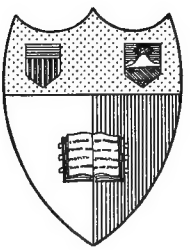
BRITISH GRASSES
AND THEIR EMPLOYMENT IN AGRICULTURE

S. F. ARMSTRONG



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AND THEIR EMPLOYMENT IN AGRICULTURE

BY

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WITH 175 ILLUSTRATIONS

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PREFACE

THE vast importance of the Natural Order Graminaceæ is partly due to the large number and world-wide distribution of its species, but more especially to the great economic value which many of these plants possess. Apart from numerous varieties some 3,600 species have been described, of which rather more than 100 are natives of the British Isles.

The enormous importance of our cereal grasses is apparent to everyone, but apart altogether from these, our native grasses are worthy of our highest attention, if only on account of the large proportion of agricultural land occupied by them. Of the total area of forty-seven million acres under grass and other crops in the United Kingdom, some twenty-seven million acres are now (1917) under permanent grass. Of the remaining area about six and a half million acres are occupied by Rotation Grasses and Clovers.

This is a time when we are all hopeful that the area under permanent grass will speedily be reduced. However, it is obvious that in proportion as we extend the area under arable cultivation, we should specialise upon and improve as much as possible our remaining grass land, in order that it may carry a correspondingly larger number of live stock.

A great proportion of the existing grass land is far from being of the best quality possible. Much of it is weed-covered in the sense that such plants as Buttercups, Daisies, Plantains, Hawkweeds, etc.—to say nothing of the inferior grasses—occupy the ground upon which our better forage plants would thrive. At a very moderate estimate twenty per cent. of the total area is weed-covered in the above sense, which means that an area equal to at least 5,000,000 acres is covered with comparatively worthless herbage.

Permanent grass suffers from the lack of all the various benefits which come to other farm crops under the rotation systems. Soil covered with a permanent turf gets the minimum amount of exposure to the beneficial actions of the atmosphere, sun, rain, etc. In many cases the available fertility is brought down to the lowest point; weeds tend to increase up to a certain maximum and more or less defy eradication. Whilst certain types of soil are more adapted for permanent grass production than for any other form of cropping, it is nevertheless true that much of the land now under grass might be brought under arable cultivation with greater profit to the nation. Under a system of alternate husbandry most of the above mentioned defects would be corrected, and a much larger yield of food obtained from a given acreage.

Although the question of the formation of permanent grass has been dealt with in considerable detail in Part II of this volume, the writer strongly advocates that much less land should be under permanent grass, and a much larger area should be devoted to alternate husbandry in which after all our most valuable fodder grasses can be employed to the best advantage.

Notwithstanding the great economic importance of grasses in British Agriculture no suitable text-book on the subject of British Agricultural Agrostology at present exists. Of the works dealing with British grasses which have been published in the past, most have been intended for the professional botanist, and certainly none of them can be said to meet the requirements of the modern student of agriculture.

The present volume has been written primarily for agricultural students, but at the same time it is hoped that it will be found useful to a much larger section of the community, especially to practical farmers, seed merchants, schoolmasters and students of nature generally.

All our native species have been described and most of them illustrated, but more attention and greater space has been given to those species which are most abundant or of greatest economic importance in the British Isles. This has been necessary in order to combine general completeness with a book of moderate size.

In the descriptions particular attention has been given to the foliage and seed characters, and to those points which, though of

special importance to the student of agriculture, are so inadequately dealt with in our Floras.

The student should first become well acquainted with the structure and functions of the different organs as dealt with in the first two chapters before proceeding to the use of the keys to the leaves, flowers, and "seeds." The study of these chapters should be supplemented by practical work in the field and laboratory with the aid of a good pocket lens and microscope.

To facilitate reference, in each of the keys the reader is referred to the page upon which the fuller description is to be found. Also in Chapters VII and VIII the Genera are arranged in alphabetical order. Those who desire further information should consult the Bibliography given at the end.

Objection may possibly be taken to the artificial arrangement of the plants and "seeds" as given in the keys. The writer however believes that while such objection would be most valid in any great Flora or systematic work where only the natural affinities should be considered, in a book of the present kind convenience should take precedence. Neither is it claimed that the keys are infallible, for the fact of variation constantly reminds us that we are dealing with organic nature—with its infinite possibilities as regards adaptations—and not with a mere mechanical structure.

By the kind permission of Messrs A. Constable and Co., of Westminster, Fig. 21 has been reproduced from *The True Grasses* by Eduard Hackel. Figs. 161 to 165 have been taken from the *New Zealand Journal of Agriculture*. With these exceptions all the illustrations have been specially drawn or produced by the author for this work.

My thanks are due to Professor R. H. Biffen, F.R.S., for much helpful advice relative to the general scheme and publication of the book.

S. F. ARMSTRONG.

SCHOOL OF AGRICULTURE,
CAMBRIDGE.
July 1917.

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BOTANICAL SECTION

CHAPTER I

THE MORPHOLOGY OF GRASSES

In beginning the study of a particular group of plants such as the grasses with a view to obtaining a knowledge of their different species, habits, uses, etc., our first aim must be to become familiar with the general structure and functions of their different organs, and special attention should be given to those points upon which their classification is based.

This introduction can be obtained most readily by examining a few typical species in detail. We may take for this purpose the common cultivated Oat (*Avena sativa*, L.), Couch-grass (*Agropyrum repens*, Beauv.), and Sheep's Fescue (*Festuca ovina*, L.). These species are well known, they can be easily obtained, and they will serve to illustrate the structure of grasses very well. Fresh specimens of these plants should be obtained and examined as this chapter is read. The underground parts must be secured as well as the leaves, stems, flowers and "seeds." The "seeds" need not be freshly gathered.

(A) The Vegetative Organs.

Root system. In the above-mentioned species the roots arise adventitiously from the lowermost node or nodes of the stem, and they are thin and fibrous in nature. In the Oat plant, which is an annual species, they arise in a dense tuft from nearly the same level; but in the case of the perennial Couch-grass they are produced at every node on the underground creeping

stems—or rhizomes as they are termed. Almost all grasses have *fibrous* roots which arise in one or both of the ways just described (see Figs. 1 and 5). In a few species only the roots are tough and cord-like.

Fig. 1. Showing mass of fibrous roots produced by wheat plants within seven weeks after sowing in pot.

Stems. The flowering stems –termed "culms"—are cylindrical, and hollow except at the nodes, where they are firm and solid (Figs. 2, 3 and 4). Each node—or joint—forms the point of attachment of a leaf. The portions of the stem between the nodes are the internodes. Every stem arises within the axil of a leaf-sheath. If each stem grows up within the sheath close tufts of foliage are formed (e.g. Oat). This is known as the *intra-vaginal* mode of

growth. If however the shoots pierce through the sheaths close to where they arise and grow out horizontally (the *extra-vaginal* mode of growth), the stems and foliage become more or less scattered and intermingled with other plants. Thus the appearance, habit, and agricultural use of a particular species depend largely upon whether the shoots are mainly intra-vaginal, or extra-vaginal in their mode of growth. In the Oat, as in all annual grasses,

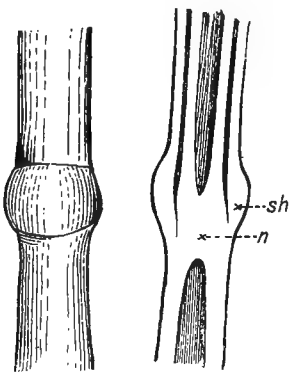


Fig. 2

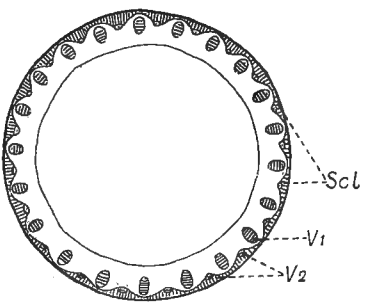


Fig. 3

Fig. 2. *A.* Portion of culm of the cultivated Oat *Avena sativa*. *B.* A longitudinal section of the same showing the structure of a node. The swollen appearance of the node is due to the enlargement of the base of the leaf-sheath (*sh*). The actual stem-node or joint (*n*) is not enlarged. This is the case in most grasses. ×2.

Fig. 3. Diagrammatic transverse section through internode of Wheat culm, showing the position of the strongly developed ring of sclerenchyma (*Scl.*) (thick walled tissue) just beneath the epidermis. It is this band of sclerenchyma which largely contributes to the firmness and strength of grass culms. Note also the ring of principal fibro-vascular bundles (V_1), with secondary bundles between (V_2). ×15. See also Fig. 4.

there is only one kind of stem—the flowering culm—but many of the perennial species have also the second type of stem (extra-vaginal) which grows out horizontally either on or below the surface of the soil. Couch-grass affords an excellent example of the formation of underground stems or *rhizomes*, while Rough-stalked Meadow-grass (*Poa trivialis*, L.) and Fiorin (*Agrostis alba*, L. var. *stolonifera*) and others possess thin surface-creeping offshoots—or

stolons—of a similar nature to those of the Strawberry plant. Such grasses are said to be stoloniferous.

That rhizomes and stolons are really modified stems is proved by their internal structure, by the fact that they possess nodes upon which roots and leaves are borne, and that the ordinary erect stems are but a continuation of their growth (see Fig. 5).

In both cases they serve to propagate the plants, and enable them to rapidly cover considerable areas.

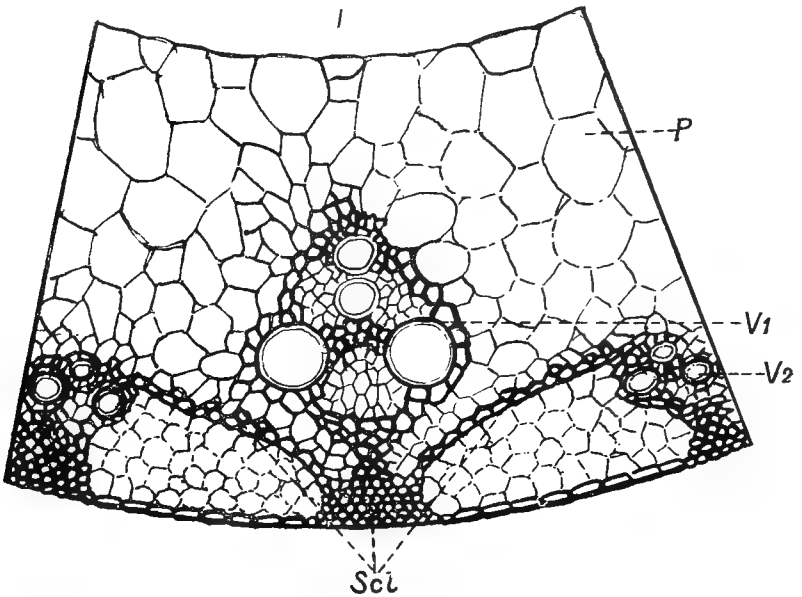


Fig. 4. Cross-section of one of the principal fibro-vascular bundles (V_1) in a Wheat culm, showing secondary bundles (V_2) on either side. Note the thick-walled tissue (sclerenchyma *Scl.*) surrounding the bundles and linking them up to the epidermis. *P*, the parenchyma. *I*, the inner side of the culm. Highly magnified.

Leaves. The leaves are arranged in two rows—or ranks—upon the stem, and alternate one with another. Each leaf consists of two parts—the lower portion surrounding the young shoot or culm—called the *sheath*; and the upper portion called the *lamina* or *blade*. (Figs. 13 and 23.)

Leaf-sheaths. The sheaths are attached to the stem at the nodes, and the thickening at these points is often chiefly due to

the enlarged bases of the sheaths (Fig. 2). They are usually smooth, but may be striated, i.e. have prominent longitudinal ridges.

