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Introduction to Crop Husbandry

including grassland

SIXTH EDITION

by

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and

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FOREWORD

THIS book was first published in February 1966—22 years ago—and written by Jim Lockhart and Tony Wiseman, two of the senior lecturers at the Royal Agricultural College, Cirencester. In their Preface to the first edition they set out the aims of the book as being to provide “An introduction to the science and practice of crop husbandry . . . in simple language without losing its technical value.” The first edition admirably performed that function and soon attracted the universal acclaim of students, teachers and farmers.

Now the book is in its sixth edition and appears at a time when British agriculture is entering a period of change and uncertainty. The students of today, who will be the farmers and farm managers of tomorrow, will be confronted with new problems. Many of these will still be of a scientific or technical nature, but to an increasing extent the farmers and landowners will be faced with economic, political and social problems, which will require new skills and new disciplines to solve them.

Despite the mounting pressures we can be fairly confident that most of the land in our countryside will be used for farming for many years to come, albeit that some of the crops will be for purposes other than food. Indeed by the end of this century, Britain will once again be a net importer of oil, and our manufacturing industry will be operating in a fiercely competitive climate. British agriculture may well be called upon to resume its import-saving role, as there will then be compelling economic reasons for continuing to produce all our temperate food requirements at home. So it must be in the nation’s interest to maintain a strong and viable agricultural industry, not only for economic reasons, but for ecological and social reasons as well.

The sixth edition of this book has been revised to take account of these developments. There is increased emphasis on quality in all crops and more on alternative combinable crops and commercial vegetable production on the farm. It is currently estimated that pests and diseases still claim 10–15% of Britain’s arable crop, which amounts to an annual loss of over £500 million. So efficient methods of crop protection, that do not harm the environment, have a major effect on farm profits in the arable sector. This important subject is fully dealt with in this edition, and the latest recommendations for weed and pest control are set out and clearly explained. The grassland and forage conservation sections illustrate the importance of more efficient management techniques and how to achieve them in practice. The impact of modern farming practices on wildlife conservation is covered, as is the latest legislation affecting farming. Moreover, the development of organic farming—its problems and possibilities—are discussed.

As a textbook for students learning the basic principles of modern crop husbandry, this book, in my view, has no equal. But its clear, “easy-to-understand” descriptions of complicated biological processes will appeal to a much wider audience. I strongly commend it to all those who have a wish to understand what is happening on our farms today. A study of this book will make visits to the countryside far more rewarding and interesting for wildlife lovers and casual visitors alike.

Louth, Lincolnshire
February 1988

SIR EMRYS JONES

PREFACE TO THE FIRST EDITION

THIS book is an introduction to the science and practice of crop husbandry. It is written in simple language without losing its technical value. Young people doing their practical training will find it helpful for explaining modern farming practices of growing and harvesting crops. All aspects of the subject are dealt with, such as the growth and development of plants, types and management of soils, drainage and irrigation, modern practices of growing and harvesting crops, management of grassland—including conservation, typical life-cycles of common pests and diseases, and the latest developments in the use of chemicals as fertilizers and in the control of weeds, pests and diseases. Suggestions for classwork are also included at the end of sections.

Students taking the City and Guilds General Agriculture (Part 1) and similar examinations can use it as a textbook, and those taking higher examinations will find the book a valuable source of basic information which will be enlarged on in their courses.

The authors acknowledge with very grateful thanks the valuable help given by their wives in preparing and typing the manuscript.

Cirencester
February 1966

J. A. R. LOCKHART
A. J. L. WISEMAN

PREFACE TO THE FIFTH EDITION

WHEN the fourth, and considerably revised, edition of *Introduction to Crop Husbandry* was published, followed just two years later by a reprint with additions, the authors believed that any fifth edition would not need to be a major revision. This has not been the case. Quite large sections have had to be revised, thus instancing again the rapid technological progress which these days so characterizes the agricultural industry.

It is hoped that this book will continue to form the basis of crop husbandry syllabi at all levels of agricultural teaching. Depending on their course, students will generally find that further reading of the subject will be necessary. References are given where appropriate, and it should be noted that the MAFF Booklets are now replacing some of the Short Term Leaflets (STL), and the L Leaflet is replacing the Advisory Leaflet (AL).

