reaction has taken place long before they are sent out. There is no question that even if there is any money saved in mixing fertilisers on the farm, which is more than doubtful, more money is lost by the inferior or smaller crop which results from the use of these imperfectly mixed, badly conditioned preparations.

It is just about as reasonable for a farmer to think that he can make an equally effective and cheaper mixture from the coarse ingredients by hand as efficiently as can be done by the manufacturer with the elaborate machinery and all the facilities at his disposal, as for him to believe that he can grind the wheat he produces into flour cheaper and better than the miller with his up-to-date machinery.

There is no difficulty in these days about farmers obtaining far more satisfactorily mixed complete fertilisers, prepared from high-class suitable materials, from any of the well-known large manufacturers, at as low, and even lower, prices than they could properly mix fertilisers of similar quality themselves.

Commercial Valuations do not indicate Agricultural Value

The one is determined by the law of supply and demand, the other by soil, crop, and climatic conditions. Take, for example, the most active nitrogenous fertilisers, nitrate of soda and sulphate of ammonia; one would suppose that the unit price would be higher than in the slower acting forms of organic nitrogen, such as dried blood, whereas the contrary is actually the case. This is the result of years of practical experience by which farmers all over the world have realised its greater agricultural value, and are prepared to pay higher prices, so as to obtain the limited supplies available. The unit of nitrogen in sulphate of ammonia is generally the lowest in price, that in nitrate of soda costing somewhat more, whilst organic nitrogen in good available forms is still more costly. It is thus obvious how very unreasonable it is to base the valuation of fertilisers, so far as nitrogen is concerned, on the cost of its lowest source. To be correct, an average must be taken, and a difficulty lies in the constant and sometimes considerable fluctuations which occur in the cost of nitrogenous materials. This does not apply, however, with so much force in the case of phosphates and potash.

**Valuation of
Fertilisers.**

**Difficulties of
close values.**

The intelligent farmer buys fertiliser in order to obtain available plant food, not a large bulk of material irrespective of the amount and

quality of the plant food which it contains. Low-grade fertilisers are often made from inferior materials, whereas high-grade fertilisers *must* be prepared from the very best class of materials.

It is very poor judgment to buy a fertiliser because it costs comparatively little per ton unless it contains a fair value of plant foods. To estimate this is unfortunately not generally so well understood as it should be. The manner in which an analysis is stated is apt to mystify, because it is customary to describe a fertiliser as containing so much per cent. or units of soluble phosphate, nitrogen, and so forth, but it is often not understood by the farmer that this simply means pounds per hundred.

For example, compare a ton of low-grade fertiliser which is offered for, say, £3 10s. od. per ton delivered, and analyses 1.25 per cent. nitrogen and 8 per cent. total phosphate, with one ton of high-grade fertiliser offered for say £6 per ton analysing 2.50 per cent. nitrogen, 16 per cent. soluble phosphate, 3 per cent. undissolved bone phosphate and 3 per cent. of potash. It will be seen that the latter contains twice as much nitrogen, nearly two and a half times as much phosphates, and in more soluble form as does the low-grade fertiliser, and potash in addition, making a complete fertiliser. Nevertheless the farmer who buys on the ton basis or is guided only by the price per ton will be induced to purchase the low-grade because he apparently saves £2 10s. od. per ton. The farmer, however, who studies the relation of pounds of plant food

per ton to selling price will purchase the high-grade because he finds from a simple calculation that about $7\frac{1}{2}$ cwt. of it contains as much plant food and of superior value to that contained in one ton of the low-grade fertiliser.

Briefly it stands thus :—

	£	s.	d.
The Farmer who buys 1 ton low-grade Fertiliser			
pays	3	10	0
The Farmer who buys $7\frac{1}{2}$ cwt. High-Grade Fertiliser at £6 per ton pays	2	5	0
And saves	£1	5	0

Notwithstanding the educational efforts that have been put forth by agricultural societies and others, for many years, and more recently by the Board of Agriculture, the sale of fertilisers containing extremely low percentages of phosphates and nitrogen, at prices far beyond the commercial value of the plant food supplied, appears to flourish as much as ever. There is no excuse for this in these days. The trade in fertilisers is regulated by The Fertiliser and Feeding Stuffs Act of 1906, which requires that the sellers shall, amongst other things, declare the percentages, if any, of nitrogen, phosphates, and potash in the article. With this information before him, it is a simple matter for the farmer to calculate the approximate commercial value of what is offered to him before purchase, and see if the price is reasonable.

It is generally most profitable to employ

Concentrated Fertilisers

because it costs no more to grind, compound,

bag, transport and sell one ton of high-grade fertiliser than it does a low-grade one containing perhaps less than one-half the quantity of plant food. Moreover, superior crop results are obtained from the use of a complete fertiliser of suitable composition for each particular crop, &c.

Manuring of General Farm Crops

It will already be clear that whilst a combination of phosphates, nitrogen, and potash is necessary for the profitable growth of all crops, it must be borne in mind that these are required in varying proportions according to the dominant or principal element demanded by each particular crop.

As certain important factors must be taken into consideration, such as variations of soil, climate, rainfall, &c., it is practically impossible to lay down any hard and fast rules as to the best fertiliser or combination of fertiliser to use in each particular case. The most that can be done is to show the results of independent experiments and observations in different parts of the country, modifications of which can be adapted by practical men as most suitable to their individual circumstances, always bearing in mind that whatever the crop and wherever it is grown, it will require the same elements of plant food and in the same proportions.

PART II

Large profits obtainable by the judicious use of suitable fertilisers as proved by authentic records of independent manurial trials on farm crops.

Wheat

In former years it was customary in the great corn-growing districts of England to apply a dressing of fertiliser in the autumn, just before sowing, because it paid a handsome profit on the outlay. There is every reason to suppose it would pay as well now, as fertilisers are sold at about half the cost of those days.

Wheat generally follows clover "leys" or "seeds" or a root crop. If these have not been previously heavily dunged, or if the land has lain fallow, it is usual to plough in a dressing of farm-yard manure. In practice it is found that the addition of 2 to 3 cwt. of high-grade superphosphate or dissolved bones per acre before sowing is most beneficial and strengthens the plant, enabling it to withstand better a hard winter.

In the early spring, if the crop should appear backward, a top dressing of one of the quick-acting nitrogenous fertilisers (preferably nitrate of soda or nitrate of lime) will be found very advantageous, of which there is abundant evidence on record.

The following are a few recorded results on poor heavy land. Returns per acre :—

No Manure	... ..	gave 15 bus. Wheat and 15 cwt. Straw.
Dissolved Bones in autumn and Nitrate Soda in the spring	... ..	„ 38 „, Wheat „ 23 „, Straw.

Again, on an average of twenty years—

No Manure	... ..	gave 22 bus. Wheat and 18 $\frac{3}{4}$ cwt. Straw.
Superphosphate in autumn and Nitrate Soda in spring	... ..	„ 36 „, Wheat „ 30 „, Straw.

These figures show very conclusively that the clear profit from the increased crop must be considerably more than 150 per cent. on the outlay for fertilisers.

The Cambridge University Department of Agriculture, in conjunction with the East Suffolk County Education Committee, conducted experiments for eight years on poor clay land at Saxmundham, and in their report, dated October 1908, it is stated, “The most useful information these trials give is the wonderful efficacy of phosphatic manures. Superphosphate, compared with no manure, gave a gross return due to the Phosphatic manure of £1. 9s. per acre, and as this was obtained with a dressing costing less than 8s. per acre, it is highly remunerative. Superphosphate stands at the head of the list.”