The sheath may form a cylindrical tube enclosing the stem—when it is said to be "entire," or the margins may be more or less membranous and overlap one another, in which case the sheath is said to be "split." Generally it is only possible to be certain

Fig. 5. Portion of plant of *Poa pratensis* showing its extensively creeping rhizomes producing separate tufts of foliage. The true (fibrous) roots are seen to arise from the nodes of the rhizomes.

whether a sheath is "entire" or "split" in the case of the sheaths of the flowering stems, and even in these the sheaths may often be mechanically torn away for an inch or two at the top.

The shape of the young sheaths—and therefore of the young shoot—is determined by the arrangement of the leaf-blades in the shoot (Figs. 6 and 7). If the blades are folded (*conduplicate*) the sheaths are more or less flattened or compressed, and usually then have acute edges or *keels*. If the blades are rolled (*convolute*) in

the shoot, the sheaths are cylindrical and without strongly marked keels. In the Oat and Couch-grass notice that the sheaths are split, and the leaves are rolled in the shoot. Soft Brome-grass (*Bromus mollis*, L.) is an example of a grass with entire sheaths, and Cock's-foot (*Dactylis glomerata*, L.) shows the folding of the leaves in the young shoots very well indeed.

Near the surface of the ground the sheaths of many grasses, either while quite young, or as they age, become characteristically coloured. The colour is constant for each species, and may either be present all round the sheath, or confined to the veins only.

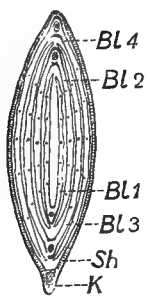


Fig. 6

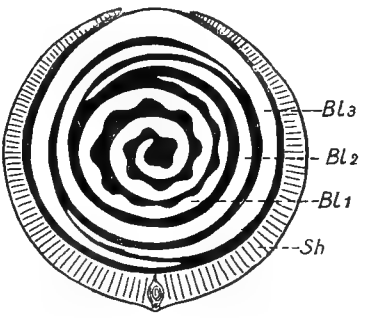


Fig. 7

Fig. 6. Transverse section of young shoot of *Poa trivialis* × 20, showing the conduplicate (folded) arrangement of the leaf-blades Bl_1, Bl_2 etc. *Sh.* the outer entire sheath (shaded). *K.* Keel of sheath.

Fig. 7. Transverse section of young shoot of *Phleum pratense* × 20, showing convolute (rolled) arrangement of the leaf-blades Bl_1, Bl_2 etc. *Sh.* the split sheath.

Leaf-blades. These are attached to the upper part of the sheaths and may be either expanded or closed, i.e. the blade may remain almost flat, or the two sides of its upper surface may be folded one upon the other; or again the blade may be rolled up like a roll of paper. This rolling or folding of the blade may be only temporary and due to drought or exposure, but in some species, e.g. Sheep's Fescue, this type of leaf is normal and permanent. In order to understand more clearly this process of rolling up and unrolling, etc., and to realise its great significance, it is necessary to consider briefly the internal structure of the blade and its modifications. See also Chap. II, p. 21.

The veins, i.e. *vascular bundles*—surrounded by a sheath of thick-walled tissue—run along parallel to each other from the base to the apex of the blade. The thickness of the latter may be almost uniform from edge to edge, but usually the tissue is raised over the vascular bundles and forms the well-known longi-

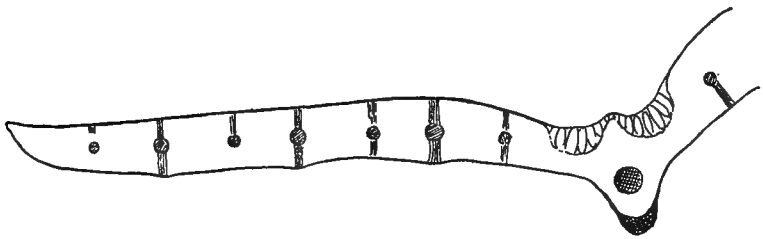


Fig. 8. Transverse section of one-half of a blade of *Poa pratensis* ×50. The blade is ribless above. Below is seen the prominent mid-rib (keel) which is flanked on either side above by a row of motor cells. The motor cells are confined to this area of the blade which therefore tends to fold up under dry conditions.

tudinal ridges or *ribs* on the upper surface. These ridges vary much in outline and prominence in different species as is shown by Figs. 9—11.

The tops of these ridges often consist of very hard tissue called *sclerenchyma* which is composed of thick-walled cells.

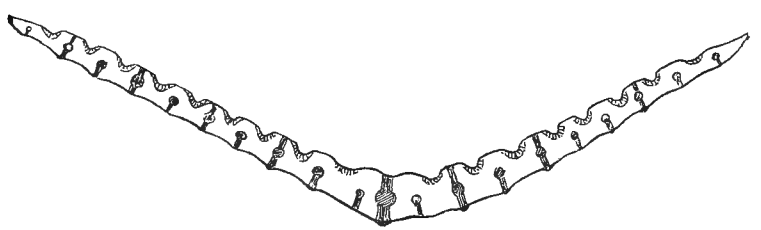


Fig. 9. Transverse section of a blade of *Alopecurus pratensis* ×20. Note the low flat-topped ridges (ribs) with the well-developed motor cells situated in the furrows between. The vascular bundles of the first order are girdered both above and below.

Continuous longitudinal bands of sclerenchyma also run along the blade close to the lower epidermis. These bands again vary much in relative size and strength with different species, in some being very slight, in others joining up and forming a continuous layer across the lower surface. This sclerenchyma tissue serves

to give firmness and rigidity to the blade, as well as to reduce its loss of moisture by transpiration. Further, strengthening girder-like bands of similar tissue sometimes connect the vascular bundles with the sclerenchyma bands of the ridges above, or with the bands near the lower surface, or with both (see Fig. 9). The space between the upper and lower epidermis not occupied by the vascular bundles, strengthening bands, etc., is filled up with the chlorophyll-containing tissue, but in some aquatic species, e.g. *Glyceria aquatica*, Sm., large air cavities also occur.

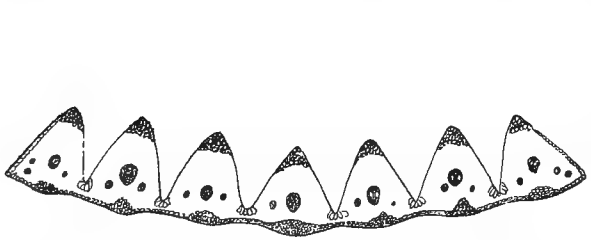


Fig. 10

Fig. 11

Fig. 10. Transverse section of a leaf of *Aira cæspitosa* ×20. The high ridges are tipped with thick-walled tissue (sclerenchyma) which also forms an almost continuous layer near the lower epidermis. Note the thin-walled motor cells situated at the base of each groove.

Fig. 11. Transverse section of leaf of *Festuca rubra* var. *genuina* ×30. Note the well-defined groups of strengthening tissue (sclerenchyma) at the keel and margins, and also below each vascular bundle.

When the blade is of the expanded, ribless type (Fig. 8), the stomata are generally distributed almost equally over both surfaces, as for example in most of the *Poas*, *Dactylis*, etc.

When ridges and their intervening grooves are conspicuous above, it is found that either all the stomata are situated on the upper surface, as in *Festuca ovina* and *Aira cæspitosa*; or that the larger number are on the upper surface as in *Lolium* sps., and *Cynosurus cristatus*. In species with marked ribs the stomata are situated on the lower slopes of these ridges, and in some cases are even sunk in the chlorophyll tissue.

In most grasses there are specially modified epidermal cells found on the upper surface of the blade. They are large in size, thin-walled, and transparent, and are definitely situated, either

flanking the mid-rib, or at the base of the grooves between all the ribs. They are known as *motor cells* (see Figs. 8 and 10).

The special function of these cells must be left till the next chapter, but it may be noted here that the transparent lines

Fig. 12. Typical outlines of leaf-blades. Left to right:—*Dactylis glomerata* (broadest near base), *Bromus sterilis*, *Poa trivialis*, *P. annua*, *P. pratensis* (edges almost parallel throughout), *Brachypodium sylvaticum* (tapering above and below), *Holcus lanatus*, *Agrostis stolonifera*, *Festuca rubra* (needle-like).

frequently seen running longitudinally between the ribs are largely due to the presence of these motor cells. The higher the ridges and the more these motor cells are developed, the greater will be the contrast in opacity observed between the ribs and the grooves when a blade is held up to the light.

In noting the shape of the blade the relation of length to breadth, the amount of tapering below or upwards, and the nature of the apex should be considered. Also whether the blade is broadest at its base or near its middle; and whether the mid-rib is prominent below, forming a keel from the base to the apex (Fig. 12).

At the base the blade frequently widens out into a ledge-like process, or forms ear-like projections on either side which more or less clasp the stem. These latter are called ears or *auricles*.

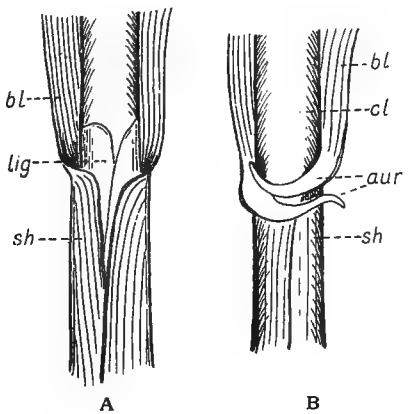


Fig. 13. *A. Avena sativa,* showing the well-developed ligule (*lig.*) standing up between the culm and the base of the blade (*bl.*). *sh.* the sheath. ×2. *B. Hordeum sativum,* showing the well-developed auricles (*aur.*) clasping the culm (*cl.*). The short ligule is not shown. ×2.

At the point where the blade joins the sheath there is usually an erect delicate membranous outgrowth of the latter which partly surrounds the stem or sheath above it. This is called the *ligule* and may be long or short, pointed or blunt, etc. The presence or absence of the ligule and auricles, and the various characters afforded by them being constant for each species, afford considerable help in the identification of grasses in their non-flowering condition (see Fig. 13).

In addition to the above points, the student should observe in regard to the foliage:

(*a*) The usual position assumed by the blades, i.e. whether erect, drooping, or at right angles to the sheath.

(*b*) The position of the hairs (when present); whether these are most abundant on the sheath, or on the upper or lower surface of the blade, and whether they are uniformly scattered over the surface or confined to the ribs, margins, etc.

(*c*) The particular shade of green normally possessed by the foliage.

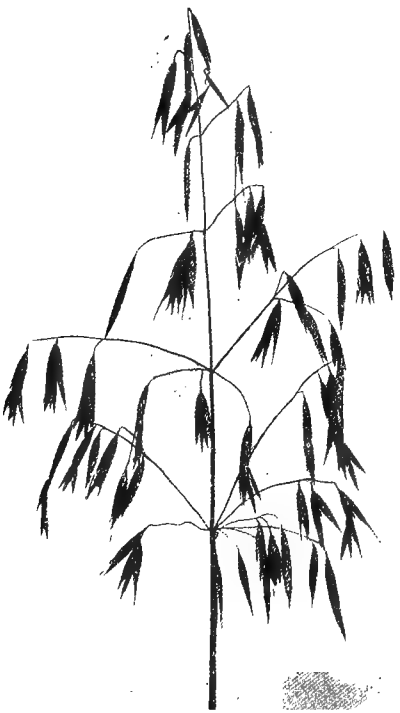


Fig. 14. Panicle of *Avena nuda*. About $\frac{1}{3}$ nat. size.

In the Oat plant note that the blades are expanded, broad, almost ribless, and without auricles. The ligule is white, membranous, and ragged at its margin. The foliage is entirely glabrous except for a few hairs usually on the lower margins of the blade. In Couch-grass note the auricles clasping the stem; the short, blunt, and rather thick ligule; and the scattered hairs (occasionally absent) on the blade—chiefly on its upper surface.