As in previous editions, we are glad to acknowledge the help given by Mr. R. Churchill and Mr. W. Heatherington in the revision of the Pest and Diseases chapter.

Cirencester
June 1982

J. A. R. LOCKHART
A. J. L. WISEMAN

PREFACE TO THE SIXTH EDITION

Since the revision of the fifth edition in 1983 there have been some important new developments in crop husbandry methods, although at the same time growers are facing an increasing number of problems. Because of the surplus production of cereals and the consequent necessity to reduce costs where possible, more attention is now being paid to the growing of alternative combinable crops as a means of helping to maintain income. However, many consumers are changing to organically grown foods without applied chemicals, and environmentalists are having a not insignificant influence on farming practices. Nitrate leaching into rivers and aquifers is also causing some concern. These, and other matters, are dealt with in the fully revised and enlarged sixth edition.

As in previous editions our object has been to present modern crop production methods in a comprehensive and easily understood manner. It is impossible in one book to cover all the factual information now available, so many references are given for further information and study. The financial side of crop production is, of course, very important and constantly changing; only passing reference to details about labour requirements, costs and returns are included in the text, but readers are recommended to refer to the very useful and annually revised management handbooks produced by university departments and the Scottish Agricultural Colleges.

The need for a balance between farming and conservation is argued in Appendix 3. Since the previous edition a new series of leaflets has been published which attempts to show that even with modern techniques of crop production it is still possible to pay heed to conservation on the farm. References to these CAE leaflets (Conservation in Agricultural Education) are made in the recommendations for further reading.

Better pesticides have now been introduced and, due to legal regulations replacing the PSPS (Pesticides Safety Precautions Scheme) and ACAS (Agricultural Chemicals Approval Scheme) voluntary schemes, many hitherto widely used chemicals have been withdrawn or limitations have been put on their use. Although every effort has been made to give up-to-date recommendations for Approved Products, readers are asked to check all product labels before use.

We are glad to acknowledge the valuable help given by Mr. R. Churchill and Mr. W. Heatherington in the revision of the Pests and Diseases chapter. Mr. D. Barling, Mr. R. Sylvester-Bradley, Mr. David Tottman and Mrs. Cathy Knott (particularly for information on crop-growth stages shown in Appendix 15) are also especially thanked.

We hope that this edition will continue to be the standard textbook for all crop husbandry syllabuses at all levels of agricultural teaching.

Cirencester
February 1988

J. A. R. LOCKHART
A. J. L. WISEMAN

INTRODUCTION

Crops are plants which have been carefully selected and developed to produce food for man and animals.

Crop husbandry is the practice of growing and harvesting crops. The main objective is to produce good crops as economically as possible without impoverishing the land.

The methods used have been developed over the past centuries from practical experience and experiments. In recent years there have been many sweeping changes as the result of:

- (a) better understanding of crop growth and its manipulation;
- (b) improved soil and water management;
- (c) introduction of many new and improved varieties (cultivars);
- (d) better use of manures and fertilizers;
- (e) introduction of many chemicals for better control of weeds, pests and diseases;
- (f) improvements in mechanization for operations such as cultivations, seedbed preparation, planting, applying chemicals, forage conservation, harvesting of grain, root and vegetable crops, drying, storage and grading; also many improvements in tractor design, power and capabilities, and materials handling;
- (g) improvements in marketing—better grading, presentation, packaging, processing, and contract production; also increase in pick-your-own and farm-gate sales.

An understanding of how plants grow, and what they need, is a useful guide when providing for their requirements.

Good crop husbandry is really good management of crop plants so that they are provided with the best possible conditions for growth.

1

PLANTS

WHAT THEY ARE; WHAT THEY DO; AND HOW THEY LIVE

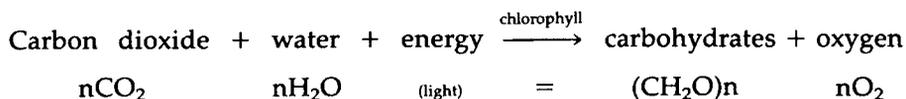
PLANTS are living organisms consisting of innumerable tiny cells. They differ from animals in many ways but the most important difference is that plants can build up valuable organic substances from simple materials. The most important part of this building process, which is called *photosynthesis*, is the production of *carbohydrates* such as *sugars*, *starches* and *cellulose*.

