

MAINTENANCE SOIL FERTILITY

Prepared by the Canterbury Agricultural College, Lincoln

It is the purpose of this bulletin to outline on a general basis factors depleting the fertility of farm lands and to indicate methods and procedures by which fertility may be restored and maintained.

The soils of New Zealand possess vast reserves of plant nutrients. Losses from, and additions to, these reserves are taking place constantly. The losses are chargeable against removal by crops and animals, burning, erosion, and drainage. The additions are mainly to be credited to organic matter from many sources, crop residues and animal manures, lime and artificial fertilisers.

Under the systems of farming practised in New Zealand the annual losses of plant nutrients are far in excess of the annual additions. This has resulted in drawing heavily on the natural fertility built up in the soils as the result of centuries of soil forming processes. If this natural fertility of the soils is considered as a national bank deposit then, up to the present time, the greatest part of the cheques for the gross income of the farming community has been drawn against the deposit, and additions to the reserves have been small. Such a state of affairs cannot continue indefinitely without resulting in greatly reduced production. Already there are indications that the natural fertility of many Canterbury soils has been reduced to a point where it is affecting production. Production of primary produce in Canterbury has not increased to any great extent over the past 30 years despite the increased effort put into farming operations. More intensive methods of soil management must be practised and particular attention must be paid to the restoration and maintenance of fertility of farm lands. It is easier and more profitable to keep soil productive than to restore fertility to exhausted land.

Soil building is a long time process. If every farmer is to hand over his farm to his successor in as good heart or better heart than when he took it over then planned methods for the maintenance of soil fertility must be included in his farming programme.

Depletion of Soil Fertility

This is frequently indicated by open weedy pastures and the presence of plants such as manuka, gorse, and fern, which can grow under low fertility conditions. The most important factor in the depletion of soil fertility is the losses of plant foods. These are lost from the farm by:—

- (1) Selling crops and livestock. (Affects particularly lime and phosphate).
- (2) By erosion or washing away of the fertile top soil particularly where the organic matter has been reduced by burning (affects all nutrients).
- (3) By loss of materials dissolved in the drainage. (Affects mainly nitrogen, lime, and potash).

Some idea of the magnitude of these losses may be gained from the following illustration.

A good cereal crop removes per acre, nitrogen equivalent to that contained in 300lbs. of sulphate of ammonia, phosphate equal to that contained in 100lbs of superphosphate, potash equal to that in 170 lbs. of 30 per cent potash salts and lime equal to 20lbs of ground limestone. Pastures and hay crops remove rather more lime and less phosphate and root crops considerably greater amounts of nitrogen and potash than cereal crops.

Where the crops are fed to stock on the farm about one-third to one-half of these quantities is returned to the available soil supply, the other half is retained by the ani-

mal or lost into the atmosphere or the drainage.

An indication of the quantities of lime, phosphate, and potash lost annually in connexion with exported livestock products can be approximately calculated from the 1935 export figures for meat, wool, butter, and cheese, etc. These show that the equivalent of 20,000 tons of limestone, 50,000 tons of superphosphate and 50,000 tons of 30 per cent potash salts and 190,000 tons of sulphate of ammonia (or 600,000 tons of blood and bone) were withdrawn from the soil reserves during that one year alone. Further additions to those quantities must be made for products consumed within the country and for the growth and maintenance requirements of the animals.

Losses of these plant foods through erosion and drainage are less obvious than those resulting from the selling of crops and livestock products but according to competent authorities overseas they are at least as great as, and in many cases, greater than these. This is particularly the case with lime, which is constantly being removed in large quantities in the drainage waters.

Erosion is responsible not only for losses in soil fertility but also for the filling of stream beds and the covering of good soils with infertile materials. Inadequacy of a protective cover on the high country is largely responsible for damaging floods.