(B) Floral Organs. These consist of the flowering-culm, with the more or less branched collection of flowers borne upon it and forming the *inflorescence*. The inflorescence varies in form and structure very much indeed in the different genera, but it is always composed of a varying number of partial inflores-

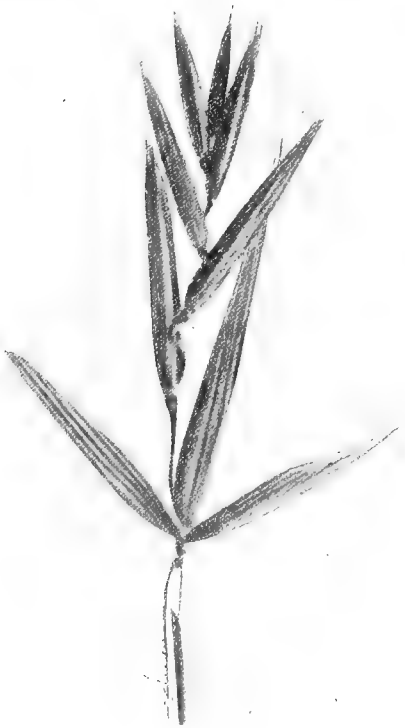


Fig. 15. Seven-flowered spikelet of the naked-grained Oat (*Avena nuda*) slightly enlarged. Note the alternate arrangement of the glumes and flowers (right to left, from below upwards).

cences called *spikelets*, which again are composed of one or more flowers with their enveloping bracts (Figs. 14 and 15). We will describe the structure of the flower first.

The Flower. The flower of our grasses is composed typically of one carpel and three stamens (see Figs. 16 and 17). The stamens

(when ripe) have long slender filaments which are attached to the long anthers, as shown in Fig. 16, thus allowing considerable freedom of movement to the latter. Other numbers of stamens are present in certain exotic species, but all British species have three with the exception of Sweet Vernal-grass (*Anthoxanthum*),

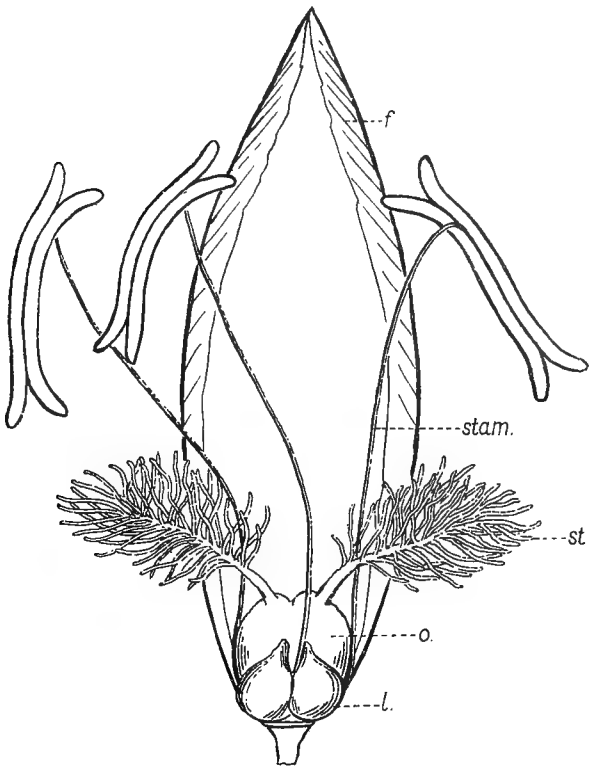


Fig. 16. Flower of *Lolium perenne* much enlarged, showing the position of the ovary (*o.*), with its feathery stigmas (*st.*), the three stamens (*stam.*) with their versatile anthers (hung so as to turn freely), and the two lodicules (*l.*). The inner palea is shown at the back with its folded margins (*f.*). The outer palea has been removed.

which has only two. The ovary consists of a small ovoid body, which is either glabrous or hairy, and bears a pair of divergent feathery stigmas at its apex. At the base of the ovary are two very small scales which can only be readily observed with a magnifying glass at about the time of flowering. They are known as

the *lodicules*[1], and are considered to represent bracteoles (i.e. secondary bracts) subtending the flower. The ovary and stamens —the essential parts of the flower—are enclosed between two boat-shaped scales called the *paleæ*. These paleæ are also considered to be of the nature of bracts or bracteoles, i.e. enveloping protective organs. The inner or upper palea is usually thin and sometimes membranous; the outer or lower palea is larger, stouter, and more or less overlaps the inner one, and frequently bears a bristle-like appendage or *awn*. Morphologically the awn bears the same relationship to the outer palea as the leaf-blade bears to

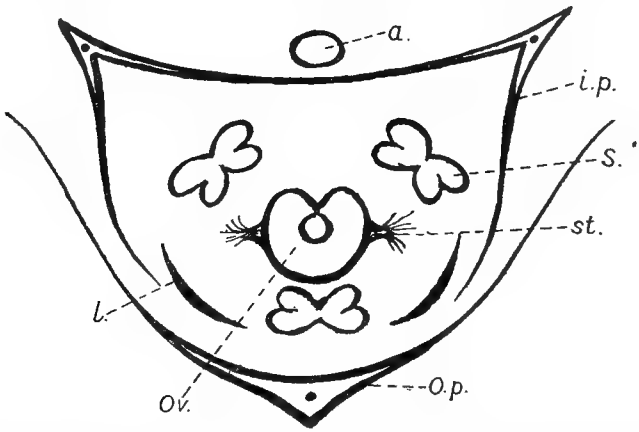


Fig. 17. Floral diagram of a typical grass. The outer palea (*o.p.*), and the inner palea (*i.p.*) enclose two bracteoles (the lodicules) (*l.*), three stamens (*S.*), and the ovary (*ov.*). *st.* the stigmatic plumes. *a.* axis = rachilla.

the leaf-sheath. Very useful distinctive characters are afforded by the nature of the awn and its position on the palea.

The Spikelet. Each spikelet or partial inflorescence consists of a little spike of flowers with their paleæ arranged as shown diagrammatically in Fig. 18, the whole being enclosed by one[2] or more (usually two) bracts called the empty glumes—or briefly the glumes. The flower and spikelets of the Oat are large and afford good material for examination.

Forms of Inflorescence. The form of inflorescence is determined

[1] In a few genera the lodicules are absent, e.g. *Alopecurus*, *Anthoxanthum*, etc.

[2] Except in *Nardus*, where the glume is obsolete.

by the way in which the spikelets are attached to the main axis. If they are borne directly upon the rachis, as in Fig. 27, we have a *spike of spikelets* or briefly a *spike* (see Couch-grass). If they are supported upon primary or simple branches we have a *raceme*. In the majority of species, however, the spikelets are borne on secondary, tertiary, or even further subdivided branches, and this compound class of inflorescence is a panicle of spikelets

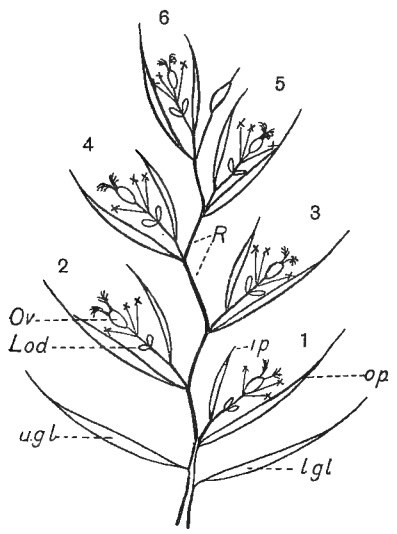


Fig. 18

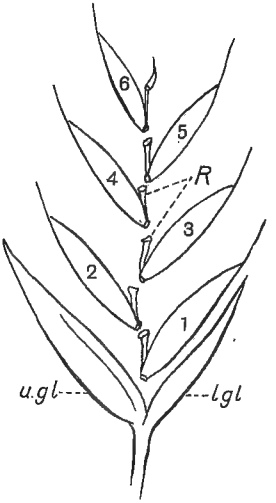


Fig. 19

Fig. 18. Diagram of a grass spikelet (*Festuca rubra*) showing the alternate arrangement of the flowers (Nos. 1—6), within, or above, the empty glumes. *l.gl.* lower glume, *u.gl.* upper glume, *o.p.* outer palea, and *i.p.* inner palea of the first flower. The stamens are represented by crosses. *Ov.* ovary, *Lod.* lodicules, *R.* rachis.

Fig. 19. The same, showing the manner in which the spikelet breaks up when the "seeds" (1—6) are ripe. *R.* rachillæ. Usually one or more of the uppermost flowers fail to produce mature "seed."

or briefly a *panicle* (see Oat, Fig. 14). It is evident that panicles may differ very much in appearance according to the relative length and stoutness of the branches. Thus they may be erect, close, or even spike-like; or long, loose, spreading, or drooping; or they may come anywhere between these extremes in structure and appearance (see Figs. 46, 71, 73 and 87).

(C) Fruits ("*Seeds*"). When the fruit (grain) of a grass ripens the rachis of the spikelet usually breaks up and allows each grain to fall away tightly entrapped between the two paleæ (Fig. 19). When the paleæ are present there is usually a small portion of the axis of the spikelet attached to their base upon which the

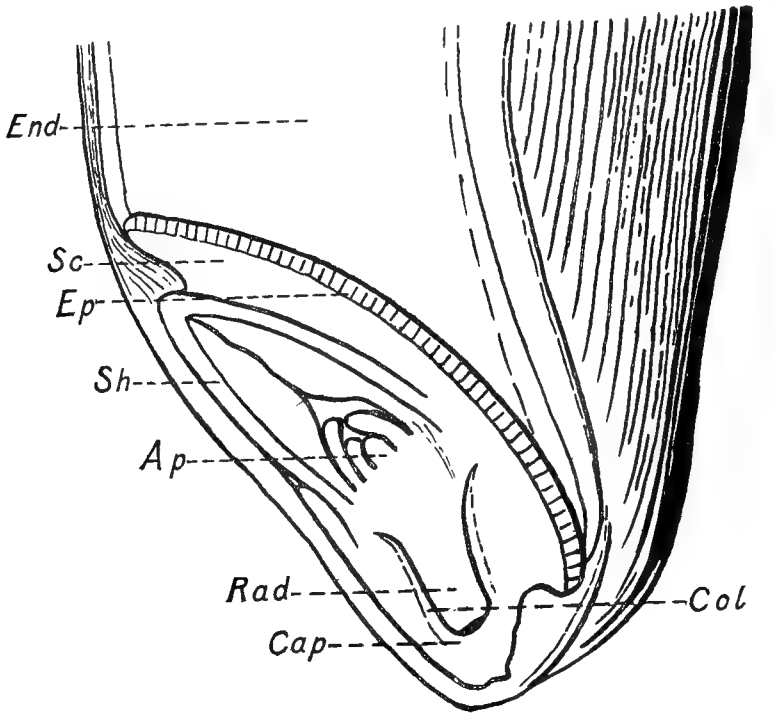


Fig. 20. Median longitudinal section through the lower part of a wheat grain, showing the position and structure of the embryo. *End.* endosperm, *Sc.* scutellum in contact with the endosperm by *Ep.* the epithelial layer. *Ap.* the growing apex, and *Rad.* the primary root of the embryo. *Sh.* the germ-sheath, *Col.* the root-sheath, *Cap.* the root-cap. × about 15.