Photosynthesis

In photosynthesis a special green substance called *chlorophyll* uses *light* energy (normally sunlight) to change *carbon dioxide* and *water* into *sugars* (carbohydrates) in the *green* parts of the plant. The daily amount of photosynthesis is limited by the duration and intensity of sunlight. The amount of carbon dioxide available is also a limiting factor. Shortage of water and low temperatures can also reduce photosynthesis.

The cells which contain chlorophyll also have yellow pigments such as *carotene*. Crop plants can only build up chlorophyll in the light and so any leaves which develop in the dark are yellow and cannot produce carbohydrates.

Oxygen is released during photosynthesis and the process may be set out as follows:



This process not only provides the basis for all our food but it also supplies the oxygen which animals and plants need for respiration.

The simple carbohydrates, such as *glucose*, may build up to form *starch* for storage purposes, or to *cellulose* for building cell walls. *Fats* and *oils* are formed from carbohydrates. *Protein* material, which is an essential part of all living cells, is made from carbohydrates and nitrogen compounds.

Most plants consist of *roots*, *stems*, *leaves* and *reproductive parts* and need *soil* in which to grow.

The *roots* spread through the spaces between the particles in the soil and anchor the plant. In a plant such as wheat the root system may total many miles.

The *leaves*, with their broad surfaces, are the main parts of the plant where photosynthesis occurs (see Fig. 1).

A very important feature of the leaf structure is the presence of large numbers of tiny pores (*stomata*) on the surface of the leaf (see Fig. 2). There are usually thousands of stomata per square cm of leaf surface. Each pore (stoma) is oval-shaped and surrounded by two guard cells. When the guard cells are turgid (full of water) the stoma is open and when they lose water the stoma closes.

The carbon dioxide used in photosynthesis *diffuses* into the leaf through the stomata and most of the water vapour leaving the plant, and

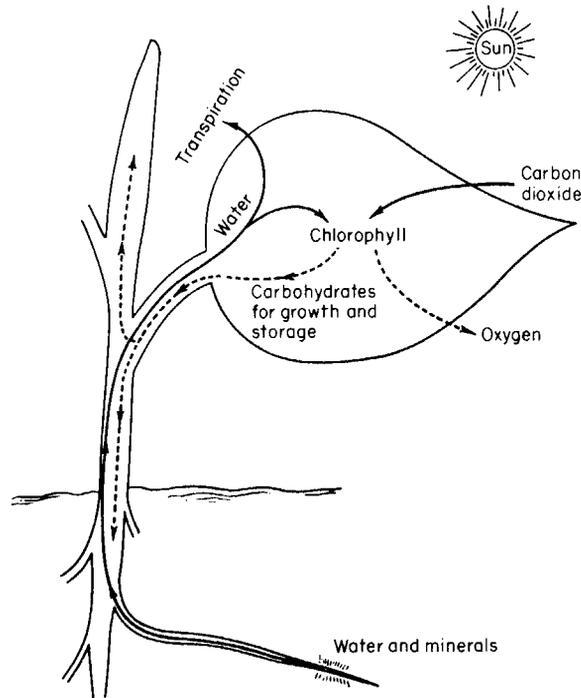


FIG. 1. Photosynthesis illustrated diagrammatically.

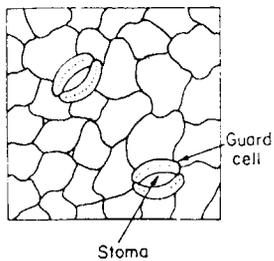


FIG. 2. Stomata on leaf surface.

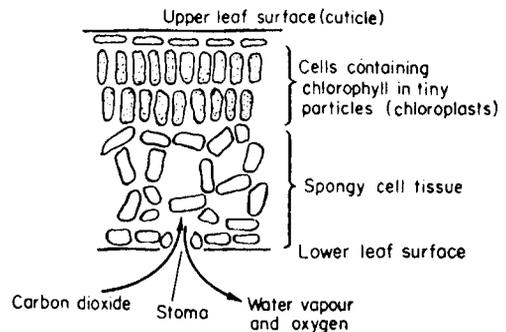


FIG. 3. Cross-section of green leaf showing gaseous movements during daylight.

the oxygen from photosynthesis diffuses out through the stomata.

