CONSERVATION OF SOIL FERTILITY IN THE MAIZE BELT*

AGRICULTURE is a permanent industry which must necessarily exist as long as human society, and it is indeed the most important foundation stone on which other industries rest. Since the fertility of the soil is the greatest of the natural resources and the most important factor in agriculture, it follows that it is desirable that every farmer and landowner should not only appreciate the importance but also do everything possible to maintain or increase the fertility of the soil. For this reason, it is worth while to consider the change which has taken place in our maize area, that is, from its original grass covering to its present cultivated condition.

FACTORS RESPONSIBLE FOR CHANGE IN SOIL FERTILITY

The natural vegetation, mainly grass, and a dense layer of litter, formed a carpet which protected the soil against the extreme heat of the sun, the beating of rain and hail, and against erosion. This carpet of plant material retarded evaporation, which made conditions favourable for microscopic life, insects, worms, &c. Subsequent decay of the plant again left a residue, known as humus, which still further improved the physical conditions of the soil, while, by the decomposition of the organic matter and more favourable weathering conditions, elements essential for further plant growth were made available to the soil. The result was a dark-coloured topsoil, with a layer of undecomposed organic matter still on the surface and a lighter coloured subsoil. In this condition of potential high productivity, the soil was at first grazed and cultivated by the pioneers.

Over-stocking, systematic veld burning, and sheet erosion, were unknown, but to satisfy his needs, man created conditions which brought about a complete change. Lands were ploughed annually and planted to maize, and as the productivity decreased, new lands were started on virgin soil. The time, however, arrived when this practice could not be continued, and farmers were compelled to make use of artificial fertilizers. The mineral plantfood was to some extent restored by the artificial fertilizers, but the organic-matter content which is of the greatest importance in soil fertility did not receive attention.

Although it is admitted that our modern requirements have necessitated the substitution of cultivated crops for this natural cover, yet, with the removal of the cover, a change has taken place in the natural development of the granular

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soil structure, and there is no reason to doubt that the major factor responsible for the change in physical condition and for the reduced fertility, is the unwitting removal of the natural protection of the soil afforded by the perennial cover of grass.

During tillage operations for these crops, the soil is temporarily loosened and the destruction of the soil structure which takes place very slowly under natural conditions is accelerated. The smaller particles of the crushed granules must take in a new position, which may lead to clogging of the pores between the remaining granules, and in this way an impervious layer or plough sole is formed. When cultivation is carried out under unfavourable soil-moisture conditions, this destruction of granules is intensified.

Cultivation always brings fresh soil to the surface where it is exposed to the direct rays of the sun, the whole of the top soil is aerated, and all these changes are conducive to the burning-out of humus in the soil. The result is that, to-day, we have a soil which is more compact owing to reduced porosity, in consequence of which root development is hampered, water-storage capacity reduced, run-off water increased and greater damage is caused by frequent droughts.

Much has already been written on the value of organic matter in cultivated soils, and it has been proved again and again by experiments, that organic matter is one of the most important factors in the formation of a granular structure of soils. A brief discussion is advisable in order to indicate its indispensibility in crop farming. The improvement of the structure induced by organic matter also results in the improvement of moisture conditions. In a very loose sandy soil drainage is rapid and plants are badly injured during short periods of drought. This means that the water-holding capacity of a sandy soil is very low. Ploughing under plant residues will improve the water relationship in the soil, owing to the favourable physical effect on the factors influencing water-holding capacity. Humus, which is partially decomposed organic matter, serves as the binding material of the coarse sand particles.

In clayey soil, where cultivation is difficult, drainage and aeration are unsatisfactory, the action of humus is reversed to some extent. Granular structure is promoted and the soil is brought into a friable state which facilitates better drainage, aeration, cultivation and favourable conditions for micro-organisms. In acid soils of a clayey nature, the application of agricultural lime assists the organic matter in bringing about these ideal physical conditions.

For the process of changing fresh organic matter into humus, moisture is indispensable. Manuring with undecomposed or resistant materials must therefore be executed while the soil still contains a fair amount of moisture during the rainy season.

EFFECT OF CHANGE ON EROSION

The substitution of annual crops for the perennial covering also caused great trouble in the form of erosion. Natural agencies only very rarely produce abnormal erosion, but the activity of man, by reducing vegetative cover or altering soil conditions, upsets the balance of nature, so that, in districts with

a high rainfall, the surface begins to wash away, and in those with a low rainfall, to blow away. A bare land surface and the depletion of humus content are the chief causes of erosion.

The results of a 14-year experiment in America, published in 1932, are very interesting in this connexion. It was found that the surface run-off was 12 per cent. of the total rainfall where the soil was subjected to a grass sod, 29 per cent. where continuously planted to maize, and 13·8 per cent. where a rotation of maize, wheat and clover was carried out, and the average annual erosion was found to be 0·34 tons, 19·74 tons, and 2·78 tons of soil per acre, respectively. A somewhat similar experiment was conducted at the University of Pretoria and at the Glen and Grootfontein Schools of Agriculture, the experiment is being repeated. The facts stated above should prompt the farmers concerned seriously to consider changing over from the single-crop system of rotational cropping.

