Possibilities of Improving the Fertility of the Soil in The Netherlands by More Rational Application of Lime, Inorganic and Organic Manures and by Improvement of its Texture

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with the assistance of

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ABSTRACT

The results of experiments made by institutions of agricultural research, by the advisory service and by the Laboratory for Soil Testing, according to standardized methods, on behalf of agriculture, lead to certain conclusions.

By improvements of inorganic manuring, the yielding capacity of the arable area in the Netherlands may be raised by 15 to 20 per cent. Of this total, 10 per cent would be due to nitrogen, 1 to 2 per cent to phosphates, 2 to 3 per cent to potash and 3 per cent to lime.

In regard to phosphates, it is presumed that present supplies will not be added to by increased imports; in regard to potash, savings are possible on present supplies. Some improvements can also be expected from application of other fertilizers, particularly of those containing magnesium.

Losses of lime and magnesia by leaching and assimilation by the crops are now only partly covered by manuring.

The yielding capacity of permanent pasture may be raised by 20 per cent if the status of both phosphate and potash in the soil is improved, coupled with better drainage and parcelling. Changes in farm management are involved by the application of large dressings with nitrogenous fertilizers and the yielding capacity of grassland can be raised by 40 per cent.

Intensification of application of organic manures on arable land may result in considerable improvements in several agricultural districts. However, they cannot as yet be expressed in an average figure.

The possibilities of improvements in regard to grassland are estimated at 5 per cent as an average; owing to the requirement of large amounts of organic material in agriculture treatment of domestic and other refuse of urban areas has become an urgent problem, only a very small percentage of the refuse being utilized at present.

Agriculture will benefit considerably by adopting better methods of making and storing farmyard manure. Research in this problem will be intensified.

In the Netherlands, application of improved methods of agriculture is strongly promoted by education and by the work of the advisory service.

The results attained at agricultural research institutes and from experiments carried out by government agricultural advisers are disseminated amongst farmers by an extensive advisory service and by an efficient system of agricultural education.

During the last twenty-five years, results of scientific research have been successfully applied for judging the state of fertility of arable and grassland. All soil samples forwarded by farmers are examined in Holland at the Soil Testing Laboratory at Groningen according to well-defined standardized methods.

Soon it became apparent that a rough estimate of the possibilities of improving soil fertility by more rational manuring could be arrived at. This was done by summaries of results of trial plots in regard to the connexion between yields and composition of soils (P, K, pH), and by frequency curves constructed from results of analyses of soils in different agricultural districts. From these data it became easier to decide upon the factors to which the special attention of students and farmers should be drawn by advisers and teachers.

The influence of various factors upon soil fertility of arable and grassland will now be described.

ARABLE LAND

Nitrogen

The right quantities of nitrogen to be supplied to various crops on different kinds of soil to procure optimal yields is not determined by soil analyses. Results from trial plots and practical experience are here the decisive considerations.

In order to ascertain the increases in yield still attainable in the Netherlands by larger supplies of nitrogenous fertilizers, it was not only necessary to investigate the manner in which nitrogen stimulates the yield, but also to determine the difference between the quantity usually applied and the optimum quantity.

In the years 1940–1945, a large number of nitrogen-phosphate, nitrogen-potash, nitrogen-magnesium and nitrogen-copper experimental plots were laid out by our Institute and the data collected served to get an impression of the effect of increasing applications of nitrogen on soils with varying contents of P, K, Mg and Cu. Although affected by the supplies of other nutritive elements to the plants, the following calculations are based upon results of small plots, supplied with optimum dressings of phosphate, potash, magnesium and copper, while certified seedstock was used.

The curves representing the yields recorded with various nitrogen applications on the plots over several years are concentrated into a few general curves. This had to be done with great care as the yield resulting from a certain application of nitrogen cannot be attributed simply to the nitrogen supplied, it depends also upon the store of nitrogen in the soil. This store varies for different soils.