Transpiration

The evaporation of water from plants is called *transpiration*. It mainly occurs through the stomata and has a cooling effect on the leaf cells. Water in the cells of the leaf can pass into the pore spaces in the leaf and then out through the stomata as water vapour (see Fig. 3).

The rate of transpiration varies considerably. It is greatest when the plant is well supplied with water and the air outside the leaf is warm and dry. In very hot or windy weather water evaporates from the guard cells and so the stomata close and reduce the rate of transpiration. The stomata also close in very cold weather, e.g. 0°C.

The rate of loss is reduced if the plant is short of water because the guard cells then lose water and close the stomata; it is also retarded if the humidity of the atmosphere is high.

The stomata guard cells close (and so transpiration ceases) during darkness. They close because photosynthesis ceases and water is lost from the guard cells (osmosis) when some of the sugars present change to starch.

Respiration

Plants, like animals, breathe, i.e. they take in oxygen which combines with organic foodstuffs and this releases energy, carbon dioxide and water. Farm crops are likely to be checked in growth if the roots are deprived of oxygen for respiration as might occur in a waterlogged soil.

Translocation

The movement of materials through the plant is known as *translocation*.

The *xylem* or *wood vessels* which carry the water and mineral salts (*sap*) from the roots to the leaves are tubes made from dead cells. The cross walls of the cells have disappeared and the longitudinal walls are thickened with *lignum* to form wood. These tubes help to strengthen the stem.

The *phloem tubes (bast)* carry organic material through the plant, for example, sugars and amino acids from the leaves to storage parts or growing points. These vessels are chains of living cells, not lignified, and with cross walls which are perforated—hence the alternative name—*sieve tubes*.

In the stem the xylem and phloem tubes are usually found in a ring near the outside of the stem.

In the root, the xylem and phloem tubes form separate bundles and are found near the centre of the root.

Uptake of water

Water is taken into the plant from the soil. This occurs mainly through the root hairs near the root tip. There are thousands (perhaps millions) of root tips (and root hair regions) on a single healthy crop plant (see Fig. 4).

The absorption of water into the plant in this way is due to suction pull which starts in the leaves. As water transpires (evaporates) from the cells in the leaf more water is drawn from the xylem tubes which extend from the leaves to the root tips. In these tubes the water is stretched like a taut wire or thread. This is possible because the tiny particles (molecules) of water hold together very firmly when in narrow tubes.

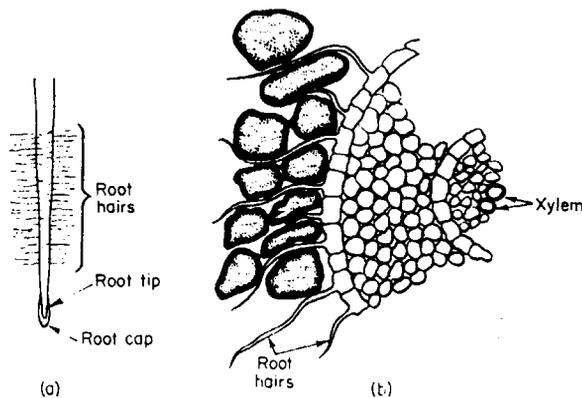


FIG. 4. (a) Section of root tip and root hair region, (b) cross-section of root showing the root hairs as tube-like elongations of the surface cells in contact with soil particles.

The pull of this water in the xylem tubes of the root is transferred through the root cells to the root hairs and so water is absorbed into the roots and up to the leaves. In general, the greater the rate of transpiration, the greater is the amount of water taken into the plant. The rate of absorption is slowed down by:

- (a) shortage of water in the soil,
- (b) lack of oxygen for root respiration (e.g. in waterlogged soils),
- (c) a high concentration of salts in the soil water near the roots.

Normally, the concentration of the soil solution does not interfere with water absorption. High soil water concentration can occur in salty soils and near bands of fertilizer. Too much fertilizer near developing seedlings may damage germination by restricting the uptake of water.

Osmosis

Much of the water movements into and from cell in plants is due to *osmosis*. This is a process in which a solvent, such as water, will flow through a *semi-permeable* membrane (e.g. a cell wall) from a weak solution to a more concentrated one. The cell wall may allow only the water to pass through. The force exerted by such a flow is called the *osmotic pressure*. In plants, the normal movement of the water is into the cell. However, if the concentration of a solution outside the cell is greater than that inside, there is a loss of water from the cell, and its contents contract (shriveled); this is called *plasmolysis*.