"seed" immediately above was borne. This is called the *rachilla* and lies in front of the inner palea at the base of the "seed." This is the usual type of what is commonly called a grass "seed." In some cases however the "seed" consists of the entire spikelets, i.e. of the glumes, paleæ, and grain of one or more flowers, as in

Holcus, *Alopecurus*, *Panicum*, etc.[1] In the genus *Hordeum* the so-called "seeds" often consist of the three united mature spikelets. In a few instances the "seed" consists of the grain

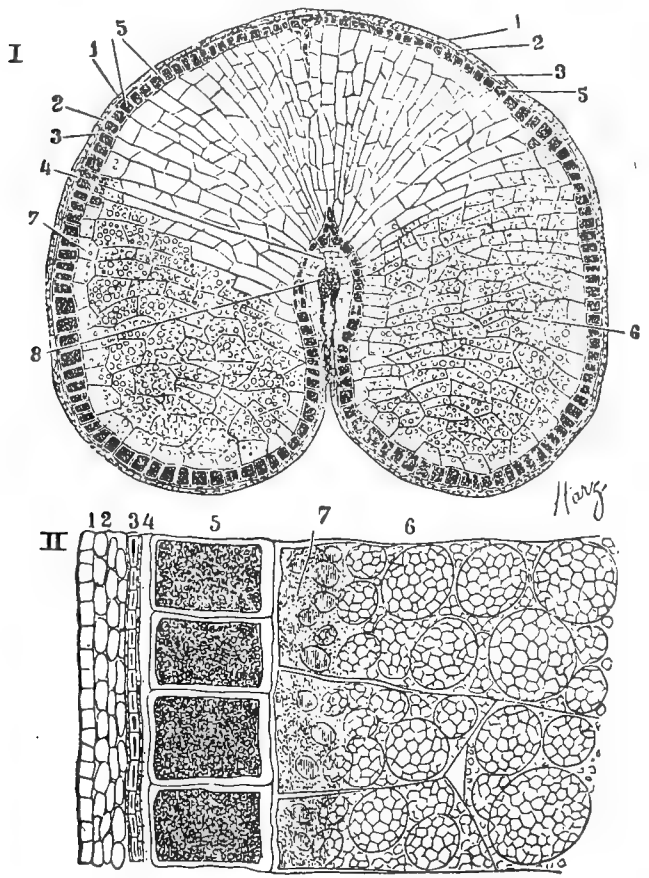


Fig. 21. I. Central cross-section of a grain of the cultivated Oat, *Avena sativa*, L. II. A small piece of the peripheral portion more highly magnified. 1 and 2, the pericarp; 3, testa; 4, remains of the nucellus; 5—7, amylaceous tissue; 5, gluten cells; 6 and 7, cells of albumen containing compound starch-grains—at 7 they are richer in albumen and poor in starch; 8, fibro-vascular bundle of the seed-coat. Harz.

shed free from its paleæ, as in the common varieties of Wheat, and sometimes Timothy-grass.

[1] For other types see *Anthoxanthum* and *Arrhenatherum*.

The naked grain of grasses forms a special type of fruit technically known as a *caryopsis*. It is a one-seeded, dry, indehiscent[1] fruit, with the fruit-wall (*pericarp*) fused to the seed-coat (*testa*). The true seed then, consists of the embryo with its store of endosperm, enclosed within the seed-coat. The thin fruit-wall surrounding the seed-coat makes up the complete *grain*. The embryo forms but a small portion of the entire grain, the bulk of the latter being composed of the starchy endosperm, reserved for the nourishment of the seedling during the early stages of its growth. If the embryo is examined under the microscope it is seen to consist of a primary shoot (*plumule*), a primary root (*radicle*)—often with secondary rootlets visible—and of a flat shield-like structure, one face of which is applied to the mass of endosperm. This organ is known as the *scutellum*, and is generally regarded as the cotyledon.

Figs. 20 and 21 give longitudinal and transverse sectional views of cereal grains, and show the position and parts of the embryo, and also the different parts or layers of the rest of the grain.

CHAPTER II

GENERAL BIOLOGY OF GRASSES

In this chapter it is only intended to deal briefly and in a general way with the development and functions of the different organs. For fuller details of the physiology of grasses reference must be made to special works on that subject (see also Bibliography, Nos. 10, 34).

Germination. The "seeds" of grasses—like those of other plants—require as essential for their germination (1) moisture, (2) a suitable temperature, (3) the presence of air or oxygen. Other factors may influence the rapidity of the process, or the percentage of germination, but these three are essential to it. The most favourable temperature for the germination of most grass "seeds" lies between 20° and 25° C. Under such conditions

[1] A few exceptions occur in exotic species.

Fig. 22

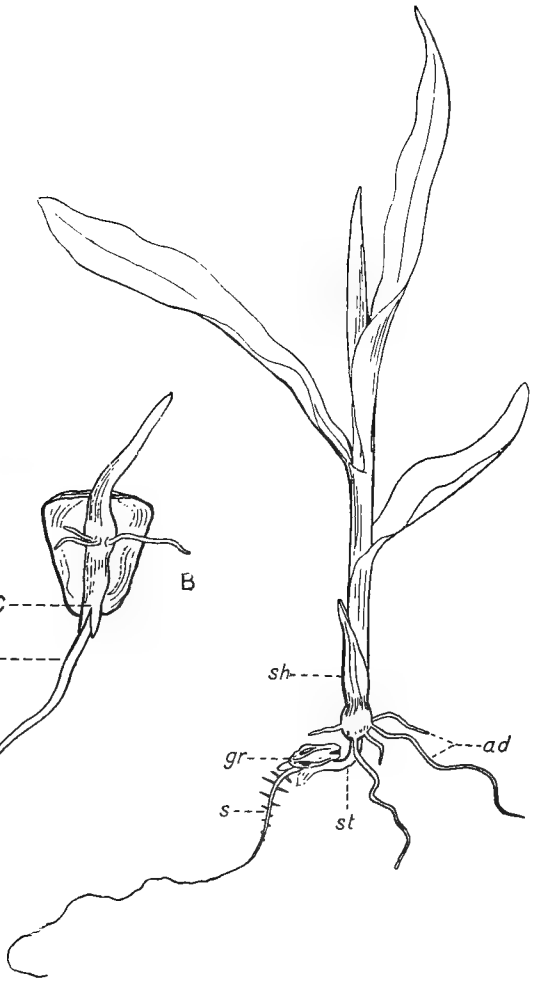


Fig. 23

Fig. 22. Germinating Maize, natural size. *A*. Early stage, after three day growth. *B*. The same after five days growth. *C*, coleorhiza. *R*, primary root. In *B* the first adventitious roots are shown arising from the primary node.

Fig. 23. Young plant of *Zea mais*. ½ nat. size. *s*. seminal root; *ad*. adventitious roots arising from the lowest node; *st*. rhizomatous stem; *sh*. first sheathing leaf; *gr*. shrivelled grain.

the "seed" soon swells up owing to the absorption of a considerable quantity of water. At the same time, the epithelium cells of the scutellum—which lie in contact with the endosperm—secrete an enzyme known as the *diastase of secretion.* This enzyme diffuses into the endosperm, corrodes away the substance of the starch grains, until the latter become finally changed into a sugar—*maltose*—and a smaller proportion into a gum-like substance called *dextrin.* These soluble and diffusible substances can readily be carried through the cells to the growing points of the embryo. Very soon the embryo puts forth a small number of "*seminal*" rootlets, which are only intended to assist in establishing the seedling for a very brief period, after a few days being replaced by more permanent ones which arise from the first or lowermost node of the stem (Figs. 22 and 23).

At the same time the embryo sends up a delicate white tube-like sheath—the *germ-sheath*—and out of the apex of this the first green foliage leaf appears.

Subsequent Development. For a considerable time in most grasses no distinct stems are noticeable, only the green foliage is to be seen. In reality, however, the formation of the flowering stems begins quite early in the case of annual grasses, and even in the perennial species they are being formed long before we see them. They arise as lateral buds from the crown of the rhizomatous stem, at nearly the same point from which the first adventitious roots arise. For some weeks or months they remain very minute and in an undeveloped condition, but as summer approaches the internodes lengthen very rapidly, and the young inflorescence is finally pushed out of the uppermost sheath. This process is termed the "shooting" of the corn in the case of our cultivated cereals. Since one or more shoots may arise in this manner in the axil of each of the lower leaves a considerable cluster or *tuft* of young stems is often formed. This process of multiplication of the stems is termed *tillering* and the number of *tillers* produced may vary from one or two up to two or three score or more according to the species, available space, etc.

Roots. The roots of grasses on account of their thin and fibrous nature are admirably adapted to the task of thoroughly searching out the layer of soil at their disposal for the water and

plant food materials they need (Fig. 1). Their adventitious origin at the lower nodes of the stem, together with the production of rhizomes or stolons in many species, enable the plants to spread rapidly and cover large areas.

Leaves. The leaves have two principal functions to perform, and for both of these they show signs of great adaptation. The assimilation of carbon from the carbon-dioxide of the air and the formation of starches and sugars from the elements carbon, hydrogen and oxygen (*photo-synthesis*) is the work of the chlorophyll corpuscles. The thin, long, blades of grasses probably expose a larger area of chlorophyll granules to the sunlight than any other class of plants if the proportional dry weight of the plants be taken into consideration.

We find even greater adaptation for the control of the rate of transpiration. Many species are markedly adapted to xerophytic conditions, i.e. to grow under circumstances which allow only the minimum moisture supply.

In such xerophytic species the motor cells (p. 9) are well developed and serve to regulate the rate of transpiration. Their thin elastic walls enable them to take up or part with excess of moisture readily. When moisture is plentiful they become turgid, and, owing to their situation between the ribs, the blades are kept fully expanded. When the moisture supply fails these cells become flaccid, and as they shrink they permit the ribs to come together. In this way they cause the blade to roll or fold up, and since the stomata are chiefly or wholly upon the upper surface and between the ribs, the transpiration is very much reduced. The lower and exposed surface moreover is protected by hard tissue, and in extreme cases the blade itself may be reduced in size, e.g. *Aira flexuosa* and Sheep's Fescue. If the motor cells are confined to the sides of the mid-rib the blade folds under dry conditions; but if they are developed between all the ribs the blade rolls up. The presence of the hard tissue at the top of the ribs and on the lower surface, together with the girders joining them up to the vascular bundles, all assist in the closing up or expansion of the blades and in maintaining the required position. In many species the presence of hairs also assists in the regulation of the rate of transpiration. In the case of shade species the

blades are thin, flat, and have stomata freely exposed on both surfaces, e.g. *Brachypodium sylvaticum.*

Very little is known of the functions of the ligule and auricles, and they appear to be unimportant physiologically. Possibly they may serve to shoot off the water as it runs to the base of the blade and so prevent it from getting into the sheath.

Pollination. When the reproductive organs are mature the lodicules swell and push apart the paleæ, thus exposing the stigmas which are now spread to their fullest extent. About the same time the filaments of the stamens, which have up till now remained very short, rapidly elongate and carry out into the air the dangling anthers, which burst and shed abundance of pollen. In some cases the stigmas are mature and ready for pollination before the pollen of the same flower is ripe, e.g. Meadow Foxtail, but in most cases the pollen is ripe and begins to be shed before the stigmas of the same flower are mature.

The feathery nature of the stigmatic plumes, their size and spreading position, together with the large quantities of pollen produced, indicate that wind is the principal agent in the cross-pollination of the flowers. In some species however, e.g. wheat, barley, etc., the flowers are cleistogamous, i.e. pollination and fertilisation are accomplished before or even without the opening of the paleæ. In such cases cross-fertilisation is normally impossible.

The dissemination of grass "seeds" is probably much facilitated by the attached glumes (*Holcus*, *Alopecurus*, etc.), inflated paleæ (*Briza*, etc.), or by the silky hairs at the base of the "seed" ("web" in *Poa* sps.), or on the rachilla (e.g. *Arundo*, Wild Oat, etc.), each of which are aids to their distribution by wind. See Figs. 45, 52, 58, 62, 114, 126 and 142.

Bristles and barbed awns (e.g. Barren Brome) also serve to fasten the "seeds" to animals. Again, the hardened base of many grass "seeds," the presence of bent or twisted awns (False Oat), and the position occupied by the hairs all assist in burying the "seed" in the soil in order that it may germinate. Figs. 55 and 74.

CHAPTER III

DISTRIBUTION OF BRITISH GRASSES

A study of the distribution of grasses affords both interest and profit. While several of our common species are *vagabonds*, i.e. generally distributed without any apparent preference for one habitat more than another, it is nevertheless true that most grasses do show a decided preference for certain definite conditions as regards soil, moisture, degree of shade, etc. Indeed as we have already seen in the previous chapter many species possess obvious adaptations for growing in dry and exposed situations (*Xerophytes*).