Consequently the zero of a nitrogen-manuring curve does not coincide with the zero of a yield curve, but with a point determined by the natural nitrogen content of the soil. By ascertaining the absolute zero of each curve by extrapolation, the curves became mutually comparable and the courses of separate curves for the different crops could be calculated (see Figure 1). As the nitrogen reaction of cereals on various soils showed only very small differences, only one common curve was constructed. For wheat on sandy soil, poor in humus, a rather diverging curve had to be drawn. Two curves have been constructed for potatoes as the two varieties used in the trials showed large differences in reaction. If it is known how much nitrogen on the average is available from the soil for the plants and how much nitrogen is usually supplied to different crops by farmers, it will be possible to verify from the curve of the averages how much further the yield can still be raised by defined larger applications of nitrogenous fertilizers. As for cereals, the quantity of the N in the soil available for the crop can be estimated at 60 kg. per hectare on the average; and for potatoes at 80 (Voran) and 60 kg. (Noordeling) per hectare.

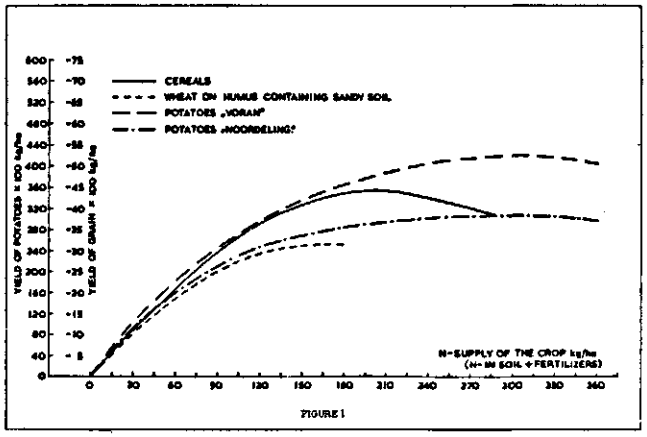

FIGURE 1

Assuming that an average dressing of nitrogen for cereals amounts to 60 kg. N per hectare (in artificials and dung), and for potatoes to 70 kg. N per hectare, it could be stated that the yield of cereals can still be raised by 20 per cent and of potatoes by 15 per cent by increasing the applications of nitrogen. The figures refer to fields treated like the experimental plots. In practice, however, it is not possible to tend crops with so much care and increases of yields due to higher nitrogen supplies up to 10 to 15 per cent for cereals and approximately 10 per cent for potatoes can be expected.

Phosphates

Since the end of the last century it has become common practice to apply generous dressings of phosphates to arable land. Usually this plant nutrient was deficient under natural conditions but owing to that practice the position as to phosphate requirements of soils has greatly improved and is now in general satisfactory. The common opinion is that these favourable conditions should be maintained in order to assure high yields, even if the provision of phosphatic fertilizers might moderately be wanting. Individual differences in treatment added to natural causes have resulted in a large variety of circumstances. Phosphate deficiency is experienced on newly reclaimed soils, on outlying fields, and on badly managed farms; in some districts it is partly due to phosphate fixation; but on the other hand in many cases the store of phosphates is larger than necessary. By advisory work coupled with soil analysis, a better distribution of available phosphatic fertilizers according to need is aimed at.

It is thought possible to achieve satisfactory conditions for plant nutrition in regard to supply of phosphates embodied in the soil all over the country, with few exceptions, without an increase of the total national need for phosphates. It is even possible by applying rational fertilizing schemes to save on them, on behalf of the pastures the requirements of which are more substantial than of arable land. Improvement of methods of husbandry on badly managed farms and in backward districts to current standards would result in a rise of the total national production by 1 to 2 per cent.

A first aim is the maintenance of suitable soil conditions. In addition, moderate quantities of phosphates available to the plants regularly supplied with phosphatic fertilizers are considered to be of more value than P stored in the soil and a good crop, coupled with a small increase in yield thereby is assured. Results of further investigations will determine whether the method of application of phosphatic fertilizer (combined drilling of seed and fertilizer etc.) especially on difficult soils (fixation) and the choice of certain fertilizers on the basis of the kind of phosphate they contain, are advantageous.

