ORGANIC MANURES, COMPOSTS AND ARTIFICIAL FERTILIZERS.

By G. INGHAM.

Mineral Fertilizers.

It is considered to be the hallmark of the good agriculturist that he aims not only to produce maximum crops, but to maintain the fertility of his soil unimpaired for the benefit of posterity. Both these ends were achieved in former times by the use of animal manures, by fallowing at regular intervals, and at a later date by the practice of crop rotation in conjunction with the growing of legumes and the use of manure.

The year 1841 marks the beginning of the era of modern scientific agriculture in which mineral fertilisers have played such a prominent part.

The use of these fertilizers in place of farmyard manure was a revolutionary procedure, and regarded with much suspicion and shaking of heads by the conservative agriculturists of those days.

It seems fitting, therefore, in this year 1941, that we should review the fertilizing methods in vogue during the last hundred years and determine whether, as a result of those methods, the fertility of our soils is a wasting asset or whether those soils are becoming more and more capable of feeding the increasing populations of the world.

To Sir John Lawes belongs the distinction of being a pioneer in the manufacture of artificial fertilizers from such raw materials as mineral phosphates, sulphate of ammonia, nitrate of soda, etc.

The theoretical basis underlying the use of mineral fertilizers is that farm crops take from the soil certain mineral constituents such as phosphates, etc. which are present in limited amounts, and that if such substances are not replaced, impoverishment of the soil will ultimately ensue.

The farmers of 100 years ago could not deny that these new-fangled chemical manures gave bigger crops, but they raised the perfectly natural objection that although such fertilizers might give better crops for a time, they would prove to be mere stimulants and would ultimately ruin the soil.

Sir John Lawes realised the force of these objections and, in order to obtain an impartial verdict, he set aside a portion of his estate for the purpose of carrying out long range experiments to settle this and other problems incidental to modern agriculture. Thus began the world-famous Rothamsted Experimental Station, which was afterwards handed over to the Lawes Trust and became a purely scientific institution dissociated from fertilizer manufacturing interests. Its staff, includes men of the highest scientific qualifications whose only aim is to reach as near an approximation to the truth as is humanly possible.

Here are some of the conclusions reached after 100 years of patient investigation:

(1) Comparing the farmyard manure plot with the plot devoted to artificial fertilizers, it was shown that the average yields were approximately the same, the only difference being that the seasonal fluctuations were smaller on the farmyard manure plot.

As both plots gave the same high yields, it follows that the mineral manures after 100 years have not impaired the fertility of the soil in the slightest degree.

(2) There was no significant difference as regards either baking quality or the nutritive value of the grain.

(3) There was no evidence of any special infestation by diseases or pests on the artificially fertilized as compared with the manured plot.

(4) It was found that, unit for unit of nitrogen, farmyard manure was only half as effective as nitrate of soda or sulphate of ammonia.

Such are the conclusions derived from 100 years of careful scientific experiment, and it would naturally be supposed that the questions at issue had been settled for ever. But such a view would be optimistic in the extreme, as will be evident from the following conclusions arrived at by Sir Albert Howard:

(1) Farmyard manures and composts are the only basis of permanent fertility—artificial fertilizers being stimulants are of temporary value only and disastrous in the long run.

(2) Chemical fertilizers not only poison the soil, but the crops grown by means of them are a constant menace to the health of the human race.

(3) Crops grown by mineral fertilizers are particularly liable to infestation by diseases and pests of various kinds, and livestock fed on such produce exhibit all the symptoms of physical degeneration.

It will be noted that the above is a mere recapitulation of the errors of a century ago, with a few later additions.
Organic Manures.