**260 per cent.
profit on
outlay.**

Sometimes a second wheat crop is taken without dunging, in which case it is preferable to use a complete fertiliser or a larger quantity of dissolved bones.

At both Rothamsted Experimental Station

and Woburn Experimental Farm the demonstrations, which extend over many years, show that in each case complete manurings with phosphates, nitrogen, and potash are to be preferred.

Rothamsted,
Woburn.

The heavier soils on which wheat is preferably grown usually contain sufficient potash for the needs of this crop, therefore a dressing of superphosphate or dissolved bone in the autumn, costing about 10s. to 15s. per acre, is all that may be necessary. But if the soil is of a lighter description, potash may be deficient, and it would be preferable to employ about four cwts. of potassic superphosphate instead. As already indicated, a top dressing of nitrogenous fertiliser may be advisable in the spring.

An excellent course to adopt when a wet autumn has rendered it impossible to apply the fertiliser at the proper time, is to give a top dressing in the early winter or spring with a Complete Fertiliser containing :—

Soluble Phosphate	...	...	...	...	16'00 per cent.
Citric Soluble Phosphate	...	...	...	...	2'00 ,,
Nitrogen	...	...	...	...	5'00 ,,
Equal to Ammonia	...	...	...	...	6'00 ,,
Potash K_2O	...	...	..	...	2'00 ,,

Very satisfactory results have been recorded.

It is important to bear in mind that in wheat, as well as all other crops of cereals, a liberal and easily obtainable supply of phosphate near the roots has the effect of promoting not only earlier ripening and harvesting but also of strengthening the straw, so that there is very much less liability

Early ripen-
ing, stiff
Straw.

of "lodging." Phosphates are indispensable for the production of grain, increasing both the quantity and weight per bushel, besides improving the quality.

Barley

Barley, especially the finer malting varieties, must be grown on soils in which there is rather a low percentage of nitrogen, and fertilisers containing much of this element should be avoided if really fine quality is desired. Phosphates are the most essential element for this crop, and when barley follows roots which have been well manured with farm-yard manure, or which have been fed off, 3 to 4 cwts. superphosphate per acre (or if the soil should be very light, 3 to 4 cwts. potassic superphosphate instead) will be all the fertiliser needed, and will correct any excess of nitrogen.

**Fertilisers
for malting
Barley.**

If the land is not in high condition or on lighter varieties of soils, especially where the finest qualities of barley are not to be obtained, the manure may either consist of 3 cwts. per acre of pure dissolved bones, as recommended by the Board of Agriculture and Fisheries, applied with the seed, or a complete fertiliser.

**Fertilisers
for Light
Soils and
Ordinary
Barley.**

The University of Leeds has been conducting demonstrations for four years with various fertilisers on a variety of suitable soils, and

a complete fertiliser, supplying about 16 lbs. nitrogen, 70 lbs. soluble phosphate, and 25 lbs. potash per acre, has proved invariably most profitable, as witness these average figures for the manured plots over those with no manure.

**Yorkshire
Demonstrations.**

Gain in Saleable Grain, $8\frac{1}{2}$ bushels per acre.

„ Straw 9 cwts. „

which gives a clear profit of £1. 6s. 6d. per acre per year, after paying for the manure.

**More than
100 per cent.
clear profit
on outlay.**

The West of Scotland Agricultural College have conducted similar experiments on light loam, and record an

Increase in Grain of $11\frac{1}{2}$ bushels per acre.

„ Straw of 12 cwts. „

showing a *clear profit of £1. 8s. 8d. per acre*, after paying for the fertiliser.

Further confirmation is afforded by the manurial trials conducted at the **Shropshire.** Harper-Adams College Farm during the three years 1909 to 1911, where a complete manure supplying 110 lbs. soluble phosphate, 16 lbs. nitrogen and 10 lbs. potash on light loam, gave the following very profitable returns :—

Increase in Grain of 11 bushels per acre.

„ Straw of $7\frac{1}{2}$ cwt. „

According to Mr. A. D. Hall, the question of potash for barley of high quality is doubtful. In his book “Fertilisers and Manures” he says :—“While potash manures have been found to stiffen the straw and increase the size of the

**High Grade
Malting
Barley.**

berry by promoting starch formation, they also prolong the maturity of the barley and darken its colour slightly. Hence, potash manures must be used carefully and are only likely to be valuable on light, sandy or gravelly soils."

Oats

The manurial requirements of this crop are similar to those of barley, except that it is unnecessary to be so careful as to the presence of nitrogen, for fear of injuring the quality of the grain, and also that potash is not of so great importance owing to the short time this crop is on the land. Dissolved bones or bone compound at the rate of 3 or 4 cwts. per acre are found very efficacious for this crop. Should the land be in poor condition, 2 to 3 cwts. of superphosphate per acre at sowing, followed by a top dressing of 1 cwt. sulphate of ammonia on wet soils, or its equivalent (about $1\frac{1}{4}$ cwt.) of nitrate of soda on lighter soils, will be found of considerable advantage and profit.

Fertilisers for Oats.

Numerous experiments have been conducted for some years in Scotland and Lancashire by the West of Scotland Agricultural College and the Lancashire County Education Committee respectively at their farms, and these have demonstrated that oats which have been manured following seeds have given such an increase over unmanured as to yield the very handsome profit

of 37s. 10d. to 49s. per acre per year, after paying for the fertiliser, when a complete fertiliser, supplying about 20 lbs. nitrogen, 70 lbs. soluble phosphate, and 20 lbs. potash per acre was used.

It will thus be recognised that the practice of manuring Oats after "seeds" is decidedly profitable.

Swedes and Turnips

These crops occupy a very large proportion of our arable land every year, the average crop during the last ten years, according to the Government returns, being about 14 tons per acre. There is no question but that this could be largely increased by judicious manuring to manifest advantage. A most important consideration is the quantity of farm-yard manure that is available for this crop, and if there is a sufficiency of good quality and it is supplemented by a soluble phosphatic fertiliser, such as superphosphate, dissolved bones, &c., when seeding, a large and paying increase can always be depended upon.

The Rothamsted and other investigations have proved beyond the shadow of a doubt that phosphates, either mineral or bone, are the most important factor. Swedes and turnips must be liberally supplied with easily available phosphates, which promote a rapid and uniform growth, and enable the young plants better to escape the "fly" and mildew.

**Available
Phosphates
a paramount
necessity**

I. WHEN GROWN WITH DUNG.

If 10 or 12 tons of farm-yard manure per acre are obtainable, it is very seldom necessary to do more than apply about 4 cwts. per acre of high-grade superphosphate in addition at seeding, or proportionately larger quantities of the lower grades, except, perhaps, in the case of very light sandy soil, where 5 to 6 cwts. of potassic superphosphate might be used advantageously instead. By such a method a far more profitable return will be obtained than by using double the quantity of farm-yard manure alone.

In support of this statement the following figures are interesting.

The Irish Department of Agriculture, whose experiments have been conducted on more than 200 farm centres in every county during ten years, show :—

An example from Ireland

	No Manure	Farm-yard Manure, 20 Tons per Acre.	10 Tons Farm-yard Manure and 4 Cwts. Superphosphate.
	Tons. Cwts. Qrs.	Tons. Cwts. Qrs.	Tons. Cwts. Qrs.
Crop per acre ...	6 6 0	23 1 0	23 16 0
Average Annual Profit per acre after paying for Manure ...	...	£ s. d. 2 13 6	£ s. d. 4 6 10

Turnips valued at 8s. per Ton.
Farm-yard Manure, 4s. per Ton.