Other species (*Hydrophytes*) are adapted for aquatic conditions, e.g. *Glyceria aquatica*, *Digraphis*, etc. The grasses of this class have large expanded leaves, generally with stomata on both surfaces, and large air cavities are often present in the sheaths, etc.

A few grasses are *Halophytes*, i.e. adapted for soils rich in saline constituents, e.g. *Psamma*, *Elymus*, etc. In these transpiration is checked by the thickening of the cuticle of the leaves, by the inrolling of the blades, and by the production of a waxy substance over the entire surface of the plants.

But a knowledge of this subject is of practical value to those interested in agriculture. To the student at first it may simply afford assistance in finding or identifying the species, but after some experience he will be able to reverse the process, and to form a useful opinion about the physical properties and agricultural value of land from observation of the grasses thriving upon it. The presence of much sand, clay, chalk, or humus in a soil, or again the natural tendency of a field to be wet or dry, are all indicated with a very fair amount of accuracy by the healthy growth of certain species, or better still by groups of species. Broadly speaking our grasses may be grouped according to (*a*) the relative amount of moisture, and (*b*) the relative amount of shade which they prefer. For further information on this subject see Bibliography, Nos. 3, 20, 22 and 32.

GRASSES GROUPED ACCORDING TO THEIR HABITAT.

1. *Chalk and Limestone Formations* (dry, open, hilly areas).
   Festuca ovina var. vulgaris.
   Aira flexuosa.
   Nardus stricta.
   Sesleria cærulea (chiefly in N. Britain).
   Triodia decumbens.
   Avena pratensis.
   Kœleria cristata.
   Bromus erectus.
   Avena flavescens (less typical).

2. *Sandy Soils* (dry and porous).
   Bromus sterilis.
   B. arvensis and vars.
   Poa pratensis.
   Agrostis Spica-venti.
   Aira præcox.
   A. caryophyllea.
   A. canescens.

3. *Sandy Sea Shores.*
   Psamma arenaria.
   Elymus arenarius.
   Agropyrum junceum.
   Phleum arenarium.
   Hordeum maritimum.
   Poa maritima.
   Lepturus incurvatus (rather uncommon).
   Cynodon Dactylon.

4. *Preferring stiff moist Clays*, or wet soils generally.
   Festuca elatior and vars.
   Phleum pratense.
   Alopecurus agrestis (on arable land).
   A. pratensis (especially in semi-shade).
   Poa trivialis (especially in semi-shade).
   Anthoxanthum odoratum (especially in semi-shade).

Aira cæspitosa (especially in semi-shade).
Holcus lanatus.
Agrostis alba var. stolonifera.
Hordeum pratense.
Briza media (especially on poor soils).

5. *Aquatic or semi-aquatic species*, thriving most on Boggy soils, in Freshwater Marshes, Fens, Water-meadows, Ditches, etc.

Arundo Phragmites (Fens).
Digraphis arundinacea.
Glyceria aquatica and G. fluitans.
Agrostis alba var. palustris.
Alopecurus geniculatus (edges of ponds, etc.).
Catabrosa aquatica.
Aira cæspitosa.
Molinia cærulea.
Leersia oryzoides (rare);

and to a less extent:

Holcus.
Briza.
Festuca elatior.

6. *Heath and Moor Grasses.*

Molinia cærulea (if wet).
Nardus stricta.
Triodia decumbens.
F. ovina.
Agrostis vulgaris.
A. canina.
A. setacea.
Aira flexuosa.

7. *Shade-loving species*, Woods, etc.

Poa nemoralis (dry or moist).
Milium effusum (moist woods).
Melica uniflora (high-lying, moist woods).
M. nutans (high-lying, moist woods: rare).
Brachypodium sylvaticum.

Hordeum sylvaticum.
Bromus asper.
Festuca gigantea, Vill.
F. sylvatica (mountain woods, not common).
Holcus mollis (moist shade).
Agropyrum caninum.
Calamagrostis Epigeios.
C. lanceolata.

8. *Preferring Semi-shade*, Hedge-sides, Copses, etc.
Molinea cærulea (especially if moist).
Aira cæspitosa (especially if moist).
Anthoxanthum odoratum.
Arrhenatherum avenaceum.
Alopecurus pratensis;
and to a less extent:
Poa trivialis.
Dactylis.

9. *Preferring Open Situations.*
Festuca ovina and vars. (especially on limestone formations).
Bromus erectus (especially on limestone formations).
Brachypodium pinnatum.
Avena pratensis.
A. flavescens.
Aira flexuosa.
Nardus stricta.
Triodia decumbens.
Sesleria cærulea.
Kœleria cristata.
Cynosurus cristatus.

10. *Vagabond Species*, i.e. generally distributed without much apparent preference for habitat.
Poa annua.
Bromus arvensis and vars.
B. sterilis.
Agropyrum repens.
Lolium perenne; but thrives best on clay soils.

Some species are confined to dry, stony situations, waysides, and rocky places, e.g. *Festuca Myurus*, *Hordeum murinum*, *Poa rigida*, *Poa compressa*, etc., and will not fit well into any of the preceding groups. Others, like Crested Dog's-tail and Yellow Oat-grass, though usually abundant on dry chalky soils, will thrive equally well on moister clay soils. Other species, e.g. *Agrostis canina* and *A. setacea*, will thrive on most dry soils whether either sand or chalk predominates.

The above lists contain several species which are either uncommon or rare. They are only mentioned here on account of their value as "*Indicator plants*."

In our old pastures and meadows it is obvious that the grass flora must vary considerably with the nature of the soil, manuring, kind of grazing, etc. It is nevertheless true that some species tend to predominate on land which is always grazed, while others are more typical of land on which hay crops are usually grown. The following lists may be taken as indicating in a general way those species which are most abundant on each of these two kinds of grass land.

Grasses generally most abundant on old pastures.

Lolium perenne
Agrostis alba var. stolonifera
Holcus lanatus
Poa trivialis
Festuca rubra
} Especially on low-lying rich grazing land.

F. duriuscula
Avena flavescens
Cynosurus cristatus
Festuca ovina
Agrostis vulgaris
Poa pratensis
} Especially on higher or drier grazing land.

and to a less extent on medium or good soils:

Dactylis glomerata.
Phleum pratense.
Alopecurus pratensis.
Poa annua.

Typical grasses of Meadow Land.

Dactylis glomerata.

Poa trivialis.
Agrostis alba var. stolonifera.
Alopecurus pratensis
Bromus mollis
Holcus lanatus
} Generally tend to increase on land annually mown.
Phleum pratense.
Arrhenatherum avenaceum.
Anthoxanthum odoratum.

The following annuals are almost wholly confined to cultivated land:

Avena fatua (in corn crops).
Lolium temulentum (in corn crops and waste places).
Alopecurus agrestis (wet clays).

CHAPTER IV

COMMON BRITISH GRASSES GROUPED ACCORDING TO THEIR VEGETATIVE CHARACTERS

It is often necessary for those engaged in botanical or agricultural work, nature study, etc., to be able to distinguish with certainty our common grasses when they are not in flower. A considerable amount of experience in this direction has enabled the author to form a simple and yet very reliable key, which is given below. It includes all the species which are likely to be met with on farms in Britain. In its construction there are four steps which lead up to the identification of the species. The student should always examine his specimens in the following order:

1. Are the leaf-blades expanded or *permanently* closed?
2. Are the young leaves *rolled* or *folded* up in the shoot?
3. Is the species entirely glabrous, or more or less hairy?
4. Are auricles present or absent?

With regard to the first point, it should be noticed whether the leaves are *permanently* closed or only temporarily rolled or folded on account of drought, etc.

The second point can also be best determined—if there is any

doubt—by cutting the shoot across transversely with a sharp knife. The arrangement of the young leaves can then be easily seen with a lens (see Figs. 6 and 7). If the leaves are rolled in the shoot the latter has a cylindrical shape; if the leaves are folded the shoot is more or less flattened. If hairs are present, it should be noticed whether they are most abundant on the sheath or blade. Also, whether they are most abundant on the upper or lower surface of the blade. Again the student should observe whether the hairs are short and densely crowded together, giving a velvety surface; or whether they are long, or scattered, or confined to the ribs, leaf-margins, etc.

In all the species included in the key the sheaths are split, except where the contrary is stated. It is frequently difficult to decide whether the sheaths of some grasses are entire or split—especially when the plants are young. This character has for this reason been given a secondary place in the key. In describing the ligule of any species as long, short, acute, etc., reference is always made to the ligule of the uppermost leaf. This is necessary, because in some grasses the ligules of the upper and lower leaves differ considerably from each other in the relation of length to breadth, etc.

It should be observed that the key is based wholly upon the grasses *while in their young and undeveloped condition*, i.e. before flowering. As the plants mature they frequently alter somewhat as regards hairiness, smoothness, shoot section, etc. For example the sheaths of the young shoots of Cock's-foot and Rough-stalked Meadow-grass are quite smooth—it is only the sheaths of their flowering culms which are rough. Hence in dealing with the plants in flower, reference must be made to Chapters V and VII.

It is very desirable that not only the leaves, but also the roots —and stolons or rhizomes if present—should be examined, as these often afford conspicuous distinguishing characters. Occasional reference has been made in the key to the habitats of species, but only as a confirmatory point.

One or two exotic species have been included because of their occasional introduction into British agriculture and this remark applies also to the other keys.

KEY TO THE MORE COMMON GRASSES, BASED MAINLY UPON THEIR FOLIAGE CHARACTERS.

GROUP I. **All the leaf-blades expanded.**

A. **Shoot flattened** (*leaves folded in young shoot*), *plants entirely glabrous.*

(*a*) *With small auricles.*

Lolium perenne (p. 113), basal sheaths red or pink; blade dull above, glossy below.

(*b*) *Without auricles.*

Sheaths entire whilst young[1]:

Dactylis glomerata (p. 93), sheaths very sharply keeled; long acute ligule; no stolons, generally distinct tufts.

Poa trivialis (p. 129), ligule prominent and acute; blade glossy below; thin surface stolons if old.

Poa pratensis (p. 127), strong rhizomes if old; ligule short and blunt, sometimes almost wanting; blade dull.

Glyceria fluitans (p. 105), aquatic; sheath striated; blade ribbed; sheaths with air cavities.

Glyceria aquatica (p. 104), aquatic; blade often an inch wide, not ribbed; sheaths with air cavities.

Poa compressa (p. 123), sheaths very firm and acutely keeled.

Poa annua (p 122), ligule comparatively large and white; blades dull, often wrinkled.

[[2]*Cynosurus cristatus* (p. 90), dull dark-green blades; short blunt ligule; old basal sheaths yellowish.

Avena pratensis (p. 70) may come here.]

B. **Shoot cylindrical** (*leaves rolled in young shoot*), *plants glabrous.*

(*a*) *With auricles* (or at least ledge-like projections at base of blade).

Lolium italicum (p. 115), ligule distinct; basal sheaths red; leaves broad, dull above and glossy below.

[1] Later on the sheaths may be partially torn or split from above downwards.

[2] The shoot section varies as the young leaves may be folded or rolled.

Festuca elatior (p. 99), very similar to *L. italicum*, but stouter and coarser foliage, and small creamy-white auricles.

Festuca pratensis (p. 100), as *F. elatior*, but smaller plant and extremely short ligule.

Hordeum sativum (cultivated Barleys), auricles very large, overlapping, glabrous, and white, pink or purple.

(*b*) *Without auricles.*

Cynosurus cristatus may come here (see above, also p. 90).

Phleum pratense (p. 121), numerous, short, pale-green leaves; ligule white, and short on lower leaves; base of stem often swollen.

Alopecurus pratensis (p. 59), blades long, dark-green, with distinct flat ribs; ligule short and blunt; old basal sheaths chocolate.