Potash

The problem of raising the yield of crops on arable land by applying potassic fertilizers is quite a different proposition. Sandy soils and peaty soils do not contain natural reserves of potash. Application of correct quantities can only be based upon results of research and practical experience. Before the Second World War, manuring with potash was overdone. Higher yields are possible by improved distribution in the soil, taking the varying requirements of the crops into consideration. A rise in yield of from 2 to 3 per cent on the soils mentioned, coupled with some saving of potash fertilizers, is considered a possibility only to be attained in the course of time by advisory work and education. In consequence of the postwar shortage, potash supplies to these soils have been adversely affected, appreciable declines in yields are experienced and gradually the small reserves of potash are spent.

The highest yields of crops on sea-silt soils (all supposed to be rich in potash) can be ascertained by ample application of potassic fertilizers to crops requiring potash and on soils with low potash content. As a matter of fact, the availability of natural reserves for heavy soils is too much taken for granted.

The same applies more or less to river-silt soils but here

a material fixation of potash leads to special measures. The possibility of spot treatment is being investigated. Considering the whole arable area, it is thought to be possible to raise the total yield with a small percentage without increasing the pre-war national need of potash.

Lime

The lime status of the soil is of the utmost importance to the productivity of arable land. Both on clay and sandy soils, lime status and size of yields are closely correlated. To attain the highest yields, clay soils must contain a reserve of carbonate of lime. For sandy soils a pH of approximately 5.5 (determined electrometrically of a suspension in water) is most desirable, but the optimum varies with the fertility of the fields concerned and with the kind of crop to be grown. The average relationship between the pH of the soil and yields of crops is shown in Figure 2.

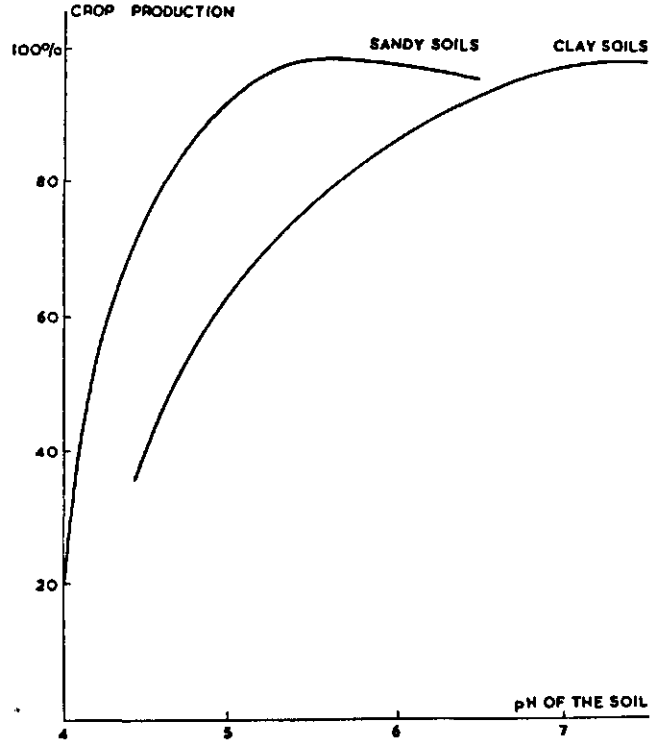

Figure 2. Relation between the pH of the soil and the average yields of arable land on sandy soils and on clay soils. As crops grown on sandy soils show differences in relation upon the pH of the soil, curves of averages have been constructed presuming that 40 per cent of the area is under rye, 20 per cent under potatoes, 20 per cent under oats and 20 per cent under mangolds, pulses and other crops.

Due to a climate enhancing podzol formation the soil is continuously losing chalk by leaching (the average annual rainfall is 717 mm. and evaporation from cultivated land 523 mm.). Silty soil with a proper lime status loses annually 400 kg.CaO per hectare on the average and sandy soil approximately 200 kg.CaO per hectare. These losses of lime, estimated at 200,000 tons annually for the whole country (excluding soils still rich in chalk) are at present only covered for just over one-half by liming and manuring. It will be necessary for advisers and teachers to stress this point.