Regarding the above, it is stated in the official *Journal* for 1912 :—“ There seems little doubt therefore that where farm-yard manure is

scarce, farmers may rely upon obtaining a perfectly satisfactory crop of turnips by using a lighter dressing of dung and supplementing it with an application of about 4 cwt. superphosphate per acre.

“The results confirm those obtained in previous years, and they indicate that while a somewhat heavier crop may be obtained by the addition of 1 cwt. sulphate of ammonia and 3 cwt. of kainit to the standard dressing of 10 tons dung and 4 cwt. superphosphate per statute acre, the increased yield is produced at too great a cost to be profitable.

“As a general rule, when farm-yard manure is applied to land in good condition, nitrogenous and potassic manures are not required by the turnip crop; on land, however, which is naturally poor, or in low condition, it is probable that such manures will pay for their application.”

Similar trials have been conducted in Durham, by the Armstrong College, Newcastle-on-Tyne, and in Gloucestershire, under control of the County Director of Agriculture, and the results confirm the efficacy of the method of manuring just described.

Durham,
Gloucester-
shire.

II. LARGE TURNIP CROPS WITHOUT DUNG.

In some parts of the Kingdom, for various reasons, principally that of short supply of farm-yard manure, Swedes and Turnips have to be grown with a very light dressing of dung, and sometimes even with none at all. It is impor-

tant to know that as large, early, and as healthy crops can be grown as profitably with suitable mixtures, or complete fertilisers alone, as is shown by the following records.

The Midland Agricultural and Dairy College have conducted trials during six years, at twenty-five farm centres and on a variety of soils in the counties of Leicester, Lincoln, Notts, and Derby, and the following are the average returns per acre per annum :—

An example from the Midlands.

	Tons.	Cwts.	Qrs.
With no Manure	10	15	1
With a Complete Manure, supplying 130 lbs. soluble phosphate, 30 lbs. nitrogen, and 30 lbs. potash per acre	18	9	1
Gain over no Manure	<u>£7</u>	<u>14</u>	<u>0</u>
Increased annual Profit per acre after paying for all Fertilisers	<u>£2</u>	<u>0</u>	<u>6</u>

In the official report of this College for 1908 there occurs this statement :—“ Superphosphate has given greater profit during the last five years than Basic Slag.”

The Devonshire County Education Committee conducted trials at several centres during two years, and the following were the results from the best combination :—

Devonshire results.

	Tons.	Cwts.
No Manure applied	9	16
A Complete Manure, supplying 150 lbs. soluble phosphates, 20 lbs. nitrogen, and 40 lbs. potash per acre	20	3
Gain over no Manure	<u>10</u>	<u>7</u>
Increased annual Profit per acre after paying for all Fertilisers	<u>£2</u>	<u>8 9</u>

The Department of Agriculture, Ireland, conducted trials at numerous farm centres without any farm-yard manure, and give the following figures in their official *Journal* as the average of six years, 1906—1911, for the most profitable combination per acre :—

**More Irish
Examples.**

				Tons.	Cwts.	Qrs.
With no Manure	... ..	per acre	5	3	2	
With a Complete Manure similar to that applied in Devonshire	... ..	„	22	1	2	
Gain over no Manure	... ..	„	16	18	0	
Annual Profit per acre after paying for Fertilisers	... ..		£5	1	2	

“ The inference to be drawn from these figures is that when farm-yard manure is not applied more satisfactory returns, both as to yield of crop and as to profit, are likely to be obtained from the use of a complete mixture of manures than from the use of an incomplete mixture.”

These results are confirmed in a striking manner by the important trials carried out by the West of Scotland Agricultural College during 1904, 1905 and 1906 on no less than thirty-eight farm centres in different Scottish counties, and on a great variety of soils. The best combination or mixture supplied similar quantities of nitrogen and potash per acre, but rather more soluble phosphates than that which did best in Devon and Ireland. The average yearly swede crop, comparing “no manure” with the combination, was :—

**Important
Scottish
Demonstra-
tions—
Turnips.**

	Tons.	Cwts.	Qrs.
No Manure	10	16	3
A Complete Manure supplying 200 lbs. soluble phosphate, 20 lbs. nitrogen, and 40 lbs. potash per acre	24	1	1
Gain over no Manure	<u>13</u>	<u>4</u>	<u>2</u>
Increased annual Profit per acre after paying for Fertilisers	<u>£3</u>	<u>12</u>	<u>2</u>

With regard to these trials reported in *Bulletin* 37 of the College, the following statement occurs:—"In both seasons it was found, as in former experiments, that superphosphate could be relied on, as a rule, to produce larger crops of turnips than basic slag."

The outstanding feature of all these figures is the great importance of a liberal supply of available phosphate in the soil. Turnips respond liberally to large dressings of phosphates.

More Phosphates mean more Turnips.

Attention was called on a previous page to the fact that the average ten years' crop of Swedes and Turnips was about 14 tons per acre. The average of the experiments quoted in Great Britain, where a judicious system of manuring has been adopted, is increased to about 20 tons 10 cwts. per acre. Consider for one moment what an increase of 50 per cent. in the crop from the same acreage would mean in the way of profit to each individual farmer and the country in general.

Crop possibilities.

Swedes and Turnips, as is well known, are

liable to attacks of the disease called "finger and toe," "canker," or "anbury," but which is practically unknown on soils containing an appreciable amount of carbonate of lime.

"Finger and Toe."

To avert this disease, when soils are known to be deficient in lime, it is advisable to apply it beforehand in one or other of the forms already indicated (see Lime, p. 20). If Turnips, rather than Mangolds, must be sown, only the hardier types of Swedes should be seeded.

Fine bone meal or steamed bone flour have been found efficacious in warding off attacks of this disease, so that it is advisable, unless a liberal dressing of lime has been applied, to derive some of the phosphates from one or other of these neutral sources, and include same in the mixture of a complete fertiliser.

An interesting experiment was carried out by the County of Devon Agricultural Committee in 1910 as to the best manurial methods to adopt for Swedes grown on soils deficient in lime and subject to "finger and toe" disease.

Importance of Lime.

Speaking of the trial in question, the report of the Committee states :—

"The experiment was carried out on a poor type of land on the south-west border of Dartmoor. The soil is derived from the lower carboniferous shale.

"Both the results of the field experiment and the analysis of the soil show the need of phosphate and the lack of carbonate of lime

The turnips on the unlimed area were affected with 'finger and toe' disease.

"The limed area received ground lime at the rate of half a ton to the acre."

In each trial the amount of potash and nitrogen per acre and method of application were similar. The results were:—

	With Lime.		Without Lime.	
	Tons.	Cwt.	Tons.	Cwt.
4½ cwt. Superphosphate per acre gave...	24	4	15	14
6 ,, Basic Slag per acre gave ...	19	4	20	5

The part of the field which received water-soluble phosphate in the form of superphosphate together with lime, produced 3 tons 19 cwt. or 19½ per cent. more Swedes than the best basic slag portion, and these figures speak for themselves.

The conclusion to be drawn from the facts already stated is that, on general principles, for Turnips, when the amount of dung is very limited, the application of a complete fertiliser will be found the most effective and profitable.

**Profitable
Swede
Fertilisers.**

We have already indicated the best treatment where 10 to 12 tons of farm-yard manure and more per acre are available.