While accepting the view that mineral fertilizers give big crops without causing the ultimate deterioration of the soil, it would be unwise to shut our eyes to the obvious advantages of such tried and tested organic manures as ordinary farmyard or kraal manure, guano, etc. It is generally accepted that sandy soils lacking in humus need an organic rather than a mineral fertilizer. One of the advantages of organic manures like farmyard manure probably depends on the fact that these bulky manures, which are applied at the rate of several tons per acre, have a high absorptive capacity for moisture, and the crop does not therefore suffer as much in time of drought. Another advantage is that the plant-food elements in the manure are released gradually as it undergoes decomposition in the soil, and so there is less danger of soluble plant-food being leached out of the soil before the crop can make use of it.

Since manures of this kind are produced on the farm as a by-product of the feeding of livestock, it is an act of the most ordinary farming economy to make use of them to the fullest extent and so cut down expenditure on artificial fertilizers.

The view which is held in some quarters that there is some mystic quality about organic manures, in that they are the products of the life processes of plants and animals, is quite untenable, and their value as fertilizers depends on their chemical composition, enhanced in some cases by their favourable physical effect on the soil.

Composts.

The chief drawback to the more extended use of organic manures is that, unless produced on the farm, they cost more per unit of plant-food than mineral fertilizers. Hence the making of composts has come into vogue, because by taking the limited amount of animal manure available and composting it with such waste materials as cane trash, weeds, straw, etc., a much greater bulk of organic manure is ultimately obtained. While emphasising its importance as a fertilizer, the advocates of compost generally claim that its most important function is to maintain the humus content of the soil, which is said to be the primary and only basis of permanent fertility.

This statement that organic matter and humus in conjunction with soil bacteria are necessary to fertility has been repeated so often in the last 100 years that one might almost be pardoned for believing it, although the most ordinary, everyday experience is against that belief.

It is only necessary to take a walk along the North or South Coast of Natal in order to see that sands almost devoid of organic matter are covered with a luxuriant growth of impenetrable bush. Similar wind-blown sands containing less than one per cent. of carbon will produce cane crops of 40 and even 70 tons per acre. The eruption of Krakatoa in 1883 destroyed all animal, vegetable and bacterial life on the island and buried it 40 feet deep under red-hot ashes. Yet after cooling, the island became again covered with luxurious tropical vegetation and humus followed later.

In these days of soil-less culture, it seems hardly necessary to point out that sterilised sand without a particle of organic matter will grow crops of tomatoes and other vegetables if watered with a nutrient solution containing minerals only. These and other examples show that it is the plant which produces humus, not humus that produces the plant.

In relegating humus to a secondary place in the economy of plant life, it is not intended to imply that it is of no value at all. But here it is important to make a distinction between humus and other organic matter in the soil. Humus is the more or less stabilised organic matter derived from centuries of plant growth and is no longer subject to chemical oxidation or bacterial action, remaining in the soil at a steady level from year to year. The organic matter supplied by crop residues and organic manures, on the other hand, disappears in a few weeks or months, leaving no trace behind. Humus is of value to the soil by virtue of its physical properties. It is an organic colloid with high buffering capacity, a good absorbent of water and mineral salts, and on account of its binding effect on the soil particles it helps to prevent erosion.

The fundamental mistake made by the advocates of compost is in regarding humus and compost as convertible terms.

Waksman, however, has shown that the organic matter in crop residues undergoes, for the most part, rapid decomposition, leaving only the more resistant lignin behind, and that only a fraction of this ultimately becomes the stable organic compound which is properly termed humus.