As pH determinations of soil-samples have taken place on a very large scale, an up-to-date review of the lime status in different agricultural districts could be composed (Figure 3 refers to sandy soils). Both sea-silt soils and sandy soils in the north of the country are much poorer in lime than those in the south. As an average, over 40 per cent of the sandy soils show a pH below standard and 15 per cent of the silty soils are too poor in lime. Of river-silt soils, about 60 per cent are short of lime.

About 25 per cent of all silty soils, i.e., 155,000 hectares are too poor in lime. The yields of the crops can be increased by 10 per cent by liming.

The acidity of 30 per cent of the sandy soils is so high that liming is a paying proposition, as yields would rise by approximately 12 per cent.

The increase in yields to be attained by liming for the whole arable area (1,100,000 hectares) can be estimated at 3 per cent.

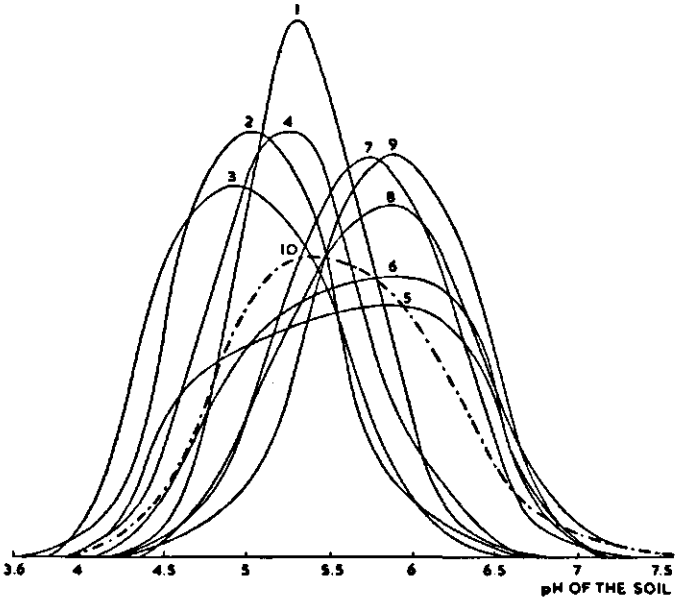

Figure 3. Frequency curves of the pH of arable fields on sandy soils in some agricultural districts: 1 to 4 in the north of the Netherlands; 5 to 7 in the middle of the Netherlands, 8 to 9 in the south of the Netherlands; and 10 the average for the whole country.

Manuring with other inorganic fertilizers

Attention should be drawn to the supply of magnesia for crops on humus sandy soils. In many places symptoms of magnesium deficiency are noticeable with cereals and potatoes. According to a rough estimate, 12,000 tons of MgO are annually applied in manures to arable land on sand but at least 32,000 tons are lost with the crops and by leaching. Therefore alertness is necessary. Before long the problem will be tackled by soil research.

Occasionally yields are held back owing to deficiency of trace elements. Fruit growers especially should take heed of this. Owing to the war, facilities for quantitative determination of trace elements (spectographic analysis) on a large scale are wanting, but this inability will soon be rectified, and then more extensive preliminary investigations will be taken in hand.

Organic manures

In the Netherlands, 12 million tons of decomposed farmyard manure (containing 48,000 tons of N, 26,000 tons of P_2O_5 and 60,000 tons of K_2O) is available annually. In addition, the same quantity of fresh dung is produced by grazing livestock. Of the former, 40 to 50 per cent is used on arable land. In many cases the making and storing of farmyard manure leaves much to be desired. According to trials carried out abroad (now to be repeated under Dutch conditions), improved methods of manure making involve a saving of 25 per cent of organic matter and of 20 per cent of nitrogen which would, of course be of economic importance. Also the way of applying farmyard manure to the land can be improved. On sandy soils the manure should be spread and ploughed in immediately after arrival at the field.

