PART I

Farming

CAMBRIDGE

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Richard W. Lacey
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Plant crops

The diet of our ancestors

When did farming begin? Or, if you like, when did *we* begin? Compared to the time taken for us to evolve from lower primates, the answer for farming is very recently indeed. So it is not surprising that in just the last few years we have realised that some serious mistakes have been made in the way we produce our food. But we still seem reluctant to test new farming methods adequately before rushing into massive commercial exploitation of them.

Our earliest ancestor is now thought to be a fairly ordinary and smallish type of monkey living in the trees of a luxuriant rain forest. This was 30 million years ago, and the territory is now barren desert in North Africa. We know from the teeth of this animal that it fed mainly on vegetation, with dagger-like canines for breaking the tough casings of fruit.

We can now assume that early primates gathered their food which was available all the year round. Each animal would concentrate on the need to feed itself, apart from the mother nourishing her young. There would be no need to store food and there would be little sociable feeding. No dinner parties!

By around 20 million years ago our ancestors were venturing outside forests, but were still predominantly vegetarian.

Thirteen million years ago one such ancestor, called *Dryopithecus*, had migrated to the European forests and evolved into gorilla-like animals, so by 10 million years ago the teeth were getting stronger and larger and this enabled tougher food to be eaten. This meant that some of the diet still essentially of vegetable origin could be stored in a dried form, so that these primates could survive in drier territory, not needing the constant availability of edible parts of trees.

Exactly when our ancestors began to eat meat is not known, but the Southern Ape of 4 million years ago was still predominantly vegetarian. However, *Homo habilis* 2 million years ago included meat in its diet. This would be obtained largely from dead mammals or birds.

It was not until just around 250,000–500,000 years ago that *Homo erectus* is thought to have purposefully killed and cooked animals such as deer and rhinoceros. Cooking might suggest some social organisation, but there would then have been no attempt to cultivate plants or rear animals specifically for food.

Up to about 4000 BC our ancestors, now sufficiently intelligent to be described as *Homo sapiens*, continued to gather edible vegetation and fruits and hunt animals. But since that date 'we' began to grow crops and to control animals and birds for food. Most evidence for this exists in the Middle and Far East. We were soon to learn to improve the desirability and yield of plant crops, and also 'improve' animals by selection and hybridisation (this means cross-fertilising two similar species to produce a range of resulting hybrids, the best of which are then grown on).

We were also to learn to exploit microorganisms – such as bacteria and yeasts – although for several thousand years we would not understand exactly why the processes involving them were effective. Brewing and the making of cheese are part of our ancient history, as is the use of early food preservatives – drying and the use of salt and sugar.

But improvements in crops and food animals were slow, and the technological changes in our food production over the last 70–80 years have been much more dramatic than in the previous 30 million. For example, the practice of artificial insemination has revolutionised animal husbandry, both in breeding and in rearing. A bull, boar or a ram are rare sights today! Genetic engineering, and the use of artificial fertilisers and chemicals against pests, have enabled the world to produce dramatically more food than it used to from the same space. Indeed the world production of food increased at an annual rate of around 3–5% during the 1980s.

The world population has also increased, and we are now acutely aware that despite increases in food production, in many countries starvation persists and we increasingly recognise diseases associated with eating either too much, or the wrong type of food.

The effect of this dramatic increase in 'efficiency' in agriculture on the world's environment is already producing tragic and potentially long-term devastating consequences.

Crops today – grassland

Apart from new buildings and factories, most of our environment seems to present to its human inhabitants a sense of permanence or timelessness. But the fields, hedges and lines of trees in the country are nearly all constructed by us. The natural vegetation of most of North America and Europe was forest, mainly conifers in the north and broadleaved trees in the south. Moreover, a great deal of the deforestation has occurred in the last few centuries and soil fertility already has to be maintained by artificial chemicals.

Most of the grassland in the world is therefore man-made, and the types of grasses that now provide the grazing for cattle and sheep would originally have had to struggle to survive within the hearts of the forests, but would have flourished at their edges – as the forests met rivers, cliffs or clearings.

There is still some natural grassland in the world such as the exposed inclement southern part of South America and Eurasia, and also high up in the mountains, where trees have given up the unequal struggle against the cold.

Grasses are a crop in themselves and keen gardeners are aware of the different types of lawn seed. Farmers are too, and use grasses mixed with for example clover, to increase the nitrogen content of the soil.

Where tropical forests have been felled to make way for grazing fields, the natural grass is different from that of most European and some North American species, tending to be coarser. Fine perennial temperate grass in Brazil is referred to as English grass!