The greater part of the compost which is applied to the soil disappears rapidly and, like farmyard manure, adds nothing or very little to the permanent organic content of the soil. I do not propose to describe the manufacture of compost in detail, as the principles on which it depends are well known. Various vegetable wastes are made into a heap, which must contain a definite proportion of nitrogenous matter, either in the form of animal manure or sulphate of ammonia, in order to secure a carbon-nitrogen ratio favourable to the activities of the micro-organisms which promote the decomposition of the heap. Soil containing the necessary bacteria is added, and lime or wood-ashes are also necessary to maintain a neutral reaction.
The product is a bulky material and for 100 acres 1,500 tons will be required. As half the organic matter is lost in the process of manufacture it will be necessary to start with a heap of 3,000 tons. The making of such a heap may be contemplated with comparative equanimity, but when we are told that it has to be unmade, turned over and made up again three times in 90 days, we may be pardoned for recoiling from a task beside which the labours of Hercules fade into comparative insignificance. Fortunately, by the time the third turning becomes necessary, half the organic matter has vanished and the labours of those who turn the heap are correspondingly less. All this labour has a monetary value which must be charged against the final product. The figures quoted at the Congress of 1938 put the cost of labour at anything from 1s. 6d. to 14s. a ton, and in a recent article in *Farming in South Africa* it is estimated at 4s. 6d. per ton for labour only.

No one grudges the labour if the value of the product shows a profit. The value of the product in this case can be determined to a nicety from the chemical analysis.

Below is the analysis of two representative samples on dry matter per cent. of compost, made at Indore and at Darnall respectively:

<table>
<thead>
<tr>
<th></th>
<th>Organic matter</th>
<th>Total ash</th>
<th>Silica</th>
<th>and sand</th>
<th>N</th>
<th>P₂O₅</th>
<th>K₂O</th>
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<tr>
<td>Indore</td>
<td>20.13</td>
<td>79.86</td>
<td>46.9</td>
<td>0.90</td>
<td>0.41</td>
<td>1.95</td>
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<tr>
<td>Darnall</td>
<td>27.60</td>
<td>72.40</td>
<td>0.78</td>
<td>0.32</td>
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The first thing that strikes the dispassionate observer when contemplating the above analyses is that compost, which is generally regarded as an organic manure, the primary function of which is to keep up the supply of organic matter in the soil, contains nearly 80 per cent. of inert mineral matter, chiefly sand.

Moreover, the above analyses are on the dry sample, but the compost which is applied to the land contains 50 per cent. of moisture, and if this is taken into account the above analytical figures must be divided by two. This brings the organic matter content down to about 10 per cent., and to get this 10 per cent. of organic matter into the soil it is necessary to cart on to the land 90 per cent. of water and sand.

Regarded as a means of supplying the soil with organic matter it must be admitted that compost, as above manufactured, is a dismal failure.

But what is its value per ton on the basis of its plant-food content? Taking as unit values 15s. for nitrogen, 5s. for potash and 3s. 6d. for phosphoric oxide, the Indore product is worth 12s. 3d. a ton, and that made at Darnall 6s. 4d. In the issue of *Farming in South Africa* already referred to, the average value of the compost there mentioned is 8s. 11d. per ton. In the same issue the analyses of two samples of Karroo manure are given and their value assessed at 46s. and 26s. 6d. respectively.

A compost worth 12s. 3d. a ton may just pass muster, but compost of which the manurial value is only 6s. 4d. is hardly worth the expense of carting on to the land.

There is one rather pleasing delusion cherished by the makers of compost, namely, that the myriad of micro-organisms in the compost heap busy themselves with fixing nitrogen from the air and so adding to the total nitrogen content of the manure. The analytical figures certainly give very little evidence of any such addition, and there is probably less nitrogen in the heap at the end of the process than at the beginning. It is a lamentable fact that azotobacter and similar organisms prefer to make use of whatever nitrogen is available to the more difficult and energy-consuming task of fixing it for themselves.

In spite of the above adverse criticisms, it is not intended to discourage the making of compost. The underlying idea is quite sound, viz. to convert waste organic matter into fertilizing material and so cut down fertilizer costs. But unless the product is at least equal in value to kraal manure it is hardly worth the cost of transport, and unless careful watch is kept on labour costs it will be found that they greatly exceed the manurial value of the compost produced.

The first thing to be done is to cut out that 80 per cent. of inert mineral matter, chiefly sand. This would at once double the value of the compost and halve the labour costs, while the resulting material would then have some claim to be regarded as an organic manure.