Organic manure not only acts as a fertilizer but has soil-improving effects as well. Several experiments and experiences indicate that more liberal supplies of organic matter (farmyard manure, compost, green manuring and ley farming) to the soil, in addition to roots and stubbles left behind by the crops, will improve the texture of the soil and increase its yielding capacity.

Further possibilities still lie ahead. Several experiments showed increases in yields of 10 per cent and more. Research along these lines is being intensified both in the field and in the laboratory. If more organic matter is going to be applied to arable land eventually, treatment of domestic refuse from urban districts for agricultural use, gains importance. At present only a negligible part of this refuse becomes available to farming. Research will be intensified in this respect, also.

GRASSLAND

The average yield of permanent grassland is estimated at 2,500 kg. starch equivalent per hectare, equal to a yield of 3,500 kg. grain for fodder per hectare, coupled with an average supply of 25 kg. N, 30 kg. P_2O_5 and 25 kg. K_2O contained in fertilizers and all the farmyard manure made on the holding. Experiments of the last twenty years have proved that yields increase considerably by heavy manuring. The reserves of phosphates in the soil leave very much to be desired on one-quarter of the total area, and on another quarter it has to be considered as being moderate or insufficient. Complete data in regard to the supply of potash are not available but the general opinion is that great improvements are possible. By more rational application an increase in yield of 20 per cent might be attained, but not unless drainage and land distribution are improved beforehand. In order to attain this higher level of productivity it will be necessary to supply 180,000 tons of P_2O_5 in total; but then it might be possible to reduce the annual dressings to an average of 15 kg. P_2O_5 per hectare meaning in total a reduction from about 40,000 tons to about 20,000 tons per annum. In regard to potash it is not so easy to make a similar calculation, the more so as the required quantities can be partly provided for by improved storage of dung and liquid manure.

From results recorded on trial plots, it can be gathered that time is not decisive for raising the productivity of soils, but in some peat regions it can be of importance. Permanent pasture on sandy soil with deficient water-supplies can most probably better be replaced by leys. As leys require more lime than permanent grass, dressings of this fertilizer will be necessary to attain yields comparable with those of good permanent pasture.

The yielding capacity of permanent grassland is now stimulated by larger applications of nitrogenous manures. The herbage of permanent pasture does not consist of more than 6 to 10 per cent clover as an average and there are no indications that increases of the clover population of the sward occasion higher yields.

It has been proved by a large number of trials that application of 200 kg. N per annum per hectare, divided into 4 to 6 separate dressings per season results in a net increased yield of 6 kg. starch equivalent per kg. nitrogen and, if combined with improved systems of manuring, of 7 kg. net.

Experience acquired from experiments conducted for some years in succession has taught that these applications can be continued without any danger to the sward and the nutritive value of the grass. If dressings with nitrogenous fertilizers were generally raised to the quantity mentioned the total yield of grass would increase by 40 per cent, and 220,000 tons of extra nitrogen would be needed annually for the total area.

As regards farmyard manure, it is known that the average yields of grass on holdings where it is regularly applied to grassland are considerably higher than on holdings where this practice is not pursued.

On silt soil we recorded a difference of 25 per cent, to the advantage of the former; in the case the supply of minerals contained in farmyard manure was not provided to grassland of the latter in some other way. By application of phosphatic and potassic fertilizers the difference will probably be reduced to 10 per cent. On sandy soils properly supplied with P and K the analogous difference was 10 per cent as an average. This difference in yields is of great importance, as it is specially due to periods of poor growth of grass during droughts.

Yet in the case of mixed farms, farmyard manure is thought to be of more value to arable land than it is to grassland.

Considering the whole country, farmyard manure will be supplied regularly only to one-half of the total area of grassland, and therefore the total yield could be raised by 5 per cent if sufficient quantities were available for general application. For this purpose 6 to 8 million tons of farmyard manure or compost would be required annually. Very strenuous efforts would have to be imposed to acquire sufficient organic material for covering such an enormous demand.

LITERATURE

Most of the particulars used for this paper have been derived from Dutch publications. Further information will be gladly supplied on application.