Reduction of Losses

Since New Zealand is primarily engaged in exporting agricultural products, very little can be done to reduce the losses of plant foods in these products. To a certain extent the losses may be reduced through more efficient utilisation of by-products and through more effective conservation and spreading of farm manure. Gains in these directions, however, are negligible compared with those which could be effected by reducing the losses of plant foods in drainage and through erosion of the topsoil. The most effective methods of doing this are by increasing the organic matter content of the topsoil and by keeping a dense cover on the soil.

Restoring Fertility

Soil fertility may be restored and maintained by:

- (1) Applying lime where necessary (there is very little farm land

in New Zealand that is not deficient in lime) in order to improve soil conditions generally, to supply lime itself as a plant food, and to stimulate the growth of leguminous crops.

- (2) Keeping up the supply of organic matter and of nitrogen by establishing clover-rich pastures in the rotation, by green manuring with lupins or by turning under stubble or other crop residues.
- (3) Applying in a readily available form, such as commercial fertilisers, the plant foods which have been most heavily depleted.

Liming

Lime is both a plant food and an improver of soil conditions generally; unless the soil is well supplied with lime it will not hold clovers well and pastures will tend to revert to undesirable grasses and weeds. With most soils liming is an important step in a progressive farming programme. It is essential in establishing favourable conditions for the work of the soil organisms, and, most important of all, in enabling clovers and other legumes to grow strongly and to gather nitrogen from the air.

In addition to benefiting legumes, lime encourages the growth of many other plants including barley and the desirable pasture grasses. Fertilisers are usually more effective, and stock healthier, on limed land. Lime is removed in the drainage waters in larger quantities than any of the other nutrients and the lime content of the soil must be kept up through heavy regular dressings. Where soils are extremely lime deficient, heavy initial dressings of lime should be applied and should be followed by regular applications. One ton to the acre initial dressing followed by annual dressing of 3-5 cwt. per acre should be applied on the heavier soils and half a ton to the acre followed by annual dressings of 3 cwt. for the lighter stony lands. The annual dressings can be replaced by heavier dressings at less frequent intervals.

Increasing Organic Matter and Nitrogen

Decaying organic matter, generally referred to as humus, acts as the stabilising material in the soil and is essential to keep the soil in good tilth, to hold moisture and to provide nitrogen.

Good yields cannot be obtained from soils depleted of active organic

matter and many soils are definitely lacking in this essential material. To maintain the present supply of organic matter in the soil is difficult; to increase it is almost impossible unless all of the means of returning organic materials to the soil are rigidly practised. Even then the increase will be slow owing to the large requirements of crops and the uncontrollable natural losses.

Organic matter may be added in many ways. A certain amount is added in the form of crop residues from cereals and root crops, but this is not sufficient to keep up the supply. Additional supplies must be added and these are best provided in the form of special green feed crops, green manure crops, or through the establishment of good pastures. The most valuable organic materials are those which contain large amounts of nitrogenous compounds. Hence, legume crops which collect nitrogen from the air and supply it to the soil by way of the nodules on their roots are most valuable. It has been shown that a good, well-established crop of lucerne will add annually to one acre of soil nitrogen equal to that in 4 cwt. of sulphate of ammonia, a crop of clover nitrogen equal to 2 cwt., and peas or tares nitrogen equal to one cwt. of sulphate of ammonia.

In the case of annual legume crops which are harvested and the straw burnt, the nitrogen added in the roots is usually insufficient to offset the nitrogen removed in the straw and seeds. Such crops are most satisfactory for green manuring and the proper use of legumes for this purpose may add large quantities of nitrogen to the soil. Blue lupins have given good results on the light soils deficient in organic matter.