A. agrestis (p. 61), ribs relatively high and acute; annual; on cultivated ground.

A. geniculatus (p. 61), culms "kneed"; ribs acute; aquatic.

Agrostis alba (pp. 54–56), var. *vulgaris*—ligule short; blades thin; var. *stolonifera*—ligule long and delicate; stolons present; blades thin; var. *repens* has stout rhizomes.

A. canina (p. 56), blades narrow; ligule long, acute.

Aira cæspitosa (p. 56), coarse tufts; leaves firm, rigid, with high sharp ribs; ligule long.

Poa nemoralis (p. 125), ligule very short or wanting; blade thin and narrow; shade grass.

[1]*Avena fatua* (p. 73), ligule short and blunt; annual; on cultivated ground.

[1]*A. sativa* (cultivated Oat), similar to *A. fatua*; ligule membranous and toothed.

Bromus inermis (p. 87), well developed rhizomes; very short ligule; entire sheaths.

[1] Some varieties are slightly hairy on the lower margins of the leaves.

Arundo Phragmites (p. 66), ligule represented by a fringe of hair; aquatic.

Digraphis arundinacea (p. 95), ligule membranous and well developed; aquatic.

B. (*continued*). **Shoot cylindrical** (circular or oval in transverse section), *plants more or less hairy or pubescent.*

(*a*) *With auricles* (very small in *H. pratense*).

Bromus asper (p. 85), sheath entire and bearing long reflexed hairs; shade species.

Hordeum pratense (p. 111), blades firm, hairy above, glabrous and glossy below.

H. murinum (p. 109), blades thin and softly hairy on both surfaces; annual.

[1]*Agropyrum repens* (p. 51), well developed rhizomes; hairs chiefly on upper surface of blade.

Triticum sativum (common Wheats), hairs on edges of auricles; sheath pubescent (different varieties vary much in these respects).

[1]*Secale cereale* (Rye), short and long hairs on sheath; base of sheath reddish in colour. Auricles slight.

(*b*) *Without auricles.*

Holcus lanatus (p. 106), blades velvety to touch; pink veins on basal sheaths.

[1]*Arrhenatherum avenaceum* (p. 63), sparsely hairy on sheath or blade; ligule blunt; roots yellow; tufted.

Avena flavescens (p. 68), pale green blades which are thin, dull, and hairy on both sides; reflexed hairs on sheath.

Anthoxanthum odoratum (p. 61), long hairs at juncture of sheath and blade; sweet-scented.

Briza media (p. 77), blades with rough hairy margins and low flat ribs.

Bromus arvensis and vars. (pp. 79–82), entire sheaths with slight keel or none; softly downy.

B. sterilis (p. 82), as *B. arvensis* but keel more prominent on sheath; ligule deeply ragged.

[1] Hairiness varies considerably in these species.

B. erectus (p. 84), long hairs on margins of blade; entire sheath. Shoot section oval. Blades tend to fold.

Brachypodium sylvaticum (p. 74), blades of pale sap-green colour, thin, long, and tapering at both ends; usually in shade.

B. pinnatum (p. 76), blades only slightly hairy, narrow, rigid and tending to roll up; ligule fringed with hairs.

Molinia cærulea (p. 118), roots tough and stringy; blades thin, narrowing below and tapering to a long point above; ligule absent or represented by hairs.

[*H. pratense* (p. 111), owing to the very slight development of its auricles may come here.]

GROUP II. **Lower leaves setaceous** (i.e. bristle-like).

A. *Leaves permanently folded* (at least the lower ones).

(*a*) Roots fibrous.

Festuca ovina (p. 101), ligule much reduced or absent.

1. Var. *vulgaris*, compact tufts; leaves firm; auricles short, erect, and rounded off.
2. Var. *tenuifolia* (p. 102), smaller tufts and finer leaves than var. *vulgaris*.
3. Var. *duriuscula* (p. 102), a more vigorous variety than *vulgaris*, with stouter dark-green leaves.

Festuca rubra, L., ligule much reduced or absent.

1. Var. *genuina* (p. 102), pink basal sheaths and creeping underground rhizomes.
2. Var. *fallax* (p. 103), like *genuina* but tufted; no rhizomes.
3. Var. *heterophylla* (p. 103), similar to var. *fallax*, but upper leaves tend to be more open.

Festuca Myurus (p. 100), hairs on ribs of infolded leaves; ligule obsolete; annual.

Aira flexuosa (p. 57), ligule prominent; leaves practically solid; no auricles.

(*b*) Roots tough and stringy.

Nardus stricta (p. 119), upper leaves erect, lower ones reflexed.

B. *Bristle-like appearance due to inrolling or folding of edges of leaves.*

Avena pratensis (p. 70).
Aira canescens (p. 58).
A. præcox (p. 59).
A. caryophyllea (p. 59).
Poa maritima (p. 125);
and sometimes others.

CHAPTER V

COMMON BRITISH GRASSES GROUPED ACCORDING TO THEIR INFLORESCENCES AND FLORAL CHARACTERS

The following key may be used to determine the different genera, and in some cases the common species; further details must be looked for in the full description given in Chapter VII.

In using this key the student should first decide whether the inflorescence of the specimen is a *spike* or a *panicle*. If a spike, whether the spikelets are borne singly or in pairs, threes, or clusters. If a panicle, to which of the four types (A, B, C, D in the key) it belongs. In addition he should observe (1) the number of flowers in the spikelet, (2) whether all the flowers in the spikelet are perfect or not, and (3) whether the outer palea bears an awn.

If an awn is present, note whether it is terminal, sub-terminal, dorsal or basal. In cases where the awn or awn-like projection is generally less than half the length of the palea bearing it, I have called it an awn-point. In the key O.P. indicates the outer palea.

I. Inflorescence a Spike of Spikelets.

(Spikelets sessile or sub-sessile on the rachis.)

A. *Spikelets solitary,* i.e. borne singly.

1. Spikelets *without empty glumes*[1] and one-flowered.

Nardus (p. 119), only one row of spikelets apparent.

[1] Or one rudimentary glume only.

2. Spikelets with *one empty glume*[1] only.
   Lolium (p. 113) has two opposite rows of spikelets.
   L. italicum, outer palea bears terminal awn[2].
   L. perenne, outer palea awnless.
3. Spikelets with *two empty glumes*.
   (The genera **Triticum** and **Secale** come here.)
   Agropyrum (p. 51), rachis strongly notched.
   A. repens (p. 51), awn wanting or not exceeding length of palea.
   A. caninum (p. 54), terminal awn exceeds length of palea.
   Brachypodium (p. 74), rachis scarcely notched.
   B. sylvaticum (p. 74), terminal awn about as long as palea.
   B. pinnatum (p. 76), terminal awn shorter than palea.

B. *Spikelets not solitary.*

1. Spikelets *in pairs*, with 3–4 flowers each.
   Elymus (p. 97).
2. Spikelets *in threes*, each having a single flower.
   Hordeum (p. 109).
   H. pratense, terminal awn not twice length of palea.
   H. murinum, terminal awn twice length of palea.
3. Spikelets *in clusters*.
   Cynosurus (p. 90), spike elongated; spikelets 3–5 flowered.
   Sesleria (p. 131), spike short and ovoid; spikelets 2–3 flowered.

II. INFLORESCENCE A PANICLE.
(Spikelets not sessile on the rachis.)

TYPE A. *Panicle cylindrical and spikelike;* spikelets one-flowered.

1. *Both paleæ present.*
   Phleum (p. 121), glumes keeled and bear awn-point.
   Anthoxanthum (p. 61), each flower has two pairs of empty glumes, and only two stamens.

[1] The terminal spikelet has two empty glumes.
[2] Under certain conditions some of the seeds may shed their awns.

Psamma (p. 129), sea-shore grass with long rhizomes, panicle 4–6 inches long.

2. *Inner palea wanting.*

Alopecurus (p. 59).

A. agrestis (p. 61), panicle long and tapering.

A. pratensis (p. 59), panicle blunter at apex.

A. geniculatus (p. 61), an aquatic species with "kneed" culms.

TYPE B. *Panicle contracted and tufted.*

Dactylis (p. 93), spikelets rough and dull; 3–5 flowered.

Kœleria (p. 112), spikelets silvery; 2–3 flowered.

Digraphis *arundinacea* (p. 95) may come here; spikelets one-flowered.

TYPE C. *Panicle close;* though the inflorescence is elongated the spikelets keep near the main axis.

1. *Branches simple* and few.

Triodia (p. 132), outer palea 3-toothed at apex.

2. *Branches divided.*

(*a*) No awns or awn-points to paleæ.

Molinia (p. 118), spikelets 2–3 flowered.

Glyceria *fluitans* (p. 105), spikelets 8–16 flowered.

(*b*) With awns or awn-points to paleæ.

Festuca *ovina* (p. 101), terminal awn-points (may sometimes come here).

F. Myurus (p. 100), long terminal awns.

Aira *præcox* (p. 59), awns dorsal, or almost basal.

TYPE D. *Panicle lax, open and spreading*, at least during the flowering period.

1. *One perfect flower only in each spikelet.*

(*a*) Awns or awn-point to outer palea.

Arrhenatherum (p. 63), lower flower staminate.

Holcus (p. 106), upper flower staminate.

Agrostis *canina* (p. 56), very small one-flowered spikelets with protruding dorsal awn.

(*b*) No awn or awn-point.

Digraphis *arundinacea* (p. 95), two hair-tufts at base of paleæ.

Melica *uniflora* (p. 118).

Milium (p. 118).
Agrostis *vulgaris* (p. 56).
A. alba (p. 54) (sometimes has basal awn).

2. *At least two perfect flowers in each spikelet.*

(*a*) *With awns or awn-points to outer paleæ*, which are:

Terminal in **Festuca** (p. 99).
F. ovina and vars. (p. 101), leaves permanently closed.
F. elatior (p. 99). Leaves expanded. Spikelets 5–10 flowered.
F. sylvatica (p. 104). Leaves expanded. Spikelets 3–5 flowered.
Arundo *Phragmites* (p. 66), panicle large and silky; spikelets 3-flowered.

Sub-terminal in **Bromus** (p. 79).
B. arvensis and vars. (pp. 79–82), O.P. broad.
B. sterilis (p. 82), panicle drooping; O.P. narrow and long; awn longer than O.P.
B. asper (p. 85), panicle drooping; awn shorter than the O.P. Shade species.

Dorsal or *Basal* in:
Avena (p. 68), awns bent, long, and conspicuous.
Aira (p. 56), awns fine, not conspicuous.

(*b*) *Outer paleæ without awns or awn-points.*

Poa (p. 122), spikelets with 2–7 flowers; O.P. less than 4 mm. long.
P. annua (p. 122), "web" wanting; spikelets 4–7 flowered.
P. pratensis (p. 127), O.P. 5-nerved, the marginal nerves hairy below; spikelets 3–5 flowered.
P. compressa (p. 123), O.P. 3-nerved, spikelets 4–7 flowered.
P. trivialis (p. 129), O.P. 5-nerved, the marginal nerves free from hairs; spikelets 2–5 flowered.
P. nemoralis (p. 125), O.P. 5-nerved, both dorsal and marginal nerves hairy below; spikelets 3–5 flowered

"Web" of hairs at base of paleæ

Festuca *pratensis* (p. 100), spikelets 5–6 flowered; O.P. 5–8 mm. long.

Glyceria *aquatica* (p. 104), aquatic; spikelets 5–10 flowered.

Catabrosa *aquatica* (p. 90), aquatic; spikelets 2-flowered.

Briza (p. 77), large inflated spikelets 6–8 flowered.

Melica *nutans* (p. 116), two perfect flowers in each spikelet.

CHAPTER VI

KEY TO GRASS "SEEDS"

It has been found most convenient to classify the "seeds" of grasses in the main by the presence or absence of an awn on the outer palea. In Group I are placed all "seeds" which are distinctly awned, i.e. having on an average awns exceeding half the length of the paleæ bearing them. In Group III the paleæ bear no trace of an awn; the apex of the outer palea is either rounded off, or is acutely pointed, but does not taper off into a long point.

