August 1952

Canterbury Chamber of Commerce Agricultural Bulletin No. 277

Cropping and Soil Fertility

J. W. CALDER
Associate Professor of Field Husbandry

SOIL fertility refers to the capacity of the soil to produce crops or pasture. It is difficult to describe a fertile soil because so many factors interact to produce the final result, e.g., temperature, moisture, organic matter, lime, soil micro-organisms, air and nutrients apart from mechanical structure. To obtain a good crop, however, a soil must be capable of supplying adequate moisture and nutrients for plant growth and development. Most agricultural soils are today not naturally fertile but can be made so by cultivation, by drainage or irrigation, by application of lime and fertilisers or by rotation of crops. The fertility of a soil determines the productivity of that soil. This is a basic principle and most normal practices in connexion with crop sequences, cultivation and fertilising aim at achieving a high level of fertility.

Effect of Cropping on Soil Fertility

The natural effect of cropping is to draw on the supply of available nutrients and moisture and thereby reduce the fertility of the soil. The preparatory cultivation provides suitable conditions for the breakdown of organic matter and the release of nutrients. Thus while cultivation is necessary for the preparation of a seed bed and while it favours crop growth by releasing nutrients it also results in an accelerated loss of organic matter which must be replaced if the fertility of the soil is to be maintained. Crops vary widely in the demands they make on soil nutrients. (See Table I).

TABLE I. Showing the approximate quantity of nutrients in pounds per acre removed from the soil by some crops.

Nutrients	N Nitrogen	P_2O_5 Phosphate	K_2O Potash	CaO Lime	Water absorbed from soil	CO_2 absorbed from air
Wheat (32 bushels)	60	20	30	10	600 tons =6 ins.	3 tons
Barley (40 bushels)	50	20	35	10	550 tons =5½ ins.	2¾ tons
Peas (30 bushels)	80	10	40	45	500 tons =5 ins.	2½ tons
Turnips (15 tons)	50	25	125	30	400 tons =4 ins.	2½ tons
Mangels (50 tons)	170	100	500	50	1800 tons =18 ins.	10 tons
Potatoes (6 tons)	45	25	80	3	450 tons =4½ ins.	2 tons
Hay (1½ tons)	50	12	50	30	400 tons =4 ins.	2 tons

A given crop may impoverish the soil in some respects and improve it in other ways either directly or indirectly. The ultimate effect depends on the balance between the losses and gains in organic matter, nutrients, moisture; it also depends on changes in soil structure. These factors vary according to: (1) The period of preparatory cultivation, (2) the length of the growing period of the crop, (3) the kind of crop—whether cereal or forage, (4) the bulk of the crop, (5) the amount of fertilisers used, (6) the amount and quality of crop residues ploughed under or grazed, (7) the nature and extent of the root systems.

With so many variables it is not possible to place crops in a fixed and definite order in regard to their effect on the soil but they can be listed in two major groups.

A. Exhaustive crops—which impoverish the soil more than they improve it.

B. Restorative crops—which improve the soil more than they impoverish it.

A. Exhaustive Crops.

The most important crops in this group are the cereals, linseed, potatoes, lupins and peas grown as cash crops, although the latter two are usually looked on as restorative. Since such crops usually give a good monetary return they are used to cash-in on the fertility which has been built up during a spell under restorative crops. Prolonged and continuous cash cropping, however, leads to a rapid deterioration of fertility through a depletion of available nutrients and a loss of soil structure. Since the recuperation of over-cropped land can be a lengthy and costly process, a clause is often inserted in leases restricting the proportion of the farm that may be sown in exhausting crops in any year and limiting the frequency in any field.

1. Cereals. The cereals, or "white straw" crops—wheat, oats and barley—are regarded as being the most depletive of all farm crops. When autumn sown, they occupy the land for a long time; during the winter the soil is consolidated and leached and they deplete the soil of moisture during the summer months. Spring sown cereals and linseed are less exhausting than autumn sown crops. Several successive cereal crops may lower the fertility and spoil the structure of the soil to such an extent that succeeding crops or pasture make indifferent growth. Barley and oats are both easier on the land than wheat, so that if more than two cereal crops are grown in five years the inclusion of one of these crops in the rotation is recommended.

2. Other cash crops. In addition to the cereals and linseed there are other widely grown crops that are exhaustive, but to a lesser degree. Lupins and peas harvested for seed and potatoes may be regarded as being partly exhaustive and partly restorative. Potatoes, though gross feeders, are of special value as a fallow and cleaning crop. The long preparatory and extensive cultivation before and after planting, and the heavy manuring given the crop are all reflected in improved conditions for the succeeding crop. Peas and lupins are legumes and as such they enrich the soil in nitrogen and improve the tilth. However, when these crops are harvested much of the nitrogen is removed in the seed and straw and the restorative effects barely compensate for the removal of other nutrients.

B. Restorative Crops.

The forage crops as a group are more restorative than they are destructive. These together with the special green-manure crops, lucerne and good grazing pastures, represent the restorative crops which are grown in rotation with exhaustive crops to offset the effects of the latter.

