CHAPTER I

ROTATIONS

A study of crop husbandry logically starts with a consideration of rotations, because the treatment that a field has received in previous years greatly affects the success of a crop which, in its turn, may have an important influence on production in succeeding years. No true picture of the right methods of husbandry can therefore be gained if each crop is regarded as a separate entity: from the outset the view to be cultivated is the long one, which embraces the effect of one crop upon another, and the considerations which should guide a farmer in determining his sequence of cropping.

At the dawn of history, when man forsook the chase for the plough as his main means of obtaining food, his principle was to crop a convenient piece of land continuously until it was exhausted, and then to abandon it and move to a fresh site. This was undoubtedly sound as long as fresh sites were available, but is scarcely to be recommended in the modern world. Nevertheless, it is still the general procedure of natives in certain parts of Africa, and the continuous growing of wheat on American prairies was essentially similar. During the agricultural depression between the two World Wars some of the poorest lands of this country were abandoned to whatever nature ordained should grow there. In the food production campaign of 1939–45 these derelict areas were reclaimed and, with proper draining, liming and manuring, produced very satisfactory and welcome crops. Whilst they were rough they slowly accumulated a small store of fertility, exemplifying the underlying principle of shifting cultivation.

Any permanent form of agriculture clearly requires a sequence of cropping which will maintain the land continuously in a cultivable condition. Such a rotation was first established in this country in the early centuries of the Christian era, and it persisted over a large part of England with very little variation for over 1500 years. The rotation—autumn corn, spring corn,

fallow—was almost universal for that long period, during which departure from it was severely discouraged, though a few bold spirits experimented to some extent. It was not until the eighteenth century, when roots and clover became established as farm crops, that any general change was made. The introduction of these two crops enabled farmers to utilise their land more fully; on the lighter soils it was no longer necessary to waste a year in fallowing, whilst on the heavier soils the proportion of fallow could be reduced well below one-third. During the eighteenth century rotations including roots and clover were slowly evolved and gradually adopted; in general it can be said that there was little further change till the beginning of the present century.

During recent years rotations have changed rapidly, but the most fundamental change has been in the rigidity to which they are adhered. Previous to 1874 a tenant farmer had no choice in the matter. His lease prescribed the rotation on which he was to farm, and he could not depart from that sequence without his landlord's permission, which was sparingly granted. A series of Acts passed from 1874 to 1908 gave tenant farmers freedom of cropping, but they are still liable to dilapidation claims on quitting their farms if their system of cropping has impaired the fertility of their land. At the present time it seems but natural that a farmer should be allowed to grow what he likes on the land that he rents, but it is not justifiable to regard the old insistence of landlords that their tenants should keep to a stated rotation as merely tyrannical. It was not only to the landlord's advantage, but also to the tenant's, that the land should be maintained in a state of high fertility, and this was achieved very largely by a good rotation. It must be remembered that chemical manures have only become available quite recently, and knowledge of their potentialities is still not universal among the farming community; now that sufficient supplies are available an informed farmer may, without impoverishing his soil, take liberties which would have been disastrous for his forefathers. Again, the tractor has given the farmer power to work the soil more thoroughly at crucial seasons, and with the further aid of modern selective weed killers has made it possible to keep the land reasonably clean of weeds, even though corn be grown

more frequently than an earlier generation of farmers would approve. Furthermore, an immutable rotation is only suitable for settled economic conditions, and since 1914 conditions have been anything but settled. It is not surprising, therefore, that rigid adherence to rotations is no longer common, that progressive men are often heard to speak with scorn of rotations, and that the present generation is seeing bold experiments made in this connection.

It would be idle to deny that many men, who have cropped their land with an eye on market probabilities rather than in conformity with established practice, have been successful; at the same time it is undoubtedly true that some who have boasted that they were untrammelled by tradition have been forced to revert to the old-established rotations. It is best to keep a very open mind on this question of originality versus custom. Conditions have changed so much in the last hundred years that old sequences of cropping may be out-of-date, but few farmers will be in a hurry to discard that which is sanctified by centuries of experience; in this they are wise, for it must be remembered that weaknesses in rotations show themselves very slowly. Thus, despite the fact that good farmers often boast that they are no slavish followers of a rotation, it is as important as ever to have a clear understanding of the principles underlying rotations; perhaps it is even more important, since if one leaves the beaten track it is more necessary to know the location of pitfalls than if one keeps to the broad highway.

