THE STORY OF A LOAF OF BREAD

CHAPTER I

WHEAT GROWING

WHEAT is one of the most adaptable of plants. It will grow on almost any kind of soil, and in almost any temperate climate. But the question which concerns the wheat grower is not whether he can grow wheat, but whether he can grow it profitably. This is a question of course that can never receive a final answer. Any increase in the price of wheat, or any improvement that lowers the cost of cultivation, may enable growers who cannot succeed under present conditions to grow wheat at a profit. Thus if the population of the world increases, and wheat becomes scarce, the wheat-growing area will doubtless be extended to districts where wheat cannot be grown profitably under present conditions. A study of the history of wheat-growing in this country during the last century shows that the reverse of this took place. In the first half of that period the population had increased, and from lack of transport facilities and other causes the importation of foreign wheat was small. Prices were high in consequence and every

acre of available land was under wheat. As transport facilities increased wheat-growing areas were developed in Canada, in the Western States of America, in the Argentine, and in Australia, and the importation of foreign wheat increased enormously. This led to a rapid decrease in prices, and wheat-growing had to be abandoned on all but the most suitable soils in the British Isles. From 1880 onwards thousands of acres of land which had grown wheat profitably for many years were laid down to grass. In the last decade the world's population has increased faster than the wheat-growing area has been extended. Prices have consequently risen, and the area under wheat in the British Isles will no doubt increase.

But although it cannot be stated with finality on what land wheat can be grown, or cannot be grown, at a profit, nevertheless accumulated experience has shown that wheat grows best on the heavier kinds of loam soils where the rainfall is between 20 and 30 inches per annum. It grows nearly as well on clay soils and on lighter loams, and with the methods of dry farming followed in the arid regions of the Western States and Canada, it will succeed with less than its normal amount of rainfall.

It is now about a hundred years since chemistry was applied with any approach to exactitude to questions affecting agriculture; since for instance it was first definitely recognised that plants must

obtain from their surroundings the carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur, potassium, calcium, and other elements of which their substance is composed. For many years there was naturally much uncertainty as to the source from which these several elements were derived. Experiment soon showed that carbon was undoubtedly taken from the air, and that its source was the carbon dioxide poured into the air by fires and by the breathing of animals. It soon became obvious too that plants obtain from the soil water and inorganic salts containing phosphorus, sulphur, potassium, calcium, and so on; but for a long time the source of the plants' supply of nitrogen was not definitely decided. Four-fifths of the air was known to be nitrogen. The soil was known to contain a small percentage of that element, which however amounts to four or five tons per acre. Which was the source of the plants' nitrogen could be decided only by careful experiment. As late as 1840 Liebig, perhaps the greatest chemist of his day, wrote a book on the application of chemistry to agriculture. In it he stated that plants could obtain from the air all the nitrogen they required, and that, to produce a full crop, it was only necessary to ensure that the soil should provide a sufficient supply of the mineral elements, as he called them, phosphorus, potassium, calcium, etc. Now of all the elements which the farmer has to buy for

application to his land as manure, nitrogen is the most costly. At the present time nitrogen in manures costs sevenpence per pound, whilst a pound of phosphorus in manures can be bought for fivepence, and a pound of potassium for twopence. The importance of deciding whether it is necessary to use nitrogen in manures needs no further comment. It was to settle definitely questions like this that John Bennet Lawes began his experiments at his home at Rothamsted, near Harpenden in Hertfordshire, on the manuring of crops. These experiments were started almost simultaneously with the publication of Liebig's book, and many of Lawes' original plots laid out over 70 years ago are still in existence. The results which he obtained in collaboration with his scientific colleague, Joseph Henry Gilbert, soon overthrew Liebig's mineral theory of manuring, and showed that in order to grow full crops of wheat it is above all things necessary to ensure that the soil should be able to supply plenty of nitrogen. Thus it was found that the soil of the Rothamsted Experiment Station was capable of growing wheat continuously year after year. With no manure the average crop was only about 13 bushels per acre. The addition of a complete mineral manure containing phosphorus, calcium, potassium, in fact all the plant wants from the soil except nitrogen, only increased the crop to 15 bushels per acre. Manuring with nitrogen on the other hand increased the crop

to 21 bushels per acre. Obviously on the Rothamsted soil wheat has great difficulty in getting all the nitrogen it wants, but is well able to fend for itself as regards what Liebig called minerals. This kind of experiment has been repeated on almost every kind of soil in the United Kingdom, and it is found that the inability of wheat to supply itself with nitrogen applies to all soils, except the black soils of the Fens which contain about ten times more nitrogen than the ordinary arable soils of the country. It is the richness in nitrogen of the virgin soils of the Western States and Canada, and of the black soils of Russia, that forms one of the chief factors in their success as wheat-growing lands. It must be added, however, that continuous cropping without manure must in time exhaust the stores of nitrogen in even the richest soil, and when this time comes the farmers in these at present favoured regions will undoubtedly find wheat-growing more costly by whatever sum per acre they may find it necessary to expend in nitrogenous manure. The world's demand for nitrogenous manure is therefore certain to increase. Such considerations as these inspired Sir William Crookes' Presidential address to the British Association in 1898, in which he foretold the probability of a nitrogen famine, and explained how it must lead to a shortage in the world's wheat supply. The remedy he suggested was the utilization of water-power to

provide the energy for generating electricity, by means of which the free nitrogen of the air should be brought into combination in such forms that it could be used for manure. It is interesting to note that these suggestions have been put into practice. In Norway, in Germany, and in America waterfalls have been made to drive dynamos, and the electricity thus generated has been used to make two new nitrogenous manures, calcium nitrate and calcium cyanamide, which are now coming on to the market at prices which will compete with sulphate of ammonia from the gas works, nitrate of soda from Chili, Peruvian guano, and the various plant and animal refuse materials which have up to the present supplied the farmer with his nitrogenous manures. This is welcome news to the wheat grower, for the price of manurial nitrogen has steadily risen during the last decade.