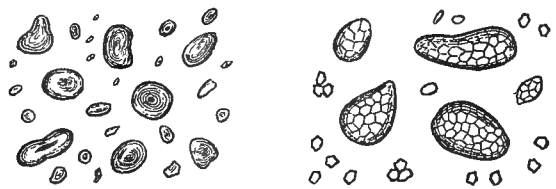
Group II is intermediate in these respects between Groups I and III, and includes "seeds" in which the apex of the outer palea either

(*a*) tapers to an awn-point;
(*b*) bears a sub-terminal point or spur;
(*c*) is two to five-toothed.

The terms "awn" and "awn-point" are of course only relative. If on an average the awn-like projections exceed half the length of the paleæ bearing them they are considered as awns; if they do not exceed this they are termed awn-points. In the case of a few species, where the length of the awn-point is subject to wide variation, the seeds have been included in more than one Group. The awn—when present—affords several other useful distinctive characters. It may arise from either the base (basal) or apex of the outer palea (terminal awn). Or it may arise from a point

just below the apex (sub-terminal), or near the middle of the palea (dorsal awn). It may be either straight, bent, twisted, smooth or barbed.

A careful examination of these points, together with the size of the "seed," the shape and relative size of the rachilla, the position of hairs, etc. will soon enable the student to distinguish most grass "seeds." In the key O.P. indicates the outer palea and I.P. the inner palea. The pages given refer to the fuller description.



Figs. 24 and 25. Types of Starch Grains.

Fig. 24. Simple grains from endosperm of *Agropyrum repens*. ×about 350.
Fig. 25. Compound grains from endosperm of *Festuca pratensis*. ×about 350.

It may here be noted that the starch grains of the endosperm also afford characters which are useful aids to the identification of species. The size, form, and structure of these are often very different in the different genera (see Figs. 24 and 25). In Maize, Wheat, Barley and Rye, and also in the genera *Panicum*, *Agropyrum* and *Elymus* they are simple and either rounded or polyhedral in form. In all other British genera compound grains occur. Further details cannot be given here. See Bibliography, Nos. 10 and 35.

Key to British Grass "Seeds."

Group I. **"Seeds" distinctly awned.**

A. **Awn terminal**, i.e. the O.P. tapers off into an awn.

1. "*Seed*" *consisting of the spikelets usually united in threes:* **Hordeum.**

(*a*) Awn exceeding twice the length of the O.P.

H. murinum (Fig. 118), empty glumes of central spikelet dilated and fringed (common) (p. 109).

H. sylvaticum, glumes only slightly dilated; those

of the central spikelet not fringed, the paleæ of the central spikelet not enclosing a grain (rare).

(*b*) Awn not exceeding twice the length of the O.P.

H. pratense, glumes all bristle-like,—not dilated (p. 111).

H. maritimum, inner glume of lateral spikelets dilated on one side.

2. "*Seed*" *consisting of only the I.P. and O.P. enclosing the* "*grain.*"

(*a*) "Seed" somewhat flattened or compressed; barge or boat-shaped.

(*x*) Awn from $\frac{1}{1}$ to $\frac{2}{1}$ the length of O.P., which is 5–7 mm. long.

Lolium italicum (p. 115), rachilla rather flattened and smooth (Fig. 124).

L. woldicum, rachilla rather flattened and smooth (p. 156).

Bromus giganteus, rachilla cylindrical, usually rough with short bristly hairs (Fig. 80) (p. 85).

(*y*) Awn from $\frac{1}{2}$ to $\frac{1}{1}$ the length of O.P., which is 9–12 mm. long; rachilla cylindrical and usually hairy.

[1]*Agropyrum caninum*, back of O.P. smooth and without a distinct keel (Fig. 30).

Bromus erectus (Fig. 75), back of O.P. scabrid or hairy and with a distinct keel (p. 84).

Brachypodium sylvaticum, back of O.P. hairy but without a distinct keel (Fig. 63) (p. 74).

(*z*) Awn-point half the length of the O.P. or less; O.P. 7–12 mm. long; rachilla round, smooth or pubescent.

Brachypodium pinnatum (Fig. 64), O.P. nerved above but without a distinct keel (p. 76).

[1] In *Agropyrum* the awn is sometimes slightly sub-terminal.

[1]*Agropyrum repens* var. *aristata*, O.P. with a distinct and one-sided keel (p. 51).

(*b*) "Seed" not flattened, rather cylindrical or triangular in transverse section, narrowing below and tapering off above.

Festuca Myurus (Fig. 99), O.P. 5–6 mm. long bearing an awn two or three times that length (p. 100).

F. ovina var. *duriuscula* (Fig. 106) (p. 102), O.P. about 4–5 mm. long, with an awn —or awn-point—usually half as long as itself.

F. ovina var. *vulgaris* (Fig. 102), O.P. 3–4 mm. long with awn-point usually less than half as long (p. 101).

[*Arundo Phragmites* (may come here), O.P. 10–12 mm. long, including its very long awn-like point; rachilla covered with long silky hairs (p. 66).

Dactylis glomerata (Fig. 88) (awned specimens would come here), see p. 93.

Nardus stricta (Fig. 131) (may come here), see p. 119.

Cynosurus echinatus (may come here), rare, see p. 93.]

B. **Awn sub-terminal**, i.e. *arising immediately but distinctly below the apex of the O.P.*

1. Awn exceeding twice the length of the O.P.

Agrostis Spica-venti (Fig. 37), O.P. 2–2·5 mm. long (p. 56).

2. Awn from about $\frac{1}{1}$ to $\frac{2}{1}$ the length of the O.P.

Bromus sterilis (Fig. 74), O.P. from 14 to 20 mm. long. "Seed" very slender (p. 82).

Lolium temulentum (Fig. 125), O.P. about 6 or 7 mm. long. "Seed" very stout.

3. Awn usually not exceeding the length of the O.P.

Bromus mollis (Fig. 72), O.P. 7–12 mm. long, broad,

[1] See footnote on previous page.

much inflated, bifid at apex, and usually hairy; awn about as long as O.P. (p. 81).

B. arvensis (Fig. 68), like *B. mollis*, but the whole "seed" usually more glabrous (p. 79).

B. asper (Fig. 78), O.P. 10–14 mm. long, with short bristly hairs on its lower part. Awn rough, straight and about half as long as the O.P. (p. 85).

Holcus mollis (Fig. 116) (may come here, but see p. 43).

4. Awn (or sub-terminal awn-point) not more than half as long as the O.P.

Sesleria cœrulea (may come here, see p. 131).

Holcus lanatus (Fig. 114), see pp. 43, 106.

C. **Awn dorsal**, arising a considerable distance below the apex, but distinctly above the base of the O.P.

1. *"Seed" consisting of the one-"seeded" spikelets with the glumes attached.*

(*a*) "Seed" *with two awns*, one straight, the other twisted and bent.

Anthoxanthum odoratum (Fig. 52) (p. 61), the awn-bearing glumes (3–4 mm. long) have silvery-white summits, and are covered with hairs of a deep rich brown hue.

A. Puelii, the hair on the awn-bearing glumes is of a paler brown colour, and the paleæ are also of a lighter colour than in *A. odoratum*. (See p. 139.)

N.B. "Seeds" of *Arrhenatherum* often have two awns, but the paleæ of two flowers are present, and the empty glumes have fallen.

(*b*) "Seed" *with O.P. bearing one awn*, which is more or less bent.

(*x*) *Inner palea wanting*, awn attached to lower part of back of O.P. = **Alopecurus**.

A. pratensis (p. 59), glumes about 5 mm. long, covered with long silky hairs especially at their edges. (Fig. 45.)

A. agrestis (p. 61), glumes about 6 mm. long, bearing much shorter and fewer hairs than *A. pratensis*. (Fig. 48.)

A. geniculatus, glumes about 2·5 mm. long. (Fig. 50.)

(*y*) *Both paleæ present* = **Holcus**.

H. mollis (p. 108), glumes 5–6 mm. long, both acutely pointed and hairy on the nerves. O.P. of lower flower (containing grain) awnless; O.P. of upper (staminate) flower bears an awn which arises from a point about three-fourths the distance up the O.P.; the awn is finely serrated throughout its entire length. (Fig. 116.)

H. lanatus (p. 106), very like *H. mollis*, but glumes 4–5 mm. long, more hairy, the upper one broader than the other and tipped with a short awn-point. The awn is almost sub-terminal, is rough (serrated) only towards its point, and is distinctly curved or hook-like. (Fig. 114.)

2. *"Seed" consisting of the paleæ enveloping the grain, and without the glumes attached.*

(*a*) Awn twisted and bent.

Avena fatua, O.P. about 13–15 mm. long by 3 mm. broad; rachilla bearing fine long bristly hairs. Basal hair-tuft below paleæ. (Fig. 62.)

A. strigosa, O.P. 12 mm. or more in length. Only the O.P. of lower "seed" of spikelet is awned. Rachilla almost or quite glabrous.

A. pratensis (p. 70), O.P. about 9 mm. long, of light straw colour, with basal hair-tuft.

Rachilla bears fine white silky hairs. (Fig. 61.)

A. flavescens (p. 68), O.P. 5–6 mm. long, yellowish-brown, bifid at apex, with basal hair-tuft. Awn attached to upper part of the back of the O.P. Rachilla long, outstanding, and bearing long silky hairs. "Seeds" very light. (Fig. 58.)

Arrhenatherum avenaceum (p. 63), "seeds" 6–10 mm. long, consisting of two pairs of paleæ, only the upper pair enclosing a grain. (Fig. 55.)

Aira caryophyllea (p. 59), O.P. about 1·7 mm. long, dark-brown, bifid at apex, with basal hair-tuft. Awn arising from lower part of O.P. and about twice its length. (Fig. 43.)

A. præcox. "Seed" very much like *A. caryophyllea*, but the basal hair-tuft is much less developed, and the awn arises nearer the base of the O.P.

(*b*) Awn straight, and not twisted.

Agrostis canina, no basal hair-tuft to "seed." (Fig. 36.)

Calamagrostis Epigeios, basal hair-tuft present exceeding the length of the O.P. (p. 89).

D. **Awn basal or nearly so.**

1. *Awn almost straight.*

Aira cæspitosa (p. 56), "seed" about 2·5 mm. long; awn hairless; rachilla with long white spreading hairs. (Fig. 40.)

Aira canescens, awn with tuft of hairs in its middle (p. 58).

2. *Awn bent or distinctly wavy.*

Aira flexuosa (p. 57), O.P. about 5 mm. long, with a conspicuous basal tuft of white silky hairs. (Fig. 41.)

Agrostis setacea, O.P. about 2 mm. long, with a few basal hairs only (p. 56).

GROUP II. **"Seeds" with the O.P. either taper-pointed, or bearing an awn-point or spur, but not distinctly awned.** (See p. 38.)

A. *O.P. without a distinct keel; "seed" round-backed, narrowing below and tapering above.*

Cynosurus cristatus (p. 90), O.P. 3–4 mm. long, with a coarsely scabrid curved point. Colour varies from light yellow to brown. (Fig. 86.)

C. echinatus, O.P. 5–6 mm. long without including the awn-point, of a pale straw colour; usually has a distinct awn.

Festuca ovina var. *vulgaris*, O.P. 3–4 mm. long, or up to 4·5 mm. with the terminal awn-point. Rachilla round and outstanding. (Fig. 102. See p. 101.)

F. ovina tenuifolia, O.P. 2–4 mm. long, acutely pointed, but without an awn-point. (Fig. 103.)

F. rubra var. *genuina*, O.P. 4–5 mm. long, usually with a very short awn-point; often with a pinkish tinge. (Fig. 107. See p. 102.)

F. elatior sub-sp. *arundinacea* (p. 99), O.P. 6–9 mm. long, tapering to an acute point, or even with an awn-point. (Fig. 95.)