Mangels

Whereas Turnips make larger demands on phosphates, Mangels, on the other hand, respond more profitably to nitrogen and potash, and need lesser quantities of phosphates. There is hardly any other crop which yields better

**Manurial
needs of
Mangels.**

returns to large dressings of manure than Mangels, and a strong plant and early start are very important factors. Phosphates in a readily available form are very necessary, because of their undoubted effect in establishing a full plant, and this is one of the great difficulties to be overcome. Potash is important and will usually more than repay its cost, though on some soils common salt gives good results because it liberates a portion of the insoluble potash in the soil. Where a good dressing of rich dung has been given there is probably sufficient potash available for the use of this crop, possibly also the beneficial action of kainit is due to the large proportion of salt which it contains. Though large increases are on record from very heavy dressings of salt, it is extremely doubtful if it is advisable to apply more than two or three cwt. per acre on heavy soils because of its injurious after-effect on the tilth.

Subjoined are some authentic records of manurial trials of Mangels, from which some useful information is to be obtained.

The average results at twenty-six farm centres in Derby, Leicester, Lincoln and Notts, during six years, 1905 to 1910, based on previous years' experience, conducted by the Midland Agricultural and Dairy College, comparing the most satisfactory of various combinations of fertilisers, added to farm-yard manure, and farm-yard manure alone :—

**Importance
of Phosphates,
early start.**

**A record
for the
Midlands.**

	Tons.	Cwts.	Qrs.	
Farm-yard manure alone, average about 15 tons, per acre, gave	24	12	1	per acre
Farm-yard manure, as above, with a complete manure supplying 20 lbs. nitrogen, 200 lbs. soluble phosphate, and 60 lbs. potash per acre, and 2½ cwts. salt, with 1 cwt. nitrate soda as top dressing at singling ...	32	14	1	„
Gain over Farm-yard manure alone	8	2	0	„
Increased Profit per acre after paying for Fertilisers	£1	13	10	„

The roots were valued at local market prices.

A special series of experiments was conducted, comparing superphosphate, basic slag, steamed bone meal, &c., so as to ascertain the best source of phosphates for this crop. In the College Report for 1905-6 it is stated as the result that “superphosphate and steamed bone meal are to be recommended. Steamed bone meal gave a considerable profit, and one only 2s. 1d. per acre less than superphosphate. Basic slag gave a loss.”

Similar records from Devonshire, where the County Board of Education carried out extensive trials during the three years 1904-6, at various farm centres, the most profitable combinations of fertilisers, in addition to farm-yard manure, resulted thus:—

**West
Country
Experiences.**

48 FERTILISERS AS AN AID TO

	Tons.	Cwts.	Qrs.	
10 tons Farm-yard manure alone gave ...	27	12	3	per acre
10 tons Farm-yard manure with a complete fertiliser supplying 20 lbs. nitrogen, 175 lbs. soluble phosphate, and 80 lbs. potash per acre, with 1½ cwt. nitrate soda as top dressing after singling	36	7	1	„
Increase over Farm-yard manure alone ...	8	14	2	„
Profit per acre after paying for Fertilisers	£1	12	3	

Salt was added in some cases, which further increased the crop from 3 to 4 tons per acre.

The official Reports of the Herefordshire County Education Committee show that very exhaustive manurial trials were conducted at no less than thirteen farm centres throughout the county during the three years 1909-11. Notwithstanding the latter dry year, the following were the average results per acre for the three years :—

	Tons.	Cwts.	Qrs.
Farm-yard manure alone, 12 tons	27	17	3
Farm-yard manure, 12 tons, with a complete manure supplying 20 lbs. nitrogen, 135 lbs. soluble phosphate, and 40 lbs. potash, together with 3 cwt. salt. A top dressing of 20 lbs. quick-acting nitrogenous manure after singling	37	2	1
Increase over Farm-yard manure alone per acre	9	4	2
Increased Profit per acre after paying for the Fertiliser, valuing the mangels at local market prices	£2	19	0

Phosphates from various sources were tested, and in the official Report for 1909 it is stated that water-soluble phosphate was decidedly more profitable than either steamed bone or basic slag.

A comparison of the foregoing manurial trials shows that the largest profit was obtained where the smaller quantities of phosphate and potash were employed. But it must be borne in mind that, though the larger quantities applied in the Midland and Devonshire experiments could not be utilised by the Mangel crop alone, they would remain in the soil for the benefit of the succeeding crop.

Similar manurial trials have been conducted by the County Authorities in Somersetshire and by the Irish Department of Agriculture, and they confirm the above examples.

A top dressing of quick-acting nitrogenous manure, such as nitrate of soda or nitrate of lime, after singling, almost invariably gives most beneficial results.

**Top dress-
ings of
Nitrates very
beneficial.**

The average crop of Mangels in Great Britain for the last ten years has been 19 tons 13 cwt. per acre. The trials quoted in England show that it is possible to increase the yield to about 35 tons, or a gain of more than 15 tons per acre. The importance of this will be better realised by the following statement which appears in the Report of the Midland Agricultural and Dairy College for 1910:—"It should be remembered that when we are manuring roots we are not only manuring for a big crop but also manuring for a big dung heap. This means improvement of the holding—a gradual raising of the condition of the soil."

There have been many suggestions in this

country recently as to the possibility of farmers and others increasing their profits by growing sugar beet for the manufacture of sugar. A difficulty arises in that this would necessitate the reduction of other crops which are considered to be of greater value. A solution of this difficulty may be found by adopting suitable manurial methods on the lines indicated. An average increase to 35 tons per acre of mangels means that for the same tonnage of roots, on the basis of the ten years average shown above, instead of 20 acres being required only $11\frac{1}{2}$ acres would be needed, thus setting free $8\frac{1}{2}$ acres for the cultivation of sugar beet, if desired. Thus there would be no interference at all with the quantity of roots at present obtained.

Potatoes

Though the weight per acre of Potatoes is inferior to that of either mangels or swedes, the greater value per ton renders it a very important crop, as well as a most profitable one, if judiciously manured. The agricultural authorities in the most important potato-growing centres have made very careful investigation into the most profitable methods of manuring this crop, and a review of these will be instructive.

Though Lancashire is not the largest potato-growing county, it stands pre-eminent from Lancashire. having produced the greatest average crop per acre for the last ten years in England, and the value of its crop is worth

annually half a million pounds sterling. It is not surprising, therefore, that the Lancashire County Education Committee have conducted numerous experiments at various farm centres during five years, commencing 1898, when more than forty trials have been made, and the best and most profitable manuring is selected for comparison. The following are the average results :—

Manuring per Acre.	Average Yearly Crop per Acre of Potatoes.			Gain over no Manure per Acre.			Average Yearly Profit per Acre after paying for Manure		
	Tons.	Cwts.	Qrs.	Tons.	Cwts.	Qrs.	£	s.	d.
No manure	5	18	1	...	...	...	...	...	...
Farm-yard manure 20 tons	10	1	1	4	13	0	6	3	4
Farm-yard manure 10 tons, and a complete manure supplying 20 lbs. nitrogen, 140 lbs. soluble phosphate and 50 lbs. potash ...	10	2	3	4	14	2	6	13	1

In *Farmers' Bulletin*, No. 13, which reports these experiments, the following conclusions are drawn, viz. :—“ A moderate dressing of farm-yard manure, in conjunction with a suitable dressing of artificial manure, is capable of producing a larger and more profitable crop than a heavy dressing of farm-yard manure alone.

“ The effect of the manure is chiefly seen in the weight of large tubers produced.

“ When farm-yard manure only was used the amount of disease was greater than when farm-yard manure and artificial manure were used.

“ Kainit is unsuitable for crop production, and it also impairs the cooking qualities of the tubers.