Before leaving the question of manuring one more point from the Rothamsted experiments must be referred to. It has already been mentioned that when manured with nitrogen alone the Rothamsted soil produced 21 bushels of wheat per acre. When, however, a complete manure containing both nitrogen and minerals was used the crop rose to 35 bushels per acre which is about the average yield per acre of wheat in England. This shows that although the yield of wheat is dependent in the first place on the nitrogen supplied

by the soil, it is still far from independent of a proper supply of minerals. A further experiment on this point showed that minerals are not used up by the crop to which they are applied, and that any excess left over remains in the soil for next year. This is not the case with nitrogenous manures. Whatever is left over from one crop is washed out of the soil by the winter rains, and lost. Translated into farm practice these results mean that nitrogenous manures should be applied direct to the wheat crop, but that wheat may as a rule be trusted to get all the minerals it wants from the phosphate and potash applied directly to other crops which are specially dependent on an abundant supply of these substances.

At Rothamsted, Lawes and Gilbert adopted the practice of growing wheat continuously on the same land year after year in order to find out as quickly as possible the manurial peculiarities of the crop. This however is not the general system of the British farmer, but it has been carried out with commercial success by Mr Prout of Sawbridgeworth in Hertfordshire. The Sawbridgeworth farm is heavy land on the London clay. Mr Prout's system was to cultivate the land by steam power, to manure on the lines suggested by the Rothamsted experiments, and to sell both grain and straw. Wheat was grown continuously year after year until the soil became infested with weeds, when

some kind of root crop was grown to give an opportunity to clean the land. A root crop is not sown until June so that the land is bare for cleaning all the spring and early summer. Such crops also are grown in rows two feet or more apart, and cultural implements can be used between the rows of plants until the latter cover the soil by the end of July or August. After cleaning the land in this way the roots are removed from the land in the winter and used to feed the stock. By this time it is too late to sow wheat, so a barley crop is sown the following spring, and with the barley clover is sown. Clover is an exception to the rule that crops must get their nitrogen from the soil.

On the roots of clover, and other plants of the same botanical order, such as lucerne, sainfoin, beans and peas, many small swellings are to be found. These swellings, or nodules as they are usually called, are produced by bacteria which possess the power of abstracting free nitrogen from the air and transforming it into combined nitrogen in such a form that the clover or other host-plant can feed on it. The clover and the bacteria live in Symbiosis, or in other words in a kind of mutual partnership. The host provides the bacteria with a home and allows them to feed on the sugar and other food substances in its juices, and they in return manufacture nitrogen for the use of the host.

When the clover is cut for hay, its roots are left in the soil, and in them is a large store of nitrogen derived from the air. A clover crop thus enriches the soil in nitrogen and is the best of all preparations for wheat-growing. After the clover, wheat was grown again year after year until it once more became necessary to clean the land. This system of wheat-growing was carried on at Sawbridgeworth for many years with commercial success. It never spread through the country because its success depends on the possibility of finding a remunerative market for the straw. The bulk of straw is so great compared with its price that it cannot profitably be carried to any considerable distance. The only market for straw in quantity is a large town, and there is no considerable area of land suitable for wheat-growing near a sufficiently large town to provide a market for the large output of straw which would result from such a system of farming.

The ordinary practice of the British farmer is to grow his wheat in rotation with other crops. Various rotations are practised to suit the special circumstances of different districts, one might almost say of special farms. This short account of wheat-growing does not profess to give a complete account of even English farming practice. It is only necessary to describe here one rotation in order to give a general idea of the advantages of that form of husbandry.

For this purpose it will suffice to describe the Norfolk or four course rotation. This rotation begins with a root crop, usually Swede turnips, manured with phosphates, and potash too on the lighter lands. This crop, as already described, provides the opportunity of cleaning the land. It produces also a large amount of food for sheep and cattle. Part of the roots are left on the land where they are eaten by sheep during the winter. The roots alone are not suitable for a complete diet. They are supplemented by hay and by some kind of concentrated food rich in nitrogen, usually linseed cake, the residue left when the oil is pressed from linseed. Now an animal only retains in its body about one-tenth of the nitrogen of its diet, so that nine-tenths of the nitrogen of the roots, hay and cake consumed by the sheep find their way back to the land. This practice of feeding sheep on the land therefore acts practically as a liberal nitrogenous manuring. The trampling of the soil in a wet condition in the winter also packs its particles closely together, and increases its water-holding power, in much the same way as the special cultural methods employed in the arid western States under the name of dry farming. The rest of the roots are carted to the homestead for feeding cattle, usually fattening cattle for beef. Again the roots are supplemented by hay, straw, and cake of some kind rich in nitrogen. The straw from former crops is used for litter. Its