Organic manures, however, while useful as fertilizers for annual crops, do not, as mentioned before, add to the humus content of the soil. For the cane planter, concerned only about the lack of humus, the making of huge compost heaps is a totally unnecessary expense. There appears to be a mistaken belief that the cane crop depletes the soil of humus. But the plain truth is that it is the ploughing up of the land that destroys organic matter—not the growing of a crop. Where annual crops are grown, requiring perhaps two or more ploughings per annum, such destruction of organic matter and the consequent erosion may be very considerable, with the result that tilth and soil structure are seriously affected. But the case of cane is different. It is a crop which in this country covers the ground for several years at a time and therefore, as in the case of land under permanent pasture, the soil increases in humus content from year to year.
At the Sugar Congress of 1938 it was mentioned that the planters in Hawaii did not worry about supplying organic matter to the soil, depending for this on the growing of big crops, the root residues of which were sufficient to supply organic matter. The opinion was, however, expressed that such methods might not suffice in Natal.

But let us face the facts, even if they happen to be favourable to one's argument. Sir A. Howard, in the work referred to, states that it is not always realised that about half of every crop—the root system—remains in the ground at harvest time, a statement which is confirmed by Weaver. It is not uncommon to get a yield of 40 tons plant cane per acre, and much higher yields are possible. Thus at Umbogintwini on a wind-blown sand containing less than 1 per cent. of carbon, a crop of P.O.J.2725 amounted to 71 tons per acre for the plant cane and 60 tons for the ratoons. In a recent report of the Director of the Mount Edgecombe Experiment Station, a crop of 73 tons per acre is recorded as having been obtained on a sandy loam at Maidstone from Co.331.

In both these cases the root system would amount to at least 35 tons, or allowing for 50 per cent. of moisture, 17.5 tons of dry organic matter per acre. Moreover, this organic matter remains in the soil and accumulates from year to year until it becomes necessary to plough the land again, when some loss of organic matter is bound to occur, but further loss is arrested when the surface is again covered with growing vegetation.

To the planter who is concerned only about the humus content of his soil I would say, "Grow cane," and if the humus is not then sufficient, "Grow more cane."

The humus is added to the soil as a by-product of the growth of cane and costs the planter nothing. Like the cane plant itself, this organic matter is derived from the carbonic acid of the air, elaborated in the leaves, translocated in soluble form to the roots, where it is finally deposited as cellulose and lignin. The numerous root hairs take hold of the soil particles and protect the soil from erosion. When the roots finally decay they leave channels of aeration and improve the tilth and other physical qualities of the soil.

Summary.

(1) The century-old experiments at Rothamsted show that artificial fertilizers are not inferior to farmyard manure, have no harmful effect on the soil or the nutritive value of the crop, and do not render the crop susceptible to the attack of insect or fungus pests.

(2) Organic manures, e.g., guanos, farmyard manure, etc., give better results than mineral fertilizers on some types of soil, but generally speaking there is very little difference if the number of units of plant-food is the same.

(3) Composts, as usually made, are of no value for increasing the humus content of the soil. They are generally much inferior to farmyard manure in fertilizing value, and the cost of labour expended in their manufacture may easily exceed the value of the product based on chemical analysis.

(4) The simplest and cheapest way of supplying the soil with humus is to grow bigger crops of cane and plough up the land as infrequently as possible.

References.

5 Weaver, J. E. (1926) : "Root Development of Field Crops."

African Explosives & Industries, Ltd., Umbogintwini.
March, 1941.

Commenting further on the paper, Mr. INGHAM said that the fact that compost as generally made contained 10 to 15 per cent. of organic matter, would come as a shock to those who had been under the impression that it was composed almost entirely of organic matter, and they would perhaps think that there must be some mistake somewhere or that examples given were not fairly representative.

To guard against any error of this kind and to avoid any suspicion of bias, the examples quoted were of compost made and analysed by the makers of the compost themselves.