It will have been gathered from what has been said above that a rotation is a settled sequence of cropping; as will be seen later, its length may be almost anything, but in general it is between 3 and 8 years. To illustrate how a rotation works in practice, a moment's consideration may be devoted to a very well-known case—the Norfolk four-course rotation of roots-barley-seeds-wheat. Approximately one-quarter of the arable land will grow these crops in the 1st, 2nd, 3rd and 4th years respectively, returning to roots in the 5th, barley in the 6th, and so on. Another quarter will follow exactly the same course, but will start one year ahead, growing barley in the 1st year; a third quarter will carry seeds in the 1st year, whilst the remaining quarter will

carry wheat. In this way the acreage of the various crops on the farm remains roughly constant from year to year, but each field grows all crops in succession.

UNDERLYING PRINCIPLES

The principles on which rotations have been built up are very diverse; some of the principles are based on science, some on economics, whilst others are matters of common sense. It will be convenient to divide their consideration into two parts, and to deal first with the advantages gained from growing crops in a rotation, and then to take the points which arise in deciding on a rotation for a particular farm.

ADVANTAGES OF A ROTATION

1. The fact that the farmer is working to a settled plan, and is not constantly improvising. In view of the varied activities and interests of the farmer, and of the way in which he has to dovetail his work and that of his men, the point is entitled to some weight. It may be wholly admirable for engineers to improvise, because they thoroughly understand the construction and working of the machines under their control, but the farmer is dealing with biological material, and his knowledge of its working is, by comparison, miserably superficial. If he keeps to a rotation carefully thought out in the light of other people's experience he has little to fear, but if he strikes out boldly for himself it may be equivalent to putting a spanner among the cog wheels. Furthermore, a settled plan of cropping may be accompanied by a more or less settled plan of manuring; advice on the plan, if necessary, can easily be obtained, and adherence to it (with, of course, variations dictated by level of fertility of particular fields, by prices, etc.) will maintain at a roughly constant level the fertility of all the arable land.

2. All the other advantages of a rotation follow from the fact that it ensures that each field receives a proper succession of crops. The points to be considered here are of paramount importance, and it will be easier to take them under three headings.

(*a*) *Cleaning*. There are many species of weeds, and between them they exhibit almost every conceivable habit of growth. It follows that if the same, or a similar, crop be grown continuously on the same piece of land there will be at least one species of weed that will be favoured by the time and type of cultivation carried out; this species will therefore spread rapidly, and from being perhaps relatively innocuous will become so prevalent that it will dominate the crop. As an example, the common infestation of heavy land with slender foxtail (commonly called black grass) may be mentioned. This weed is an annual, germinating from October to Christmas, and it ripens its seeds in June and July. On heavy land autumn sowing is very common, because farmers know from experience that on such land it may be impossible to drill in spring; thus in a large proportion of years a seedbed is prepared at the optimum time for the slender foxtail to germinate, and a corn crop is planted which will not be harvested until after the weed has ripened and shed its seed. To control the weed a very good method is to go through the motions of preparing an autumn seedbed, but not to drill the seed; then, when the slender foxtail has germinated, the land may be cultivated, or even ploughed, and the young seedlings killed in vast numbers. In other words the method rests in risking a wet spring and taking a spring-sown crop, this being more effective than late sowing of an autumn crop. This is only one example, but many others might be quoted to show that a rotation, by bringing different crops to a field in successive years, and thus ensuring cultivation at different times of the year, does much to prevent the land from becoming foul. Continuous wheat growing has often been attempted but has always broken down because the land has become foul.

There is another way in which a rotation helps to keep the farm clean. It will ensure that fallows, cleaning crops, semi-cleaning crops and smothering crops occur in due course on all the fields of the farm; the fact that this point is obvious should not blind the reader to its supreme importance.