Grassland is therefore a specialised crop in its own right, needing careful maintenance, and ideally it should be part of a crop rotation. That high ground tends to be covered in permanent grassland results from the inability to cultivate other crops, and as such is less 'efficient' than lowland grass in supporting grazing animals. This means that more sheep per acre can be reared in the flat French country than in hilly Wales, so Welsh farmers are at an inevitable disadvantage compared to the French, other things being equal. Regrettable, but true! Neither can the Rocky Mountains compete with the verdant pastures of New England.

Regular maintenance of grazing land includes the removal of nettles, thistles, trees and brambles and the upkeep of perimeter boundaries such as walls, hedges or fences.

Most grass ceases growth between November and March in the northern hemisphere, and whilst sheep can continue to graze during the winter, the density of animals at this time must be kept low. Other ruminant mammals (these have the ability to convert insoluble and usually indigestible grass cellulose to useful nutrients) include deer, goats and cattle, that often require artificial feed in winter. Traditionally this feed has been mainly silage produced by storing the previous summer's cut grass crop.

A well-kept grassland, ideally surrounded by hedges or woodland, should provide good long-term grazing and the permanent cover of vegetation should 'fix' carbon dioxide from the air, and so help counter the greenhouse effect. This effect is due to gases in the atmosphere that trap heat and so raise the temperature of the Earth. The fertility of the soil should be maintained by the grazing animals' excreta, enhanced by wildlife whose sanctuary is provided by boundary trees and hedges. Rabbits, hares, mice, moles, hedgehogs, badgers and foxes should all flourish in such an environment, together with a huge variety of wild plants. Insects will flourish too, with butterflies the most obvious.

One of the most spectacular types of this grassland is the Alpine meadow, between about 3,000 and 8,000 feet above sea level. The grass is cut just once, in the summer after the riot of alpine blooms. At lower altitudes grass can be cropped as many as three times a year. But, to maintain such a yield, artificial fertilisers may be needed.

This approach to grass management should provide safe and nutritionally excellent food for mammals and some birds; it should provide positive environmental benefit, a satisfying livelihood for the farmer, and a source of pleasure for the itinerant city dweller.

In previous decades, such grassland would have been used for rearing chickens, geese, ducks and pigs, in addition to ruminants. But now it is under the threat of extinction. This is mainly because of the move to intensive rearing of food mammals and birds in sheds, using artificial feed produced from cereals. This results in a cheaper final product compared with free-range husbandry. We seem to have (or used to have) a limitless capacity for wanting cheap meat. We shall be returning to this issue, particularly in Chapter 17.

Formation of deserts

The other problem concerns the overgrazing of vegetation, often associated with periods of near or actual drought.

Consider a territory that is situated between the tropics and the cooler temperate zones, and with low to moderate rainfall. The natural, fully developed vegetation (known as climax) will tend to consist mainly of narrow and broadleaved trees and shrubs. The leaves will release a considerable amount of water vapour into the air, which in turn may produce cloud and rain.

Over the years an ecological balance will be reached with the tree roots able to penetrate to the ground moisture, the upper boundary of which is referred to as the water table.

Suppose these trees are felled and grazing established. Initially the grass may grow, and there may be adequate moisture left in the soil to support, say, cattle. But inevitably, from time to time, phases of drier than usual climate will occur. Then the grass will not grow, the cattle will continue to graze, the vegetation will disappear. Because of the reduced amount of water vapour released into the air by the disappearing vegetation, the rainfall will lessen further, the water table will drop and the beginnings of a desert become evident. Even trees newly planted may not survive because their roots cannot reach the water table.

This sequence of events is not hypothetical. It has actually happened in Central and Eastern Africa and in the USA, notably in Iowa.

The message from this sequence of events is very clear. We should treat grassland as a very precious crop. Great care should be given to decide whether it should be created in the first place, and constant cultivation and management provided subsequently.

Cereals; wheat

Cereals are specially adapted grasses. Wild barley and oats abound in the temperate world and their seed heads look similar to the cultivated varieties. We eat the seeds of the cereal crop, and being seeds they must have a good range of nutrients to initiate new plants. It is only when a plant is, say, 2–6 inches high, that it will have exhausted the nutrients in the seed.

Cereals are the most important single type of crop for the entire human population, and of all those grown, just three – wheat, rice and maize – make up by weight 80% of the cereals that we eat. The remainder include barley, oats and rye. Wheat is grown most extensively in North America and Europe, and has been very thoroughly researched and developed to produce maximum yields.

My first memory of wheat goes back to the late 1940s, when staying with my grandparents in a cottage in the East of England. At that time the seed and stalks of wheat were cut and put into stooks on the ground to dry, before being loaded into a truck for taking to the plant to extract the grains. This was an inefficient process, quite a few ears being dropped on the ground.

So we went 'gleaning', which means rather furtively collecting the dropped wheat to feed to the chickens scratching around in the orchard. I still do not know if this activity was approved by the farmer, but my grandparents' rules were clear: on no account glean any of the wheat in the stooks.