His own analyses of numerous samples of compost were quite in accordance with those quoted above as regards the low organic matter content, and he had seen a publication of the Union Department of Agriculture on compost which also gave a number of analyses telling the same melancholy tale.

The loss of organic matter arose from the decomposition, i.e., the slow combustion of the cane trash in the heap. One of the chief objects of compost making was to conserve organic matter instead of burning the trash; but in practice it amounted to

* This is an unreleased variety undergoing trial.
burning one-half or two-thirds of the organic matter in the compost heap in order to save the remainder, hence the small amount of organic matter and the large amount of mineral ash in the final product.

The writer of the bulletin mentioned gave a very sober and impartial estimate of the value of compost, making no extravagant claims for it and emphasizing the importance of keeping costs down and reducing to a minimum the loss of organic matter.

In a recent issue of the Rhodesian Agricultural Journal, on the other hand, there was an article on compost which breathed a spirit of unrestrained optimism. By making two or three assumptions, the writer of the article had no difficulty in proving that an amount of compost costing 9s. 2d. was equal in value to sulphate of ammonia costing 39s. 6d. The first of these assumptions was that compost could be made at a cost of 1s. 6d. per ton. The second assumption was that compost (as distinguished from the dry matter of compost) should contain 0.8 per cent. of nitrogen, and the third assumption was that nitrogen in compost was of equal value unit for unit to the nitrogen in sulphate of ammonia.

The last of these assumptions was shown to be erroneous by the Rothamsted experiments, from which it appeared that, judged by crop production, nitrogen in farmyard manure was only half as effective as an equivalent amount in sulphate of ammonia.

The same conclusions held good when compost containing an equivalent amount of nitrogen was substituted for farmyard manure.

Mr. Ingham had received from Mr. T. D. Hall an account of some experiments recently completed, in which animal compost was used as a top-dressing for pastures in comparison with sulphate of ammonia containing the same amount of nitrogen. Phosphates and potash were also supplied so as to make the total fertilizer application the same in both cases.

Whether judged by total dry matter or by protein production, the sulphate of ammonia gave more than double the yield of the pasture treated with compost.

"Speed the Plough" was perhaps a very good slogan overseas at the present time. To speed the plough in South Africa might be disastrous. It was a necessary evil. One had to plough up the land to get a suitable seed-bed for the crop, but the best possible thing in South Africa was to get the land covered over with some crop as quickly as possible in order to guard against erosion. Some figures were quoted at the Congress in 1937, showing the amount of erosion which took place in the soil under various conditions. From bare, cultivated soil, the loss was about eighteen tons per acre per annum; land under maize suffered a loss of about twelve tons; but under grass, the loss was one-twentieth part of one ton. This showed that if you got the ground well covered with a growing crop you were not as likely to suffer from erosion. And that was where the advantage of a crop like cane came in. There must be far less erosion under a cane crop than under a crop like maize, which was removed and the ground ploughed up every year.

The President said that it was a most interesting paper to listen to and that he would welcome discussion, as he knew it was a subject that had given rise to a certain amount of controversy in the past.

He was not an agriculturist himself but he used to believe in humus, but in the last few years he had seen so much of the other side that he now conformed with Mr. Ingham's opinion. He referred to the work of Professor Gericke of the Department of Plant Physiology at the University of California on water cultures. Professor Gericke claimed to have been able to produce food in a water-culture equal from a nutritive point of view to that produced in soil. He also obtained astoundingly high yields.

The President said that the greens and fairways of the Country Club golf course used to be in a bad state some years ago. Compost made from the grass cuttings, wood ash, manure and sand was applied with most excellent results. Other golf courses have also benefitted from this treatment. Compost was therefore not useless but it was a question of costs. Applications of ammonium sulphate and iron sulphate resulted in sulphuric acid being left behind.