“ It is argued by some farmers that the use of artificial manures encourages disease among potatoes. This is quite contrary to the general experimental evidence of tests which have been carefully carried out, not only in this county but elsewhere.”

There is more land under potatoes in Ireland than in all the rest of the United Kingdom together. The supreme importance of this crop has therefore caused the Irish Department of Agriculture to devote much attention to exhaustive trials with various fertilisers and mixtures, which have been carried on during many years, at more than fifty farm centres each year.

The following table shows the average annual results per acre for the ten years, 1901-1910 :—

Manuring per Acre.	Average Yearly Crop per Acre of Potatoes.	Gain over no Manure per Acre.	Average Yearly Profit per Acre after Paying for Manure.
	Tons. Cwts. Qrs.	Tons. Cwts. Qrs.	£ s. d.
No manure	4 0 3	...	...
Farm - yard manure 20 tons	9 2 2	5 1 3	5 15 1
Farm - yard manure 15 tons and a complete manure supplying the same amounts of nitrogen, soluble phosphate, and potash as did best in the Lancashire Experiments	10 16 2	6 15 3	8 4 9

In regard to these experiments it is stated in the *Journal of the Department of Agriculture (Ireland)*, April, 1912:—"These experiments fully justify the advice given in previous reports that, as a general rule, and especially when it is limited in amount, farmers should apply dung in moderate quantities and supplement it with suitable artificial manure.

"This conclusion is very considerably strengthened when the results of the experiments for 1911 are compared with the average results of the similar experiments conducted during the ten previous years."

Scotland is renowned for the quality of its potatoes and for the large crops grown. It is therefore of interest to learn that the West of Scotland Agricultural College has conducted experiments at numerous farm centres during three years. Where 10 tons farm-yard manure was supplemented with a complete manure similar to what was used in the Lancashire and Irish experiments, an average maximum crop was obtained of 10 tons, 18 cwt, 3 qrs., a gain of 4 tons, 15 cwt. of potatoes per acre over the unmanured plots and an average profit, after paying for the manure, of £7. 18s. 3d. per acre.

Scotland
West.

In reference to this experiment, it is stated in *College Bulletin*, No. 38, that "it was found that with large dressings of dung, watery potatoes with inferior cooking qualities were generally produced, and that suitable artificial manures applied with small dressings of dung

improved the quality. The most valuable crop is obtained by using a light dressing of dung with suitable artificials.

“The susceptibility to disease is greatest in the plots with large dressings of dung, that with fresh dung being more than with rotted.”

In Yorkshire, where potatoes are also grown very extensively, the Agricultural Department of the University of Leeds have caused trials to be made during four years at numerous centres in the county, where, again, the best returns are from 10 tons farm-yard manure and a similar complete manure to that already described was used, the average maximum crop being 9 tons, 10 cwts., 2 qrs., a gain over the unmanured of 4 tons, 6 cwts. of potatoes per acre, and an average profit, after paying for the manures, of £5. 8s. per acre.

Similar results to the foregoing can be quoted from all over the country, but it seems hardly necessary to do more than mention that in Lincolnshire, experiments have been conducted by the Midland Agricultural and Dairy College; in Shropshire, by the Harper-Adams Agricultural College; in the large potato-growing districts of the East of Scotland, by the Edinburgh and East of Scotland Agricultural College; in Suffolk and Hertfordshire; in Devonshire, Bedfordshire, &c. Complete manures were employed in addition to farm-yard manure, and all of the experiments confirm the trials

previously quoted ; the effects of the manurial treatment were invariably most profitable.

It must not be overlooked that alkaline manures predispose the tubers to attacks of potato "scab," therefore it is not advisable to apply lime or basic slag direct if a clean healthy crop is desired.

Moreover, as the result of experiments conducted by the West of Scotland Agricultural College, reported in *Bulletin* No. 55, 1911, Professor (now Sir) R. Patrick Wright states :—
"On the potato crop the effect of liming was invariably injurious, and caused a diminution of the crop, whether applied in large or in such a small quantity as 5 cwts. per acre. If lime is applied at all it should be put on the soil as many years before the potato crop is to be grown as the rotation admits."

The average yield of potatoes in Great Britain during the ten years 1901-1910, according to the Government returns, has been 5 tons, 17 cwt. per acre. The average of the trials quoted by adopting suitable methods of manuring has been 10 tons, 4 cwt., or an increase of no less than 4 tons, 7 cwt. per acre, equivalent to 74 per cent. This shows that it would be possible to obtain as large a crop from about 12 acres as it now requires 20 acres to produce at the present average.

On rich black soil or peaty land it would be advisable to reduce the quantity of farm-yard manure.

Manuring of Grass Land Meadow Hay

It is advisable to dress meadows, or land which is cut each year for hay, every four or five years with about 10 tons of dung per acre, in the autumn, and in the intervening years a top dressing, in the early winter or spring, of 2 to 3 cwts. high grade XXX superphosphate or 4 cwts. of potassic superphosphate per acre, according to the class of soil as already indicated, which has a very excellent effect in improving the herbage. As it is quantity that is of most importance with hay, especially when it is to be sold off the farm, as soon as the grasses show signs of vigorous growth in the spring top dress with about 1 cwt. per acre of nitrate of soda, or, should the land be light, with a rather less quantity of sulphate of ammonia.

Should the land be deficient in lime, an application of 7 to 10 cwts. per acre of ground lime, or double that weight of finely ground limestone or chalk, should be applied in the autumn of the second year after application of the dung.

If there should not be sufficient farm-yard manure available to dress the meadows as described, they should be manured annually with either 6 cwts. per acre of potassic superphosphate, followed in the spring with a top dressing of nitrogenous manure, as indicated above, or with a Complete Fertiliser, which will promote

a luxuriant growth of both grasses and clovers, improving both quantity and quality of hay, followed by a distinctly increased and improved aftermath.

The Harper-Adams College have, for eight years, conducted a very thorough series of experiments at their farm on the improvement of meadows. The soil is a stiff clay loam upon a bed of clay overlying the red sandstone. The average yearly results from the annual application of a complete manure supplying 85 lbs. water-soluble phosphate, 20 lbs. nitrogen and 18 lbs. potash per acre show a gain of 16 cwt. hay, with an increased profit from this alone of 17s. 5d. per acre after paying for the manure. It is stated in the College Report for 1910:—"The application of superphosphate has given very marked increase in the crop. Apart from the weight of hay, the most striking feature of this set of trials has been the alteration in the character of the herbage. On all plots receiving superphosphate (water-soluble phosphate) the increase in leguminous plants was most noticeable, and the improved value of the herbage alone would compensate for the outlay."

Similar results are recorded in Oxfordshire, where trials under the supervision of the County Staff Instructor in Agriculture have been carried out on a variety of soils. A complete manure was employed and handsome crop increases, with great improvement in the herbage (clovers and fine grasses), are recorded.

The following observations are taken from the published Reports of manurial trials elsewhere :—

Mr. Edric Druce, Principal of the Bedfordshire County Agricultural Institute, states :—

“ The plot with complete artificials was well grazed ; a good number of fine grasses, leguminous plants were plentiful, and
Bedfordshire. it was the best plot. We can say that the application of a complete dressing containing nitrogen, phosphates, and potash, is certain to produce an *increased yield*, which is of *greater value* than *the expense incurred* in obtaining it.”

The Instructor in Agriculture for Devonshire states :—

“ The first visible effects of phosphates were an *earlier growth* and a *very great increase* in the amount of Dutch white clover and trefoil. The manured plots showed a better aftermath than the others, but it was not possible to determine the feeding value of this aftermath.
Devon.