1. Forage crops. These have an essential place on arable land as supplementary feed supplies for fattening and wintering of stock. The greater the bulk produced the more valuable the crop; hence forage crops are usually grown after pasture when the soil is richest in humus. Forage crops may be regarded as preparatory crops for cereals which generally follow them in the rotation. Through the addition of dung and urine from the grazing animals the forage crop also improves the fertility of the land on which it is fed, and it is good farming practice to feed it, if possible, on the land on which it is grown.

2. Green manure crops. These may be regarded as wholly restorative in that they are sown for the sole purpose of producing an abundant leafy growth which can be ploughed under to build up the humus content. Since they are not used for feed they are more costly than forage crops and are more effective as

fertility restorers, particularly if they include legumes grown alone or in a mixture; but the difference between the value of a green-manure crop fed off and one ploughed under, rarely justifies the practice of ploughing under. In the spring or summer when the soil temperatures are high, decomposition of the green material is active and for a period of a month or six weeks after a heavy crop is ploughed under a high proportion of the available soil nutrients are required by the decay organisms. This often accounts for the poor growth which may follow when a crop is sown shortly after ploughing under a green manure crop or cereal straw.

3. Good grazing pastures. These may be either the short rotation type of pasture consisting of Italian ryegrass and red clover, or the long rotation type based on perennial grasses and white clover. The more vigorous the pasture and the greater its clover content the greater is its restorative power. The improvement is affected by (a) the addition of nitrogen from the legume, (b) the addition of nutrients from the dung and urine of the grazing animals, (c) the addition of lime and phosphate in the form of top-dressing, (d) the improvement in soil structure through the activity of the roots of the grasses and clovers.

In an experiment on rotations conducted at the College the yield of wheat as the last crop in a rotation was 58-65 per cent greater in the rotations which included two years in pasture than in the rotations where pastures were not included. The use of improved pastures has been a feature of farming in Canterbury during the past fifteen years and this is reflected in part in increased yields which are being obtained. For example, on the College farm the average yields of wheat over five year periods since 1920 were as follows: 39.7; 46.1; 43.1; 44.3; 44.0; and 51.5 bushels per acre. It is realised that there are several factors operating to account for the sharp rise in the latter period but a major factor has been the exploitation of improved pastures in the cropping system.

Crop Rotations

One of the principal functions of crop rotations is to ensure a balance between soil exhausting and soil restorative crops. The precise arrangement can vary provided the balance is adjusted in favour of maintenance of soil fertility. The system of farming adopted, whether emphasis is given to livestock or cash crops, determines what crops and what proportions of the different classes are grown. The arrangement in sequence will depend on the judgement of the farmer. In Table II some variations in balance between crops and pastures found on mixed cropping farms in Canterbury are shown.

TABLE II. Showing Variations in Percentage of Farm in Cash Crops, Forage Crops and Pasture on Three Soil Types in Canterbury.

Type of Land	Percentage in Cash Crops	Percentage in Forage Crops	Percentage in Pasture
Light	0-10	5-10	80-95
Medium	10-20	5-15	70-85
Heavy	35-60	0-5	35-80

A few of the main variations in rotations commonly practised are:—

(1) Predominantly cash cropping.
   (a) Peas-wheat-peas-wheat, etc.
   (b) Potatoes-wheat-lupins (for green manure), potatoes-wheat, etc.
   (c) Old grass-potatoes-wheat-potatoes or peas-wheat-oats or barley-new grass.

(2) Predominantly Forage Cropping.
   (a) Old grass-turnips or swedes-new grass or rape and new grass or turnips and new grass or greenfeed and new grass or oats-greenfeed and new grass.
   (b) Old grass-turnips-rape-greenfeed and new grass.
   (c) Old grass-oats-turnips-rape and new grass.
   (d) Old grass-rape-greenfeed oats and new grass.

(3) Mixed Farming.
   (a) Old grass-peas-wheat (one or two crops)-oats or barley-new grass.
   (b) Old grass-peas-wheat-barley-Italian ryegrass and red clover (2 years)-wheat-new grass.
   (c) Old grass-potatoes-wheat-barley-new grass.
   (d) Old grass-linseed-wheat-oats or barley-new grass.
   (e) Old grass-turnips-rape-wheat-new grass.
   (f) Old grass-rape or lupins-

wheat-rape-new grass.

(g) Old grass-lupins for seed-lupins for greenfeed-wheat-new grass.

These are just a few of the possible rotations which may be adopted and they may be modified should climate, soil, needs of stock, disease, weeds or any other factor suggest a change, according to the needs of the farmer or the farm.

Conclusion:

Cropping is an essential function of arable farming and the mixed farmer must continue to crop his land in order to provide food for the people. Certain forms of cropping are exhaustive of soil fertility, but provided a balance is struck between exhaustive and restorative crops, and provided good grazing pasture is included in the rotation, there is every indication that a permanent system of production from the land can be continued. The fertility of the soil may be temporarily reduced by cash cropping but it can be recovered provided good husbandry is practised.

Copies of this Bulletin may be obtained from the Secretary, Canterbury Chamber of Commerce, P.O. Box 187, Christchurch.