Of course the cutting of the ripe wheat and extraction of the seed are performed now in one operation by the combine harvester and this accounts for one of the many changes seen in the type of wheat grown in the last 40 years – shortening of the stalk, desirable because of increased resistance to wind damage. Whilst modern harvesters can process wheat lying on the ground, there is a reduction of yield, due to damp causing fungal infection and also sprouting of the seed before it is harvested.

The other changes in wheat husbandry have all been aimed at improving efficiency. The goal seems to have been to increase maximum weight per acre of crop that matures within the shortest time possible. Of secondary importance are resistance to disease and storing quality. Even less consideration has been given to changes in the nutritional content and to the environmental impact of the new varieties.

The striving towards greater efficiency has been achieved by an enormous amount of research in the following areas. First, the search for high yielding (more and larger grains per seed head), early ripening, and optimum timing and density of planting. Because wheat takes a great deal of nourishment out of the soil, and returns little, the idea has been popular for years of using genetic engineering to creating strains whose roots could convert nitrogen gas in the air to nitrogen salts in the soil, that could then be used by the plant. This nitrogen fixing is achieved by beans, peas and clover through specialised bacteria growing around their roots. Indeed, one established cropping method is to plant nitrogen-fixing clover alongside rows of wheat, but so far the creation of a type of hybrid – part clover, part wheat – still seems some way off commercial use.

Even if wheat was developed that could fix nitrogen – and so reduce the need for nitrogenous fertiliser – other fertilising chemicals would still be needed. In particular, the supply of phosphates will pose a problem because there is an impending world shortage of this material in a form that is easily mined or extracted.

The modern types of wheat are indeed high yielding, they can succeed in relatively cold damp climates, and they do give a prolific yield and ripen early. They provide a secure, high volume, profitable product for the farmer. Wheat is easy to store and is probably the most important international food commodity, with trading (and speculation) in all the major financial markets. The research and development have paid off.

So what are the problems? The first seems to be caused by the surplus. We, the consumers, at least many of us, seem to want to eat only part of the wheat seed: the white inside (the endosperm), not the darker outside layers rich in fibre, vitamins and minerals. One reason for our preference for white over brown bread is that in general white bread can be lighter in weight than brown, because the yeast acts on more of the flour.

True, there are a substantial number of consumers who understand and prefer wholemeal bread, but surely to make white bread requires unnecessary cost and energy (to remove the outside coatings of the grain)? One of the problems of freedom of choice associated with an abundance of food is that we can select what is not best for us!

Successful high-yield production of wheat and other cereal crops requires fertilisers, and control of diseases and parasite attacks. Stored wheat, particularly under hot, humid conditions, can generate further parasitic problems, with the need for further chemicals. Certainly some chemicals have been shown to be dangerous and are no longer used, for example DDT. Others, we hope, are safe, but there is no real way of establishing this with certainty. But the approach most countries currently use towards growing wheat must damage the structure and quality of the soil over the years, particularly regarding the amount of organic matter that can be so important for water retention.

There are also potential problems as a result of early maturation of modern varieties. In a good summer, the crop can be harvested in July, with vast expanses of ground left bare, or nearly so, for 8–9 months. During this time, the soil nutrients will be dissolved by rainwater and lost from the ground, and the absence of vegetation will aggravate the greenhouse effect because there will be no extraction from the atmosphere of carbon dioxide that is constantly increasing due to burning fossil fuels. Moreover, without vegetation, the dry surface soil can literally be blown into the air.

Other cereals

Maize, or corn, is grown widely in warmish, temperate climates such as in the USA and central Europe, for both human and animal feed. Many different varieties exist, some crops producing a succession of cobs in late summer, others just one. The plant is grown in small areas, in blocks rather than rows to aid wind pollination; and it is also a greedy plant, using up much moisture and nutrients from the ground. However, the yield can be very high.

Nutritionally, corn has one problem in that vitamin B_3 (niacin) is not absorbed by the human body after eating it, and if corn is the only source of this vitamin, a disease, pellagra, can occur. However, this is rare as several other foods such as meat, fish, dairy products and potatoes all contain niacin.

Some varieties of maize produce highly coloured kernels; blue, violet or red and are grown only for decoration.

Cornflakes are made by combining the dried, powdered maize with malt extract, minerals, vitamins and water into a thick slurry, after which it is roasted.

Powdered corn or meal can also be used to make bread, more popular in the USA than the UK.

Popcorn is made from a particular variety with a thick and tough outer seed coating. As a result of pressure generated inside the kernel by heat, a critical point occurs when the coating is breached, with a minor explosion, resulting in the inside endosperm rapidly expanding as the corn 'pops'.

Maize is therefore potentially a prolific crop, relatively free from disease, but very demanding for fertilisers.

Rice is also an international commodity, with most of the world crop grown in the paddy fields of the East. It could be grown