The Chairman of the Agricultural Committee of the County of Cornwall states in his notes on
Cornwall. the experiments which have been carried on for many years :—

“ Farmers who cut hay freely for home consumption, and manure their land with judicious liberality, are on one of the surest roads to be found for improving their farms. If, as our experiments after seven years show, the fertility of the land cut annually for hay cannot only be

maintained but added to without the aid of farm-yard manure, and if, as is shown, the crops of hay on such land are quadrupled by the aid of purchased fertilisers, then it follows that the larger quantity of hay correspondingly increases the size of the heaps of farm manure. If a pasture is judiciously manured and well managed, then the better grasses will predominate."

In the Journal of the Department of Agriculture (Ireland), dated January, 1909, it is stated that as a result of their seven years' observations on a variety of soils:—

"The heaviest yield of hay and the greatest profit have been obtained from the plot receiving the complete manurial dressing."

It should be borne in mind that the profit realised from the hay is only part of the yearly profit, in fact only from less than six months' growth, therefore by far the smallest part of the profit. The increased weight of hay is of less value than the improvement in the character of the herbage and the permanently increased value of the aftermath and pasturage. According to Sir R. P. Wright, till recently Principal of the West of Scotland Agricultural College, as a result of careful observation, the increased hay crop from suitable manures "was over 30 per cent., whereas in the aftermath of the same plots there was an increase of 39 per cent."

If the land is deficient in lime it will be greatly benefited by a dressing, as previously indicated, every fourth or fifth year.

Whenever fertilisers are applied to meadows it

is important that they should always be chain or bush harrowed afterwards and then rolled.

It is hardly necessary to point out that larger and more nutritious hay crops mean not only an increase in live stock and dairy products, but a very considerable saving in the purchase of cake and feeding stuffs, which are rendered less necessary from the superior nourishing qualities of the grasses and clovers.

The great importance of improved manurial methods will be better understood when it is realised that there are more than five million acres of permanent grass land or meadows cut every year for hay in Great Britain, and yet we have to import considerable quantities of hay from abroad. Suitable manuring of these grass lands would not only render us quite independent of foreign countries for our supplies, but, owing to the superior feeding quality of the home-grown article, foreign cake and feeding stuffs could be largely dispensed with.

Increased
feeding value
of Hay.

5,000,000
acres of
Hay.

Permanent Pastures

These require different treatment to permanent haying lands. Grazed year after year in succession, they have accumulated more or less reserve stores of inert nitrogen and potash, but the phosphates have been carried away in the form of milk, or in the bones and carcasses of the live stock, as effectually, and in larger

quantities than in grain crops, and no adequate return has been made. No farmer would expect a crop from his arable land without manure, yet the pastures are generally considered to receive quite sufficient manure from the animal droppings. The consequence of this starvation is seen in the prevalence of coarse grasses and weeds, with not half the feeding qualities of the rich nutritious grasses and clovers that are to be obtained from the same land when rationally manured. Experiments have proved that the produce of our permanent grass-lands can be doubled by systematic up-to-date manuring.

There are more than twelve million acres of such land, not including mountain and heath land, in Great Britain !

It must not be expected that poor, neglected pastures can stand more than a moderate outlay for manures, at any rate at first, but it has been demonstrated over and over again that the judicious expenditure of a few shillings per acre results in undoubted profit.

The application of phosphates alone (superphosphate) or with the addition of potash (potassic superphosphate) to such pastures is often all that is required to bring about a marvellous improvement in the character and luxuriance of the herbage, which is of increased feeding and fattening value, and enables a much larger number of cattle and sheep to be effectively grazed on the same acreage.

Professor Hedworth Foulkes, of the Harper-

Adams Agricultural College, Newport, Salop,
Shropshire. writes, regarding experiments which
 have been conducted for eight
 years :—

“ Superphosphate has given most marked results, both when applied alone, and also when in combination—the best results being a combination of superphosphate and sulphate of potash. Moreover, the effect on the herbage has been very marked, and the increase in strength of clovers has become more apparent each year, which continues to be clear to the observer when walking over the plots.”

Dr. T. Milburn, Secretary of Agriculture for Lancashire, in *Farmers' Bulletin*, No. 22, which
Lancashire gives results of experiments on
pastures. “ Renovation of Poor Pasture Land ”
 conducted at six centres in the
 county during three to six seasons, states :—

“ Phosphatic manures have proved the most effective agents in improving the value of the pastures and have, on the whole, given excellent results.”

The preference of live stock for grass which
 has been dressed with fertilisers to that which
 has received dung alone, has often
 been remarked. The animals are
Live stock noticed to graze the former quite
preference close and to leave untouched the
for superior herbage on the dunged portion.
herbage. This is clear evidence that fertilisers
 promote a superior quality herbage.

It will be recognised that there is more diffi

culty in obtaining actual figures showing the improvement of pastures than with crops. The only satisfactory way is by grazing cattle or sheep and then comparing the improvement, either by the quantity of milk produced or as live weight increase. These comparisons necessitate much attention, and being also costly are necessarily few in number.

Such a comparison has recently been conducted by the Edinburgh and East of Scotland College of Aitkenden, Midlothian, during the three years 1908-1910, and is fully described in *College Report*, No. XXIII.

**Manuring
for Mutton.
Midlothian.**

“The field was raw boulder clay, somewhat wet and retentive. It had lain for many years in grass, and was clothed with a thick covering of soft inferior herbage. Uniform parts of the field were selected and fenced off; four acres received no manure whatever, the other four acres received in February, 1908, a dressing at the rate of $6\frac{1}{2}$ cwt. superphosphate (30 per cent. soluble) and 50 lbs. potash as sulphate of potash per acre. The cost of the fertilisers amounted to nearly thirty shillings per acre. On 12th June, 1908, the plots were stocked with sheep (Cheviot Dinmonts) which had been weighed, and at the conclusion of the grazing period they were again weighed. The feeding experiment was continued in 1909 and 1910, but without any further application of fertiliser. During the intervening winter and spring months the plots were grazed along with the

remainder of the field of which no account was taken.

“ At the conclusion of the three years’ period, the profit from the live weight increase on the manured plot for the three years is estimated by the College as £6 1s. 5½d., or *fully thirty shillings per acre after paying for the manures*. It was noted that at the close of the first season there was a distinct change as regards the amount of herbage and proportion of clover it contained on the manured plot, which improvement became much more apparent in the following season.

“ The manured plot provided sufficient herbage for nineteen, twenty-one, and twenty sheep in the first, second, and third year respectively, whilst the unmanured plot would only feed thirteen, fifteen, and fourteen respectively.

“ Many of the sheep were ready for the butcher when taken off the manured plot.”

It is further stated in the Report cited:—“The manured plot has probably no more than reached the height of its increased productivity. In all likelihood it will continue to give increased returns for several years ; for, in addition to the direct effect of the manuring, the great increase of clover may be relied upon to exert a beneficial influence both directly and indirectly for a considerable time.”