EFFECT OF CHANGING SOIL CONDITIONS ON MICRO-ORGANISMS

Decrease in soil organic matter as a result of cultivation and erosion, may be considered as one of the most important factors causing a reduction of micro-organisms. If it were possible for us to sterilize the soil and to keep it free from micro-organisms under arable conditions, the productivity would immediately fall to a very low standard. These soil organisms have an important effect on fertility, since they are responsible for the decomposition of organic matter, assist in rendering insoluable plant mineral nutrients available, and create new plant-nutritional compounds, *e.g.*, nitrates.

Among the specific micro-organisms commonly present in soil, the nitrifying bacteria (*B. nitrosomnas* and *B. nitrosococcus*) are responsible for the formation of nitrates. The azotobactor bacteria which bind free atmospheric nitrogen, fixing it in an available form for the plant, are very important. Some investigators even judge soil fertility by the abundance of this latter characteristic organism. Soil is usually acid and infertile when this organism is absent. Where the soil is fairly rich in phosphates and organic matter, and the reaction is neutral or sweet, these organisms occur abundantly ; this means that a larger amount of available nitrogen compounds are produced, which will ensure a larger crop for the farmer.

It is often noticed that, when phosphate is applied to the soil, the plants grow better and a larger crop is produced. Some farmers express the idea that the phosphate has a favourable effect on the germination of the seed only, but it is not the case. The increase in production must also be ascribed to the fact that the added phosphate replenishes the sources of available phosphate for the plants and at the same time serves as a nutrient for the micro-organisms responsible for nitrate formation. Not only the available nitrogen is increased, as a result of enhanced micro-organic activity, but also the soluable phosphates. As a result of the carbonic acid produced by the organisms, the insoluble phosphatic compounds are slowly rendered available to plants, a fact which has been confirmed by many investigations.

In contrast to the organisms mentioned above, there are also organisms which, under certain soil conditions, have a destructive effect on the nitrates already

formed. This becomes significant where aeration and structure are poor, or in cases of water logging. These conditions usually cause crops to assume a light green or yellowish colour during wet seasons, indicating lack of oxygen and unsatisfactory conditions for the formation of nitrates.

It is therefore quite clear that in the cultivation of soil, organic matter must receive primary attention. A soil well supplied with organic matter, and if not acid or too alkaline, must necessarily also have a good structure. Such conditions will not only facilitate plant growth, but will also make it possible for the useful bacteria to miltiply rapidly and thus help to maintain the fertility of the soil.

MAINTAINING AND IMPROVING SOIL FERTILITY

The mineral plant nutrients removed from the soil by the crops can be replaced by the application of artificial fertilizers. In most South African soils, phosphate is the limiting nutritional factor; this can be remedied at a low cost by the application of suitable phosphatic fertilizers, but it is in the case of organic matter that sound farm management plays an important rôle.

It is the necessity for conserving organic matter that has claimed the attention of investigators from practically all countries. The form of organic matter which has probably received most attention is farm manure, and, consequently we have a fairly extensive knowledge of its application and action on the soil. Unfortunately, the landowner cannot produce sufficient annually to cover the loss of humus on his cultivated lands. However, the small quantities which are collected should be properly preserved and can in many cases be increased by using more grass for bedding or by making " compost ".

There is little evidence, however, to indicate that a good physical condition of the soil can be maintained when planted continuously to intertilled crops, even though generously manured. At the Rothamsted Experiment Station, England, it was found that yields declined and physical structure apparently deteriorated even when 25 tons of manure per acre were applied annually, and we are therefore compelled to study nature's methods of developing and maintaining physical conditions favourable for plant growth. It was found that after a grass crop or preferably a grass legume mixture was ploughed under on an exhausted land, the physical conditions were much improved. It was shown that the improvement was particularly great in the second year under grass, and that there was comparatively little destruction of aggregates in the first year after cultivation. Results of recent foreign investigations also show that some grasses possess a greater ability than other plants to utilize fairly insoluble phosphates. If such a grass crop is ploughed under, the organic matter also constitutes a good reserve of minerals essential to plant growth. Under favourable conditions, the mineral reserve in the soil is therefore gradually converted into simpler or available forms, and the grass organic matter is changed into humus, which, again, has its favourable physicochemical effects on the soil. These facts teach us how essential it is to compromise with nature and the best way of maintaining soil structure and fertility would be by means of a combination of crop and grassland farming. This practice is possible in our wheat-growing districts of the summer rainfall areas. In most cases a

luxuriant sweetgrass crop is obtained on wheat lands during autumn. If this crop is turned under before winter, it will serve as an excellent green-manuring crop.

Grass green-manuring, however, is not always feasible in areas with a slightly lower rainfall, and we are forced to adopt other methods of crop rotation. It is nevertheless advisable to provide for a hay crop, and where a second cutting is obtained, as in the case of teff or sudan grass, it should rather be ploughed in to augment the organic-matter content of the soil, as this partially decomposed plant material is the most valuable single constituent of soil.

The object of every grain farmer should therefore be to introduce on the already depleted soils as much organic matter as possible, and to practice a method of crop rotation at least to retain the level of the humus where it is still fairly high.

By the addition of sufficient mineral plantfoods in the form of organic matter, the fertility of the soil is not only maintained, but greatly increased, and every farmer and landowner should recognize the importance of this basic factor in crop production.