Dr. McMartin congratulated the author on his paper. Many people looked upon "compost," "humus" and "magic" as synonymous. In the sugar industry many were trying to make compost with the object of supplying organic matter to the soils. All crops did not, however, appear to require the same amount of organic matter. It had been found elsewhere, for example, that a certain crop grown in soils of low humus content developed a disease, but whereas if transplanted in soils with a high humus content the diseased plants became healthy once more. It would, however, be dangerous to generalize on this isolated example. Good crops of cane, on the other hand, were grown on Natal sandy soils very low in humus.

Experiments at the Experiment Station, Mount Edgecombe, showed that although there was an increase in nitrogen percentage of compost heaps as
compared with the original material, there was a considerable decrease in the total amount of nitrogen. The compost heaps were made with various materials. Those heaps that rotted down best and apparently made the best compost showed the highest percentage of nitrogen, but also the greatest loss of total nitrogen.

Mr. INGHAM pointed out that the nitrogen content of cane trash was very low and by itself could never give a compost of high fertilizer value. There was an increase in nitrogen per cent., but that was due to its concentration as a result of the disappearance of organic matter and not as a result of it being fixed by micro-organisms. Under South African conditions of heat and moisture, the losses of organic matter in composting were very great, and if decomposition was allowed to go too far the fertilizing value of the product became very low indeed.

Mr. RAULT said that people had been given a prospectus on the formation of compost from garbage, market refuse and cabbage leaves. The process was supposed to be very quick, requiring apparently only one week. He asked what the author thought of the process, and whether he thought that the losses were reduced in it and whether it might be economical.

Mr. INGHAM said he had examined compost made by this process and could not find any advantage over any other compost. He could find no evidence of an increased nitrogen content. It was about 0.8 or 0.9 per cent. He did not think the micro-organisms would fix nitrogen if it was already present in the heap. The process provided a good way of getting rid of refuse, however.

Mr. HAYES said that he did not regard the argument of the luxuriant growth along the coast as a fair one. Although bush grew well on the sand, the same could not be said about certain other crops. He had worked on an estate that had grown cane continuously from 1886 on one field and the yield was only five tons per acre. He could not see how a field like that could be made fertile by applying the author's advice to "grow more cane."

As regards Mr. Ingham's remarks about crops produced in soil-less cultures and sterilised soils, he pointed out that such sterilised soils would soon be teeming with micro-organisms unless the greatest care was taken. The author did not show any potash in the Darnall compost, but surely it must have had some potash as it was made from cane trash and tops.

He thought nitrogen fixation by micro-organisms was far more complex than was suggested by the author. If these organisms simply used the nitrogen most easily available, how was it that legumes, with their large infection by these organisms, were able to get nitrogen for themselves at all?

Mr. INGHAM said he had not seen the results of experiments on the actual amount of organic matter in soils which had been under cane for a number of years. He thought, however, a considerable amount of organic matter must accumulate.

He agreed that a sterilised soil would soon be teeming with micro-organisms. Nitrogen fixing organisms, however, required organic matter to enable them to do this work. Azobacter required 100 lbs. of organic matter to fix 1 lb. of nitrogen.

In the case where legumes were grown on compost heaps, he did not think that the legumes added any nitrogen to the heaps, but believed that the nitrogen was simply taken from the heap.

Mr. BOOTH said that although he was not an agricultural chemist, he was very interested in the agricultural side of the industry. He had followed Mr. Ingham's lectures with the greatest enthusiasm and interest. He was sorry that Mr. Dymond, a convinced believer in compost, could not be present. Mr. Dodds had often advocated organic matter from the point of view of water retention in the soil, and the speaker felt that was one of the main benefits to be derived from compost as the conservation of water in the soil was very important.

At Tongaat Estate compost was now made from sunnhemp and applied to what appeared sterile portions of the fields.

Mr. DODDS congratulated Mr. Ingham on his admirable paper. It was a pleasure to hear a sane and judicious paper on a subject on which extreme views were so often expressed. It was, of course, necessary to keep the organic content of a soil up to its maximum for that type of soil, if only to maintain its maximum power of retaining moisture.