A further test was instituted by the Edinburgh and East of Scotland College at Homebank, Berwickshire, the object being to test, by feeding, the effects of the two leading phos-

phatic manures, with and without potash, in improving an old pasture. The trials are being carried out on a field of light land which was, before treatment, mainly notable for its mossy turf. Five plots, each of $3\frac{1}{2}$ acres, were treated as follows:—(1) No manure; (2) 8 cwts. of superphosphate; (3) ditto, plus 4 cwts. of kainit; (4) 10 cwts. of basic slag; (5) ditto, plus 4 cwts. of kainit. These manures were applied in the spring of 1911, and each plot was grazed from June 29th to August 23rd in that year with eight half-bred ewes and single lambs. The experiments are to be continued for a series of years, but the results of the first season—recently published by the College—are of interest as showing the quick action of the water-soluble phosphates, notwithstanding the fact that it was one of the driest years on record. Putting the value of the live-weight increase at 3d. per lb., the following shows the results of the eight weeks' grazing in the first year of the experiment:—

**Manuring
for Mutton
Berwickshire.**

	lbs.	Value of Increase.	
		s.	d.
Superphosphate Plot	323	80	9
Superphosphate and Kainit	322	80	6
Slag and Kainit	213	53	3
Slag	195	48	9
No Manure	106	26	6

The results of the second season are reported in the "North British Agriculturist" of the 26th September, 1912. Mr. J. Elliot Scott, the County Lecturer of the College, had conducted a party of agriculturists over the experiments on the previous week.

The gains on the different plots over the unmanured one, valued at 3d. per lb. as before, are as follows :—

	lbs.	Value of Increase.	
		s.	d.
Superphosphate Plot	292	73	0
Superphosphate and Kainit	311	77	2
Slag and Kainit	211	52	9
Slag	156	39	0

The increased profit, after paying for the fertilisers, for the two years is stated as :—

	s. d.	
	s.	d.
Slag	11	2 per acre.
Slag and Kainit	15	0 „
Superphosphate	20	10 „
Superphosphate and Kainit	22	3 „

The following description of the plots is taken from the same source :—

“ The plot which was treated with superphosphate showed a considerable improvement, and was considered by the company present to be the best of the five. The clover on this plot had greatly increased, and now, when the plots were being grazed as one, it was noticeable that the sheep lay much more on it than any of the others.

“ The plot to which superphosphate and kainit was applied showed similar results to the former.

“ On the plot which was treated with slag and kainit a considerable improvement was also seen, but it was not so good as that treated with superphosphate.

“ The last plot inspected was that which had been treated with slag, and it was considered by the company present to be the poorest of the five, showing a larger proportion of bent than in any of the others.”

To illustrate another manner of estimating the improved value of herbage by the use of suitable fertilisers, an experiment has been conducted by the Midland Agricultural and Dairy College, near Derby.

Manuring
for Milk.

It was commenced in the spring of 1909, and a full description is given in the *College Bulletins*, entitled "Manuring for Milk," from which the following brief description is taken:—The field was poor, having been "laid down six years previously in dirty condition, the grasses most in evidence being cocksfoot, tall fescue, and twitch." The soil is of a strong clayey nature, typical of most soils on the keuper marl formation.

Two plots, each of four acres, were fenced, every care being taken to have them equal in all respects. Owing to the prevalence of moss and other indications of the need of lime, 10 cwt. of ground lime per acre was applied to both plots. Two days after applying the lime, 4 cwt. of XXX superphosphate (35 per cent. soluble) and $1\frac{1}{2}$ cwt. sulphate of potash per acre, costing together £1. 9s. per acre, were broadcasted over plot B, plot A receiving nothing further than the lime. Both plots were chain harrowed, but no other treatment was given.

"Three weeks after the fertilisers had been applied to plot B, their effect was noticeable. Natural grasses seemed to spring up, and white clover gradually covered all patches previously bare."

Two lots of cows were drafted from the Col-

68 FERTILISERS AS AN AID TO

lege herd with known records and equal in most respects. One lot was turned on to plot A (unmanured) and the other on to plot B (manured) seven weeks after the application of the fertilisers. After each milking the yield of every cow was weighed and sampled for testing.

After grazing for twenty weeks the cows were removed and nothing more was done to the plots. Early in May, 1910, cows were again placed upon the plots, similar care being taken as at first, and they were grazed for twenty weeks.

In May, 1911, the plots were again stocked with cows, the same care in selection being taken as in previous years. Owing to the very dry season it was only possible to graze them for sixteen weeks. Nothing further in the way of manuring or otherwise has been done to either of the plots since the trial commenced.

The following are the results at the end of the three years' grazing period :—

	1909.	1910.	1911.
	Lbs.	Lbs.	Lbs.
Total yield of Milk from Manured Plot	9,020½	10,233	8,921½
Total yield of Milk from Unmanured Plot	5,531	6,688	5,586½
Actual Gain from Fertilisers ...	3,489½	3,545	3,334½

Gain from fertilisers for three years, 10,369½ lbs., which being reduced to gallons per acre is an increased yield of 251 gallons of milk per statute acre.

Estimating the value of the milk at the low price of 6d. per imperial gallon at the farm :—

251 Gallons of Milk at 6d. per gallon	...	...	£	s.	d.
			6	5	6
Less cost of production (Fertilisers)	...	...	1	9	0
			Total Net Profit per acre		
			£4 16 6		

or an annual average net profit of £1. 12s. 2d. per acre.

If the milk is valued at 8d. per imperial gallon, the total clear profit is £6. 18s. 4d., or £2. 6s. 1d. per annum per acre.

Here again the quick action of the water-soluble phosphatic manure is to be noted. Within three weeks after application the beneficial effect of the fertilisers was clearly visible, and within six months of their application the outlay was practically covered. But this is not all; there has been other grazing during the remaining thirty weeks of each year which is not included in these figures.

We have no hesitation in stating that it is only possible to realise such immediate returns from a fertiliser in which the phosphate is *water-soluble*.

The speedy effects of water-soluble phosphate are further confirmed by experiments at Hook, Hants. The field, described as "a moss and weed-ridden pasture, the soil being a gravelly loam on gravel," was manured on the 8th February, 1912, two days previously lime, at the rate of 10 cwt. per acre, having been applied to some of the plots. About the middle of

July or, approximately five months after application of the manures, the grass was cut and the yields of hay were found to be as follows, per acre :—

	Cwts,	Qrs.	Lbs,
Where no Manure was applied	7	3	4
Super 30 %, 4 cwt. ; Lime and Potash ...	23	1	4
Basic Slag, 6 cwt., and same quantity of Potash	20	2	4

There can be little doubt but that water-soluble phosphate is the most profitable form in which to apply this indispensable plant food, for its beneficial effects begin almost at once. Farmers ought to lose no time in adopting such very profitable methods of manuring their pastures, for in these days of intense farming no one can afford to employ slow acting phosphatic fertilisers, for which no compensation is to be obtained for unexhausted manurial value due to the "lasting" properties sometimes claimed for them.

**Unexhausted
Manurial
Values.**

Old permanent pastures which have been grazed continuously are, as we have stated previously, usually rich in nitrogen, and especially on clay soil, may often need only a dressing of high grade XXX superphosphate to very greatly improve the herbage. If the soil is of a lighter character (sand, gravel, peat, or chalk), and sometimes even on the heavier soils, it will be preferable to use potassic superphosphate instead, because it supplies both soluble phosphate and potash combined in suitable proportions and

**Fertilisers to
be employed.**

in powder ready for sowing by hand or machine.

On some very thin limestone or chalky soils it may be preferable to employ a Complete Fertiliser as recommended for meadow hay on p. 56.

These fertilisers should be applied in the early winter or spring, and the land afterwards chain or bush harrowed and rolled.

If the pasture should be mossy and very rough, it will be advisable to run a toothed harrow over it to tear this out, and thus loosen the surface before sowing the fertiliser.

In Cornwall it has been demonstrated that new-made superphosphate had a very great effect in eradicating moss.