The establishment of good permanent pastures rich in clovers is the most satisfactory method of increasing the supply of organic matter and of nitrogen on the greatest portion of the arable areas. Pasture grasses, if allowed to grow for several years, produce a considerable mass of roots which are constantly being added to the soil organic matter. When clovers are grown with the grasses, better root and herbage development occurs. This is due to the utilisation of atmospheric nitrogen by the clover and its subsequent release in the soil, thus encouraging increased growth of the grasses. Certified strains of white clover are most suitable for permanent or semi-permanent pastures on areas where it can be grown. On

soils too light for white clover, subterranean clover should be used. In general more organic matter and plant nutrients are lost from the soil when it is under root or cereal crops than when it is under pasture. With the root crops and cereal crops conditions are more favourable for decomposition and the organic matter decays more rapidly than under pasture. This results in a larger use of nitrogen by the crops and in more loss of nutrients in the drainage before planting and after harvesting. For these reasons root and cereal crops should be grown in rotation with good pastures.

Applying Fertilisers

The three main plant foods, apart from lime, which crops must obtain from the soil, are nitrogen, phosphate, and potash. Only a small percentage of the total amount of each of these plant foods in the soil is in a form which can be used directly by plants. This supply is often quickly utilised by the growing crop, and additional soil supplies which become available slowly, are insufficient to carry on the crop. Under these conditions the use of a readily available source of plant food or fertiliser is essential. The most widely deficient plant food is phosphate, and phosphatic manures should be used on nearly all crops over the greater portion of New Zealand. Although they are used almost universally on cereal and root crops this is certainly not the case with pastures, and to avoid further depletion a considerable expansion in the top-dressing of pastures must take place within the next few years.

Deficiencies of nitrogen are also widespread but except for special cases such as horticultural and market garden crops and high producing root crops and out of season herbage production these can best be overcome by stimulating the legumes in the pasture or in the rotation through liberal applications of lime and phosphate. The supplies of available potash in most of the soils of New Zealand are high but steadily increasing importance will have to be paid to potash manuring as the nitrogen supplies are increased through clover-rich pastures. The total quantities of fertiliser used at the present time are quite inadequate to offset the drain upon the soil reserves of plant nutrients, and the extended use of fertilisers, both of organic and inorganic origin must play a large part in maintain-

ing the fertility of these lands in the future. Fertilisers give the best results when the other conditions affecting fertility are met.

Summary

One of the basic factors affecting the efficient production of farm produce is the fertility of the soil.

Soil Fertility as a Part of the Capital Value of Farm Land

As has been indicated, the fertility of the soil is the inherent foundation on which the economic usefulness of our farm lands rests. If fertility be depleted then the value of the land on a productive basis inevitably shrinks and so the problem resolves itself into the constant replacing by all the means at our disposal of the fertility drain which farm production must exact. From the economic point of view a new outlook must be adopted by farmers, purchasers, mortgagees, sellers and the State, towards the question of fertility maintenance and its relationship to capital values and land taxation. All valuations of farm lands must allow for the cost of the maintenance of soil fertility.

Soil fertility is depleted by:

- (1) Selling crops and livestock from the farm.
- (2) Erosion of the fertile top-soil.
- (3) Loss of plant foods in the drainage water.

Erosion may be prevented or reduced by maintaining a close vege-

tative cover on the soil.

Soil fertility may be restored and maintained by a planned farming programme. Liming where needed is the first step, addition of organic matter and nitrogen through clover-rich pastures or by feeding off or turning under green crops is the second; fertilising particularly with phosphates is the third; and feeding crops to live stock and thereby returning the manure to the land is the fourth step in the maintenance of soil fertility. On cropping areas, it is necessary in addition to practise suitable rotation of cereal and root crops with pasture.

The Bulletins are obtainable:

- (a) From the Secretary of the Canterbury Chamber of Commerce—6d each or 5/- per annum for a copy of each Bulletin as issued posted direct to the subscriber.
- (b) Through Farmers' Unions or other organisations where a group of farmers is supplied with Bulletins—1/- for each ten copies. Under this arrangement distribution of the Bulletins to individual farmers is undertaken by the group.
- (c) Bound volumes containing 50 Bulletins with index, £1.