Uptake of nutrients

The absorption of chemical substances (nutrients) into the root cells is partly due to a *diffusion* process but it is mainly due to ability of the cells near root tips to *accumulate* such nutrients. The process is complicated and not fully understood. It is slowed up if root respiration is checked by a shortage of oxygen.

PLANT GROUPS

Plants can be divided into annuals, biennials and perennials according to their total length of life.

Annuals

Typical examples are wheat, barley and oats which complete their life history in one growing season, i.e. starting from the seed, in 1 year they develop roots, stem and leaves and then produce flowers and seed before dying.

Biennials

These plants grow for 2 years. They spend the first year in producing roots, stem and leaves, and the following year in producing the flowering stem and seeds, after which they die.

Sugar beet, swedes and turnips are typical biennials, although the grower treats these crops as annuals, harvesting them at the end of the first year when all the foodstuff is stored up in the root.

Perennials

They live for more than 2 years and, once fully developed, they usually produce seeds each year. Many of the grasses and legumes are perennials.

STRUCTURE OF THE SEED

Plants are also classified as *dicotyledons* and *monocotyledons* according to the structure of the seed.

Dicotyledon

A good example of a dicotyledon seed is the broad bean because it is large and easy to study. If a pod of the broad bean plant is opened when it is nearly ripe it will be seen that each seed is attached to the inside of the pod by a short stalk called the *funicle*. All the nourishment which the

developing seed requires passes through the funicle from the bean plant.

When the seed is ripe and has separated from the pod a black scar, known as the *hilum*, can be seen where the funicle was attached. Near one end of this hilum is a minute hole called the *micropyle* (see Fig. 5).

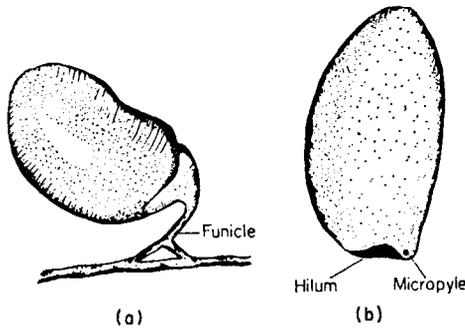


FIG. 5. (a) Bean seed attached to the inside of the pod by the funicle, (b) bean seed showing the hilum and micropyle.

If a bean is soaked in water the seed coat can be removed easily and all that is left is largely made up of the *embryo (germ)*. This consists of two seed leaves, or *cotyledons*, which contain the food for the young seedling.

Lying between the two cotyledons is the *radicle*, which eventually forms the *primary root*, and a continuation of the radicle the other end, the *plumule* (see Fig. 6). This develops into the young *shoot*, and is the first *bud* of the plant.

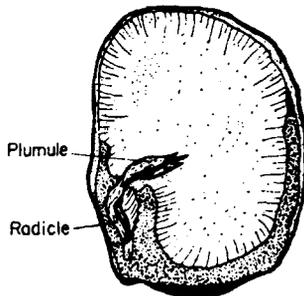


FIG. 6. Bean seed with one cotyledon removed.

Monocotyledon

This class includes all the cereals and grasses and it is, therefore, very important.

The wheat grain is a typical example. It is not a true seed (it should be called a single-seeded fruit). The seed completely fills the whole grain, being practically united with the inside wall of the grain or fruit.

This fruit wall is made up of many different layers which are separated on milling into varying degrees of fineness, e.g. bran and pollards, and these are valuable livestock feed.

Most of the interior of the grain is taken up by the floury *endosperm*. The embryo occupies the small raised area at the base. The *scutellum*, a shield-like structure, separates the embryo from the endosperm. Attached to the base of the scutellum are the five roots of the embryo, one primary and two pairs of *secondary rootlets*. The roots are enclosed by a sheath called the *coleorhiza*. The position of the radicle and the plumule can be seen in the diagram (Fig. 7).

The scutellum can be regarded as the cotyledon of the seed. There is only *one* cotyledon present and so wheat is a monocotyledon.