There was the question of what would be the most economic way of restoring organic matter. The simplest way was to plough in the cane trash when ploughing out old ratoons. Trash, however, was low in nitrogen. There was also an indirect method of restoring organic matter and it was used very successfully in Hawaii. Mineral fertilizer was used to produce such large crops as to leave root residues which would be sufficient to retain the organic matter in the soil. To accomplish this a sufficient application of water as well as of fertilizer was necessary, and in South Africa water was often the limiting factor. The making of compost was a third method. Recently experiments at the Experiment Station were started in which trash was mixed with alternate layers of sunnhemp or other
legume to supply the nitrogen. Whether this was more effective and economical than simply ploughing in the legume where it was grown remained to be seen. In South Africa, moreover, the cost of making compost was much higher than in countries such as India, with a low standard and cost of living and a high degree of overstocking.

He said that the continuous use of ammonium sulphate only resulted in leaving the soil acid and useless as pointed out by the President, and wherever ammonia salts were used systematically some basic corrective substance must be added. For this, lime, filter cake or almost any phosphatic fertilizer that leaves a residue of calcium could be used, or alternatively, the occasional use in rotation of a nitrogenous fertilizer with a basic residual effect such as sodium nitrate.

Mr. FOWLIE regarded the paper as a very complete and exhaustive account of the whole position with regard to fertilizers. He pointed out that before the days of artificial fertilizers, farmyard manure only was used. In Scotland, in cases where farms were fairly big, this was applied on a portion of the farm only and the difference between the fertilized and unfertilized portions was very marked. Artificial fertilizers changed that, however, and in a country like Great Britain production jumped up tremendously. This was not entirely due to artificial fertilizers, but very largely so. Crops raised with artificial fertilizers were just as good in quality, in feed value and in every way. Thus Great Britain, a leading country in the use of artificials, might also be called the breeding ground of valuable animals of all sorts. These animals were fed on crops produced with artificial fertilizers and it had no ill effect on them.

Mr. TAYLOR said that at present many looked upon compost as a cure-all. A few years ago many went to the other extreme and regarded artificial fertilizers as the only essential in manuring. Like everything else it was, however, a question of balance, and each aspect had to be considered in regard to its own problems. At Cedara, on a red doleritic soil, where maize was grown requiring annual ploughing, conditions were ideal for humus oxidation. Humus was quickly destroyed and the physical qualities of the soils deteriorated rapidly. Their system was therefore to keep the land covered as far as possible. Crop rotation was practised and it was found that a few years under pasture largely restored the humus content and physical qualities of the soil.

The making and turning of compost heaps were rather costly. Wherever possible, waste organic refuse should be utilised by adding it to the farmyard manure heap or pit. A less costly method of making compost was the kraal system, whereby animals were kept during winter in a temporary barbed wire enclosure into which any waste material was thrown. They trampled and mixed it with dung and urine and commenced the process of conversion into humus. At the commencement of the rainy season the partly-rotted material was collected into long, narrow heaps and left to rot with occasional turning, if that could be accomplished by casual labour at such times as it was not fully employed.

Compost made at Cedara and some other samples examined by Mr. Taylor were not quite as bad as the instances quoted by Mr. Ingham, but still the insoluble mineral content was high.

Dr. VAN ZYL associated himself with the remarks made by Mr. Taylor that a balanced view should be taken. His experience in the Chemical Services, where the whole problem of soil fertility was dealt with, was that people were inclined to go to extremes. He advised planters not to go "all-out" for one practice and to neglect the other.

He thought that the value of 6s. 4½d. per ton of Darnall compost was rather an under-estimation. The author apparently did not take the potash which the compost must contain into account.