Many old pastures are sadly deficient in lime, and will be greatly benefited by a light dressing every four or five years, say 8 to 10 cwts. per acre (*vide* p. 20). But on no account must reliance be placed upon lime entirely, no matter how good the appearance of the herbage following its application, or impoverishment will surely follow. It *must always* be backed up by full applications of proper fertilisers.

It must be obvious, after consideration of the examples taken from all parts of Great Britain, which have been recorded in the previous pages, that the statement which has been made that "nothing pays the farmer so well as his manure bill" has been amply proven.

Those who have conducted manurial trials are fully aware of the difficulties surrounding the work owing to variation in soils, seasons and

other factors which have to be provided for in actual practice. This is confirmed by Mr. A. D. Hall, who is careful to point out that the "experimental error" in ordinary farming in this country must be considered as ten per cent., which means that unless there is a greater difference between results than this, they are not to be accepted as conclusive evidence. This is particularly applicable to experiments which are carried on only for one year. When they extend over a series of years at one or more centres, the "experimental error" becomes so much reduced as to be practically negligible.

Manurial trials. Therefore in comparing results of various manurings this factor must on no account be lost sight of.

Interpretation of Results.

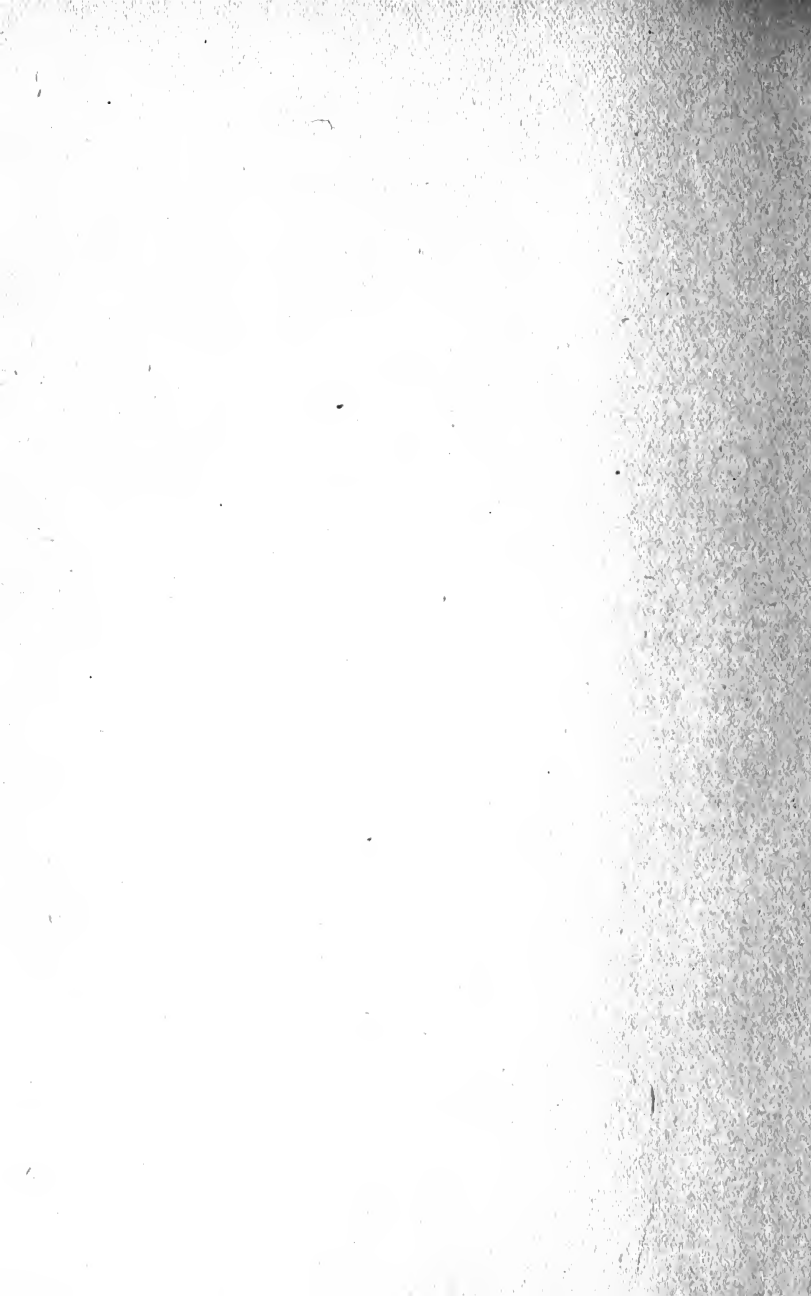
In the experiments quoted in these pages we have been careful only to exhibit those which fulfil these conditions, and in every case they will be found to be well over the required ten per cent. margin.

It is of course impossible to lay down absolute rules for each individual case, as to the most economical and suitable methods to pursue on all varieties of soils, and under varying conditions of rainfall, climate and exposure. A most important factor, as all practical farmers know, is the manner in which the previous crop or crops have been manured, but the

foregoing recommendations may be accepted as a guide to general principles on average soils. Should anyone be in doubt as to what is likely to best suit his own particular conditions, he should make some experiments on the lines indicated before going to any extensive outlay, care being taken that the land is neither in high condition, nor that manures have been applied previously for at least four years. As judgment by the eye alone is apt to deceive, it should not be considered conclusive evidence. Only actual weights should be accepted as proof.

The increase from the land is the primary and greatest source of wealth. It should be abundantly evident from the proofs which have been recorded that, notwithstanding all that has been written and said about the unprofitable condition of farming, as well as the uncertainty of our seasons, when everything is taken into consideration there is absolutely no investment to be obtained that will pay such handsome dividends as will money judiciously expended in suitable fertilisers, thus proving that the old Roman maxim "The more you give to a field the more it returns to you," holds as good to-day as when first promulgated.

G. CAMPBELL ARNOTT.





HARPER-ADAMS AGRICULTURAL EXPERIMENT STATION NEWPORT

Manuring of

PERCENTAGE COMPOSITION OF HERBAGE
SHOWING VARIATION IN

Weeds Grasses Clovers

MANURING USED
ANNUALLY
PER ACRE

No MANURE



NITRATE OF SODA
SUPERPHOSPHATE
SULPHATE OF POTASH

CWTS.
1 1/2
2 1/2
1/3



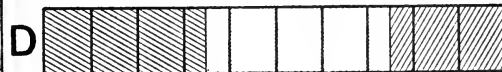
SUPERPHOSPHATE
SULPHATE OF POTASH

CWTS.
2 1/2
1/3



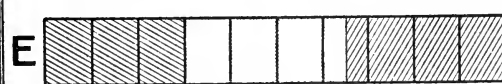
DUNG 1903 & 1907

TONS.
10



DUNG 1903 & 1907
NITRATE OF SODA
SUPERPHOSPHATE
SULPHATE OF POTASH

TONS.
10
CWTS.
1 1/2
2 1/2
1/3



NITRATE OF SODA

CWTS.
1 1/2



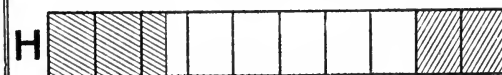
SUPERPHOSPHATE

CWTS.
2 1/2



SULPHATE OF POTASH

CWTS.
1/3



CULTURAL COLLEGE

SALOP.

Meadow Land.

HAY PER ACRE
AVERAGE FOR 1903-1909

PROPORTIONATE CROP INCREASE
OVER PLOT A (NO MANURE).

T.	C.	LBS.
1	3	82

2	0	14
---	---	----

1	17	52
---	----	----

1	15	4
---	----	---

2	2	4
---	---	---

1	7	30
---	---	----

1	14	90
---	----	----

1	5	42
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