Germination of bean—the dicotyledon

Given suitable conditions for germination, i.e. water, heat and air, the seed coat of the dormant

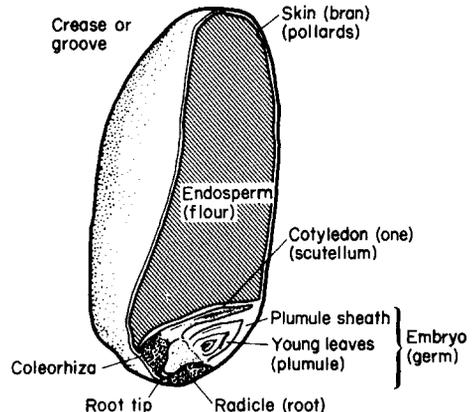


FIG. 7. Wheat grain cut in half at the crease.

but living seed splits near the micropyle, and the radicle begins to grow downwards through this split to form the main, or primary root, from which lateral branches will soon develop (see Fig. 8).

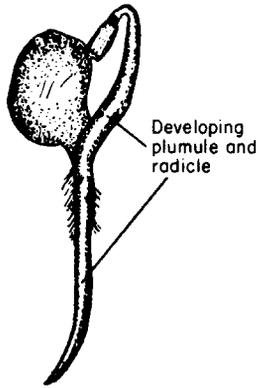


FIG. 8. Germination of the bean, one cotyledon removed.

When the root is firmly held in the soil, the plumule starts to grow by pushing its way out of the same opening in the seed coat. As it grows upwards its tip is bent to protect it from injury in passing through the soil, but it straightens out on reaching the surface, and *leaves* very quickly develop from the plumular shoot.

With the broad bean the cotyledons remain underground—gradually giving up their stored food materials to the developing plant, but with the French bean, and many other dicotyledon seeds, the cotyledons are brought about ground with the plumule.

Germination of wheat—the monocotyledon

When the grain germinates the coleorhiza expands and splits open the seed coat, and at the same time the roots break through the coleorhiza (see Fig. 9).

The primary root is soon formed, supported by the two pairs of secondary rootlets, but this root system (the seminal roots) is only temporary and is soon replaced by *adventitious roots* (see

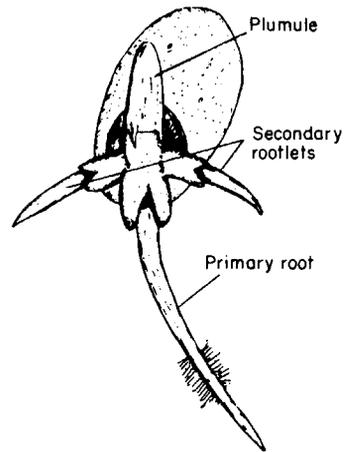


FIG. 9. Germination of the wheat grain.

Figs. 10 and 14). As the first root system is being formed at the base of the stem so the plumule starts to grow upwards, and its first leaf, the *coleoptile*, appears above the ground as a single pale tube-like structure.

From a slit in the top of the leaf there appears the first *true leaf* which is quickly followed by others, the younger leaves growing from the older leaves (see Fig. 11).

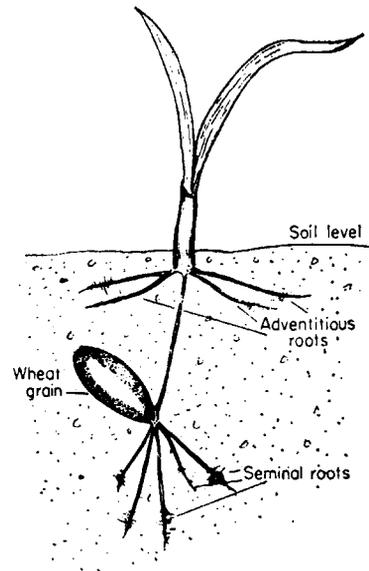


FIG. 10. Developing wheat plant.

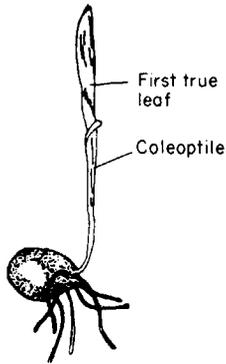


FIG. 11. Seedling wheat plant.

As the wheat embryo grows so the floury endosperm is used up by the developing roots and plumule, and the scutellum has the important function of changing the endosperm into digestible food for the growing parts.