(*b*) *Diseases and Pests*. Many and varied are the diseases and pests to which crops are subject, but most of the ills are specific to one or two crops; where, therefore, the organism lives in the soil, the first method of control is not to grow susceptible crops

frequently on the same field, and thus to avoid providing the organism with hosts on which to multiply. It is true that some farmers have neglected the danger with impunity, but they do so at great peril, and many grim tales can be told to show how real the danger is. Eelworm provides an example. Eelworm may be present in a field in considerable numbers without any appreciable harm to a crop, but if the numbers of a particular strain of eelworm exceed a certain figure (which may be of the order of 200,000,000,000 per acre) practically complete failure of crops susceptible to that strain results. It is a merciful fact that the different strains of eelworm rigidly adhere to one or two crops each as their victims, and consequently ordinary good farming—of which growing crops in a rotation forms a part—is sufficient to keep the numbers down; but there have been cases, where rotations have been discarded, where the most serious results have occurred. There is an area of greensand in Bedfordshire eminently suited by its soil and situation to market gardening and, in particular, to the production of early potatoes, and that crop has been taken continuously on the same field by a number of farmers; the potato eelworm has increased on some of these fields so much that it has become impossible to grow a crop of potatoes at all. The land is practically pure sand and must be farmed very highly if a crop is to be grown, and only early potatoes appear to justify the generous treatment necessary; when that crop becomes impossible the land is not worth farming and consequently fields, which previously commanded rents of £3 per acre or more, have been allowed to go derelict. Then the eelworm slowly dies out and after 12 or 15 years the land is no longer 'potato sick' so that it can be brought back to production again; there arises again the temptation to crop too closely with potatoes and thus to build up once more an overwhelming population of eelworm. The fact that the severe infestation with eelworm was simply due to bad farming has been recognised in law, and heavy damages have been awarded against a farmer for ruining his landlord's property by growing potatoes too frequently. It is not only in Bedfordshire that the trouble has arisen; there are many other districts in the country which could be quoted to show how neglect of the principle of rotations, by growing potatoes too frequently, has led to disaster.

The sugar-beet eelworm has also had devastating effects, and some sugar-beet factories have had to close down in Germany because the area they served became so badly infested with the pest, through too frequent growing of the crop. It is a reproach to British farming that within 15 years of the introduction of sugar beet to general cultivation crop failures due to eelworm occurred. The peril was appreciated by the sugar-beet factories and a clause was introduced into the farmers' contract with the factory, prohibiting the growing of sugar beet for 2 years running on the same field; this was a wise clause but not sufficiently stringent and in 1943 the Sugar Beet Eelworm Order was made to give a tighter control. The latest Order (1952) prohibits, save under special licence from the County Agricultural Committee, the growing of sugar beet, mangolds, red beet, spinach and the brassicae on any land where sugar-beet eelworm is known to exist, and on all land within an Infected Area where any of those crops have been grown during the two preceding years. In the schedule attached to the Order nine Infected Areas are listed—a large one embracing parts of the counties of Cambridgeshire, Huntingdonshire, Isle of Ely, Norfolk and West Suffolk: a second including parts of the Soke of Peterborough and of the Holland Division of Lincolnshire: and seven sewage farms, those of Loughborough, Norwich, Haverhill, Bury St Edmunds, Higham Ferrers, Rushden and Wisbech; others may be added from time to time. The brassicae are included because their growth on infected land builds up the population of sugar-beet eelworm, although they do not themselves succumb to the pest. A further stipulation of the Order is worth noting, as it shows how easily the eelworm can be spread. Potatoes grown on land in which sugar-beet eelworm is known to exist may not be sold for planting on any other farm; the danger is that the sugar-beet eelworm may be in the soil adhering to the potato tubers. There are other strains of eelworm which attack different crops, but the point need not be laboured further. Eelworm is not the most common pest in the country and is mentioned here only as an example of the danger of growing the same crop too frequently on the same field; it must be clearly stated that there are numerous other insect pests, and many fungi, which may cause serious trouble if the principles of rotation are flouted. It

is important to realise that similar crops may be susceptible to the same dangers, so that a change from one to the other may not tend to check a disease; for instance, wheat and barley are both susceptible to take-all.

(*c*) *Maintenance of Condition.* As applied to land the word 'condition' is frequently, but improperly, held to be synonymous with fertility. The latter is inherent and is in fact that for which the farmer pays rent. Condition is that for which the farmer alone is responsible, and is not static but cumulative. It includes the state of cleanliness of the land and its freedom from disease, but in this section it is only proposed to deal with the question of plant food. The necessity of maintaining the stores of plant food in the land by a reasoned sequence of cropping was, in bygone days, of the very first importance; in fact it was nothing less than a *sine qua non* of any system of permanent agriculture. Its importance has undoubtedly decreased, now that an abundant supply of nitrogen is available, but though the prices of chemical manures are reasonable, they are high enough to warrant careful economy in their use. Furthermore, too much reliance on chemical fertilisers is not to be advised, because of the danger of miscalculation, and consequent unbalance of plant nutrients in the soil.