Although compost was low in plant foods, the fact that it was applied in large quantities of about ten tons per acre insured that a good deal of plant food was added to the soil as well as a considerable quantity of organic matter. Analyses made by the Division of Chemical Services showed that the composts they examined commonly contained between 30 and 45 per cent. organic matter on the dry basis and not only 20 per cent. The inorganic matter was always high, but it was not all valueless, as it was largely derived from decomposed plants. One should avoid adding more extraneous matter than was absolutely necessary. It was incorrect to imagine atmospheric nitrogen was added in some mysterious way to compost heaps; in fact there was usually an appreciable loss of nitrogen and one should try to avoid this loss as far as possible even if it could not be avoided completely.

Reference had been made to a process developed in America which was now being tried out here. Garbage and municipal waste were used and it was a two-stage process. First cultures were added and worked up to the right temperature and other conditions. A little lime or phosphate was used to reduce acidity and dure the right growing medium. Results were obtained in 48 hours that would take three months on a farm; but this stage of the process did not add nitrogen from extraneous sources. The second stage was to add nitrogen-fixing organisms to the compost and allow them to
multiply. Such compost, when added to the soil, would cause fixation of atmospheric nitrogen and increase the nitrogen content. The speaker did not know how successful this was in practice.

There was another process of working up municipal garbage and other waste recently developed at Kensington, London. Here, too, they inoculated at a certain stage. They claimed to have produced a very good type of compost in a fortnight's time.

He concluded by saying that compost was certainly a valuable article under suitable conditions, and that the Department of Agriculture was therefore generally encouraging farmers to make and use it. So many wild claims were, however, being made for it nowadays that there was every chance that people would ultimately be disappointed. It was therefore very opportune that Mr. Ingham had stressed certain fallacies.

Mr. INGHAM said that in arriving at a value of the Darnall compost he made use of Mr. Dymond's analyses, but even if there was one per cent. potash present it would only raise its value to 8s. 10d. per ton.

Mr. DYMOND sent the following written comments:

“My belief in the value of compost originated in simple observations, which nobody can deny and so far nobody has explained.

“Defecation filter press cake gives in most cases in Natal a remarkable increase in yields, as compared with the erratic results obtained from artificial fertilizers. Even Mr. Ingham cannot ascribe this to his NPK yardstick of unit values. Perhaps it is undefined "magic" as suggested by Dr. McMartin. However, subsequent observations showed that the same results were obtained by using compost; "magic" again: These experiments are being repeated, and when the magic has repeated itself to my satisfaction, I shall get on with the practical side and leave others to wrangle about the causes.

“I have recently had the privilege of visiting the Island of Mauritius, where sugarcane has been grown, and well grown, for over a hundred years. It is a curious fact that despite, or rather in conjunction with, their highly rated Experiment Station the practice of making "fumier" and "saccarogene" has gone on for all those years. The average cost of production is from 5/8 to 6/6 per ton. I am afraid that the advent of Mr. Ingham’s paper will not wean them from their ways, though it would be highly interesting to note the effect were they to discontinue this practice over the next hundred years.

In 1937 Dr. George Sheffield Oliver published a three volume report on his scientific findings, “Our Friend the Earth Worm.” Perhaps the humble earthworm is the cause of the “magic,” for he likes composts and the like and not artificials, for as Darwin says: “Without the humble earthworm, who knows nothings of the benefits he confers upon mankind, agriculture, as we know it, would be very difficult, if not impossible.”

“One has only to study the laborious results of fertilizer experiments to realise what a “hit and miss” business it is. How much fertilizer may go down the drain is shown in Mr. Foster’s excellent paper.

“My own suspicions about the results obtained from artificials in cane agriculture in Natal are the results of personal observations. It is probable that these results would become more systematic were the soil first treated by common “magic” as in Mauritius. I agree with Mr. Ingham’s slogan, “Grow more cane,” only I would alter it to read, “Grow more earthworms first.”

The PRESIDENT said we were all very grateful to Mr. Ingham for having presented his paper, which had produced such a lot of interesting discussion.

A vote of thanks was carried with applause.