With the broad bean, the cotyledons provide

the food for the early nutrition of the plant, whilst the wheat grain is dependent upon the endosperm and scutellum, and in both cases it is not until the plumule has reached the light and turned green that the plants can begin to be independent.

This point is important in relation to the depth at which seeds should be sown. Small seeds, such as the clovers and many of the grasses, must, as far as possible, be sown very shallow. Their food reserves will be exhausted before the shoot reaches the surface if sown too deeply. Larger seeds, such as the beans and peas, can and should be sown deeper.

When the leaves of the plant begin to manufacture food by photosynthesis (see page 1) and when the primary root has established itself sufficiently well to absorb nutrients from the soil (see page 4) then the plant can develop independently, provided there is sufficient moisture and air present.

The main differences between the two groups of plants can be summarized as follows:

Dicotyledons

- The embryo has two seed leaves.
- A primary root system is developed and persists.
- Usually broad-leaved plants, e.g. clovers, cabbage and potato.

Monocotyledons

- The embryo has one seed leaf.
- A primary root system is developed, but is replaced by an adventitious root system.
- Usually narrow-leaved plants, e.g. the cereals and grasses, and most bulbous plants.

These two great groups of flowering plants can be further divided in the following way:

Families or orders, e.g.	The legume family, potato, the grasses and cereals.
Genus	Clovers of the legume family, and wheat of the cereal family.
Species	Red clover.
Cultivar or Variety	Late red clover.

PLANT STRUCTURE

The plant can be divided into two parts:

The root system

The root system is concerned with the parts of the plant growing in the soil and there are two main types:

(a) *The tap root or primary system.* This is made up of the primary root called the tap root with *lateral secondary* roots branching out from it, and from these *tertiary* roots may develop obliquely to form, in some cases, a very extensive system of roots (see Fig. 12).

The root of the bean plant is a good example of a tap root system, and if this is split it will be seen that there is a slightly darker central woody core; this is the *skeleton* of the root. It helps to anchor the plant, and also transports foodstuffs. The lateral secondary roots arise from this central core (see Fig. 13).

Carrots, and other true root crops, such as sugar beet and mangolds, have very well-developed tap roots. These biennials store food in their roots during the first year of growth to be used in the following year for the production of the flowering shoot and seeds. However, they are normally harvested after one season and the roots are used as food for man and stock.

(b) *The adventitious root system.* This is found on all grasses and cereals, and it is, in fact, the main root system of most monocotyledons. The primary root is quickly replaced by adventitious roots, which arise from the base of the stem (see Fig. 14).

Actually, these roots can develop from any part of the stem, and they are found on some dicotyledons as well, but not as the main root system, e.g. underground stems of the potato.

Root hairs (see Fig. 4). These are very small white hair-like structures which are found near the tips of all roots. As the root grows, the hairs on the older parts die off, and others develop on the younger parts of the root.

Root hairs play a very important part in the life of a plant (see page 3).

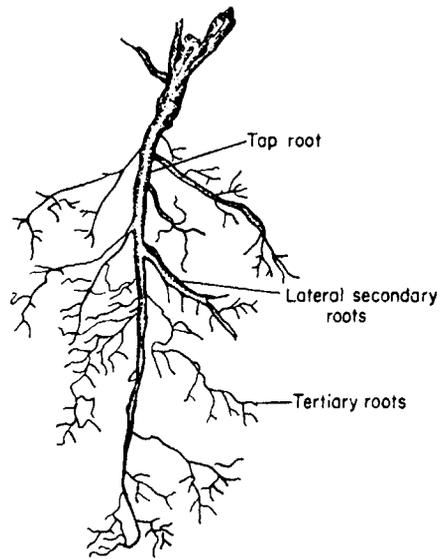


FIG. 12. Tap root or primary root system.

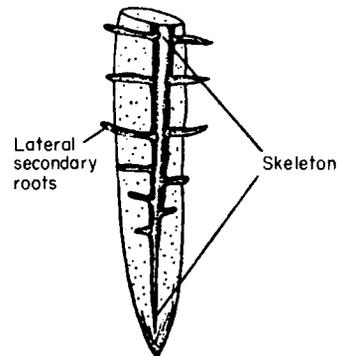


FIG. 13. Tap root of the bean plant.



FIG. 14. Adventitious root system.