The different crops remove from the soil varying amounts of the several nutrients; this is illustrated by Table 1, which gives the amounts of the four chief plant nutrients removed from the soil per acre, by six different crops. The yield and also the composition of a crop vary so much that the figures can only be accepted as representing very approximately the drain on the soil, but they do suffice to show the fact that the plant food removed varies widely from crop to crop. There is clearly a danger that the too frequent growth of one crop may so denude the soil of the available part of one plant nutrient that it becomes the limiting factor in the condition of the field.

The different crops have root systems of varying depth, and consequently a rotation, by bringing various crops to a field in turn, ensures, as far as is possible, that the upper and lower layers of soil shall all be searched by roots for the plant nutrients they contain. Then it must be remembered that some crops respond generously to, and therefore justify, heavy manuring, and a rota-

tion ensures that the heavily manured crops shall not tend to occur too frequently on a few fields, but shall be equally spread over the farm, and so maintain the general level of condition. Finally, some crops require more thorough and deeper cultivation than others; it is believed that good cultivation is beneficial, by promoting aeration and thus making unavailable plant food available, so that in this way, too, a rotation may help to maintain the general condition of the farm.

TABLE I. PLANT NUTRIENTS REMOVED BY DIFFERENT CROPS

Crop	Amount removed per acre (lb.)			
	Nitrogen (N_2)	Phosphate (P_2O_5)	Potash (K_2O)	Lime (CaO)
Wheat: 40 bushels and 30 cwt. straw	60	26	42	11
Beans: 28 bushels and 20 cwt. straw	88*	23	66	30
Red clover: 2 tons hay	97*	17	99	72
Swedes: 15 tons roots	71	27	101	27
Sugar beet: 10 tons roots and 7 tons tops	90	35	169	80
Potatoes: 8 tons tubers	61	32	108	5

* These, being leguminous crops, do not, of course, denude the soil of nitrogen.

POINTS TO CONSIDER IN DECIDING ON A ROTATION

(i) *Part of the Farming System*

Rotations are fundamental to crop husbandry, but crop husbandry is only a part of farming. The first question to be decided is what is to be produced from the farm, and then the crops must be selected and apportioned, as far as circumstances permit, to fit in to a well-knit system. There is little to be said for regarding a farm as a series of water-tight compartments; it may be large enough to justify some specialisation among the men, but the farmer has to look at it as a whole, and he may find it advisable to plan, or to change, his rotation with his eye more on animal, than on crop, husbandry. If, for instance, a grassland flock is kept, and it is found to be more profitable to keep the lambs for selling fat during the winter, a sufficient acreage of fodder roots

must be provided to fatten them. Where an arable flock is being kept the rotation will be largely determined by the necessity of providing food for the flock in every month of the year. It is possible to feed a dairy herd entirely on purchased foods, but it is generally more profitable to produce at least the roughages in its ration on the farm. The head of livestock will determine the requirements of hay, and deficiency in the supply from the grassland must be made up by short leys on the arable land. If it is proposed to winter a number of cattle in open yards they will need a generous allowance of straw for bedding, and a mixed farmer rarely expects to buy straw. Beans and peas are the only home-grown concentrates rich in protein, and they may well find a place in the rotation as a way of keeping down cake bills. Nor is it only requirements of stock that have to be considered. In the Fens one very good reason, in some cases the chief reason, for growing wheat is to provide straw for covering potato clamps. The widest possible view of the whole undertaking must be the starting point, and this will usually show that certain minimum requirements of particular crops should be met, and so provide important guidance in determining the rotation.

(ii) *Suitable Crops*

The success of a farming venture clearly demands that the crops sown should be suitable to the situation of the farm, in regard to soil and climate. The suitability of a crop to a particular soil type is by no means a clear-cut matter. Of most crops there are a number of varieties in this country, and the varieties often show predilections for different soils. Sugar beet grows well on heavy land, and in a dry summer may do better there than on light soil; but the difficulty of getting the roots out of the ground, the labour of carting the crop off in the autumn, and the resulting poaching of the soil, make it unsuited to clay. Roots for winter folding are restricted to light land, chiefly because it is only on such soil that it is possible to fold them during winter.

A list showing the suitability of crops to different soils must not, therefore, be regarded as definite and clear-cut; with this proviso the following may be given for the common crops:

Lightest sands: rye, lupins, carrots, kidney vetch.