Agropyrum repens, O.P. 7–12 mm. long including the taper-point, or terminal awn-point. (Fig. 29.)

Elymus arenarius, may have the keel of its O.P. very slight and come here (see p. 46).

B. *O.P. with a distinct keel; "seed" either compressed, or at least triangular in central transverse section.*

1. *Keel of O.P. very marked.*

Bromus Schraderi, O. P. 14–22 mm. long, taper-pointed; grain about 7 mm. long. (Fig. 83, p. 88.)

Dactylis glomerata (p. 93), O. P. usually 5–6 mm. long, with curved taper-point; keel serrated or with bristly hairs above. (Figs. 88, 89.)

Kœleria cristata, O. P. about 4 mm. long, taper-pointed. Inner palea thin and silvery. "Seed" much compressed. (Fig. 120.)

2. *Keel of O.P. slight.*

Nardus stricta, O. P. 8–12 mm. long including the tapering awn-point which is rough. No rachilla. (Fig. 131.)

Molinia cœrulea, O.P. 3–4 mm. long, acutely pointed, often purplish; the paleæ usually gape open above; rachilla frequently kinked, and "knobbed" at top. (Fig. 130.)

Psamma arenaria, O.P. about 10 mm. long, 5-nerved, the slight keel (central nerve) ending in a short sub-terminal spur. A basal tuft of silky hairs present. (Fig. 147.)

Elymus arenarius, O.P. 12–17 mm. long, very hairy and with a terminal spur-point. (Fig. 93.)

Arundo Phragmites, O.P. about 11 mm. long, taper-pointed; rachilla covered with long silky hairs (generally goes into Group I).

Sesleria cœrulea, O.P. about 4 mm. long, 5-nerved, the central nerve ending in a short awn-point, the other nerves forming teeth at the top (p. 131).

GROUP III. **"Seeds" without awns or awn-like points.** *The apex of the O.P. is either rounded off or simply acute.*

A. *"Seeds" less than 4 mm. in average length.*

1. *"Seed" three-sided or triangular in transverse section* (owing to prominent keel and marginal ribs of O.P.). Rachilla cylindrical.

Poa nemoralis (p. 125), O.P. average 2·5 mm. long, with rather acute apex; keel and marginal nerves hairy below. Rachilla microscopically rough. (Fig. 139.)

Poa trivialis (p. 129), O.P. average 2·3 mm. long, 5-nerved, with acute apex; the "seed" is acutely triangular in transverse section, and without hairs on the marginal ribs; rachilla smooth and slender. (Fig. 143.)

Poa pratensis (p. 127), O.P. average 2·2 mm. long, with blunt apex; "seed" stouter, and less acutely triangular in transverse section than *P. trivialis*; a few hairs are frequently present on the marginal ribs below; rachilla smooth. (Fig. 142.)

Poa compressa, very similar in size, etc., to *P. pratensis* but there are no intermediate nerves between the keel and marginal ribs of the O.P., and the I.P. is fringed with finer and more numerous microscopic hairs. (Fig. 138, p. 124.)

N.B. "Seeds" of the above four species in their natural state have a "web" at the base; "seeds" of the two following species have no "web."

Poa annua, O.P. from 2–3 mm. long, 5–nerved, with membranous edges above; keel and lateral ribs fringed with hairs. Rachilla relatively large. The degree of hairiness is very variable. (Fig. 136.)

Poa alpina, O.P. 3–4 mm. long, 3-nerved, acutely pointed and keeled; keel and lateral nerves are covered with long white hairs. (Fig. 135.)

2. "*Seed*" *with O.P round-backed*, i.e. without a prominent keel.

(*a*) O.P. not inflated, closely investing the grain.

Phleum pratense (p. 121), "seed" about 1·8 mm. long, spherical-ovoid in form. Paleæ silvery-white; grain yellow with irregularly pitted surface. (Fig. 134.)

Festuca ovina tenuifolia, O.P. 2–4 mm. long, with acute apex, brown in colour. Rachilla outstanding. (Fig. 103.)

Agrostis alba var. *stolonifera* (p. 54), in bulk of a pale silvery-fawn colour. O.P. 1·3–2·0 mm. long; paleæ very thin and silvery-white, lower empty glume with its keel serrated throughout its entire length (some empty glumes are always present). (Fig. 34.)

A. alba var. *vulgaris*, as above but slightly smaller "seed," and lower empty glume serrated only on the upper half of its keel. Seen in bulk the "seed" is of a darker colour. (Fig. 35.)

Glyceria aquatica, O.P. 3–4 mm. long, 7-nerved; rachilla less enlarged at the top than in *G. fluitans*. (Fig. 111.)

Milium effusum, O.P. about 3 mm. long; inner palea hard and shining. (Fig. 129.)

Digraphis arundinacea, O.P. about 3 mm. long, glossy, with a pair of linear hair-tufts at its base. (Fig. 92.)

Holcus lanatus, "seed" (when free from the glumes) 2–2·5 mm. long; paleæ greyish-white, shining. (Fig. 114.)

H. mollis, when free from the glumes, also comes here. It can then only be distinguished from *H. lanatus* by the awn of the upper flower if the latter is attached, see p. 108. (Fig. 116.)

"Seeds" of the following three species may sometimes come here.

Cynosurus cristatus
Molinia cærulea
Kœleria cristata
} O.P. 3–4 mm. long and *taper-pointed* (see Group II).

(*b*) O.P. inflated, with membranous winged margins.

Briza media, O.P. 2·5–3 mm. long. (Fig. 69.)

B. minor has a similar but smaller "seed."

B. *"Seeds" 4 mm. or more in average length.*

1. *Grain tightly held between the paleæ.*

Lolium perenne (p. 113), O.P. 5–8 mm. long, usually with rounded apex. Rachilla compressed. (Fig. 123.)

Festuca pratensis (p. 100), O.P. 5–6 mm. long, rachilla cylindrical. (Fig. 97.)

Bromus inermis, O.P. 9–12 mm. long, rachilla cylindrical and hairy. (Fig. 82, p. 87.)

Glyceria fluitans, O.P. 4–5 mm. long, 7-nerved, the nerves rough; rachilla much enlarged at top. (Fig. 112.)

[In the following species the O.P. is usually either taper-pointed or bears an awn-like point, but occasionally their seeds may appear to come here (see Group II).

Festuca rubra (Fig. 107), the O.P. is 4–5 mm. long, including the awn-point.

F. elatior sub-sp. *arundinacea* (Fig. 95), O.P. 6–9 mm. long, usually tapering to an acute point.

Bromus Schraderi, O.P. 14–22 mm. long, taper-pointed. (Fig. 83.)

Arundo Phragmites, O.P. 10–12 mm. long, taper-pointed (p. 66).

Psamma arenaria, O.P. 9–11 mm. long, bearing a very short sub-terminal spur.

Elymus arenarius, O.P. 12–17 mm. long, hairy, and with a terminal spur. (Fig. 93.)]

2. *O.P. very broad and loose, allowing the grain to separate easily.*

Melica nutans, O.P. 4–6 mm. long; grain about 2·5 mm. long, shining, of a dark-brown colour. (Fig. 126.)

M. uniflora, "seed" very similar to *M. nutans*.

(N.B. "Seeds" of the last two species are not often met with.)

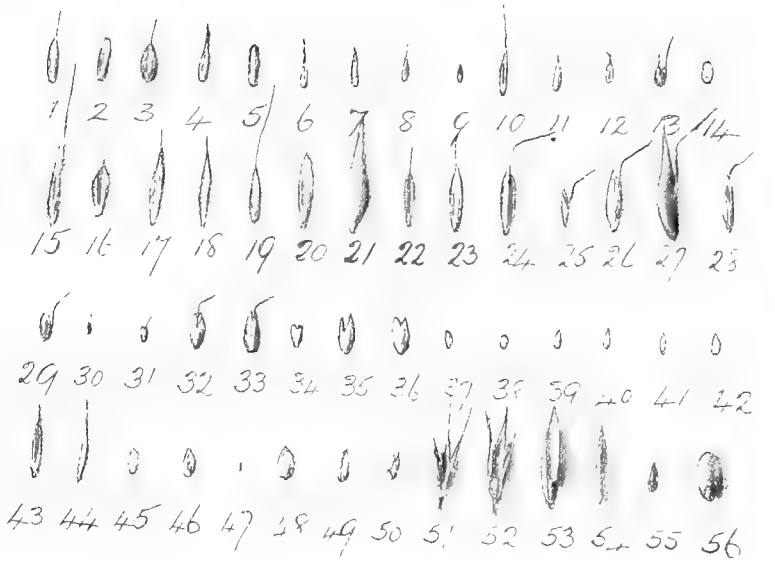


Fig. 26. Showing outline and comparative size of common grass "seeds." Natural size.

1. *Lolium italicum.*
2. *L. perenne.*
3. *L. temulentum.*
4. *Festuca elatior.*
5. *F. pratensis.*
6. *F. duriuscula.*
7. *F. rubra* var. *fallax.*
8. *F. ovina* var. *vulgaris.*
9. *F. ovina* var. *tenuifolia.*
10. *F. Myurus.*
11. *Dactylis glomerata*
12. *Cynosurus cristatus.*
13. *Anthoxanthum odoratum.*
14. *Briza media.*
15. *Bromus sterilis.*
16. *B. mollis.*
17. *B. asper.*
18. *B. erectus.*
19. *B. giganteus.*
20. *B. inermis.*
21. *B. Schraderi.*
22. *Brachypodium pinnatum.*
23. *B. sylvaticum.*
24. *Avena pratensis.*
25. *A. flavescens.*
26. *Arrhenatherum avenaceum.*
27. *Avena fatua.*
28. *A. pubescens.*
29. *Aira flexuosa.*
30. *A. caryophyllea.*
31. *A. cæspitosa.*
32. *Alopecurus pratensis.*
33. *A. agrestis.*
34. *A. geniculatus.*
35. *Holcus mollis.*
36. *H. lanatus* (in glumes).
37. *H. lanatus* (without glumes)
38. *Phleum pratense.*
39. *Poa pratensis.*
40. *P. trivialis.*
41. *P. nemoralis.*
42. *P. annua.*
43. *Agropyrum repens.*
44. *Nardus stricta.*
45. *Glyceria aquatica.*
46. *G. fluitans.*
47. *Agrostis alba.*
48. *Melica nutans.*
49. *Kœleria cristata.*
50. *Molinia cœrulea*
51. *Hordeum pratense.*
52. *H. murinum.*
53. *Elymus arenarius.*
54. *Psamma arenaria.*
55. *Digraphis arundinacea.*
56. Wheat grain (for comparison of size).

CHAPTER VII

BOTANICAL DESCRIPTION OF SPECIES

(N.B. *The Genera are arranged in alphabetical order*)

Agropyrum *repens,* Beauv. (Couch-grass.) (Fig. 27.)

A perennial, *creeping very extensively* by means of numerous, long, stout, and sharply-pointed rhizomes which bear rudimentary leaves and adventitious roots at the nodes. Leaf-sheaths split,

Fig. 27. Spikate inflorescence of *Agropyrum repens*, about $\frac{2}{3}$ nat. size. Left hand, ordinary awnless type. Right hand, var. *aristatum*.

Fig. 28. *Agropyrum caninum*, about $\frac{1}{2}$ nat. size.

and without distinct keels; the lower ones usually pubescent or hairy—the upper ones often glabrous. *Blade rolled* in the shoot, dull, long, and rather thin; broadest in middle, tapering to an acute apex, and narrowing below. Upper surface sparsely hairy, almost ribless, and rough, especially downwards. Lower surface slightly keeled near base, occasionally hairy. (The hairiness of

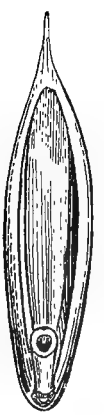


Fig. 29. "Seed" of *Agropyrum repens.* ×5. Front view.

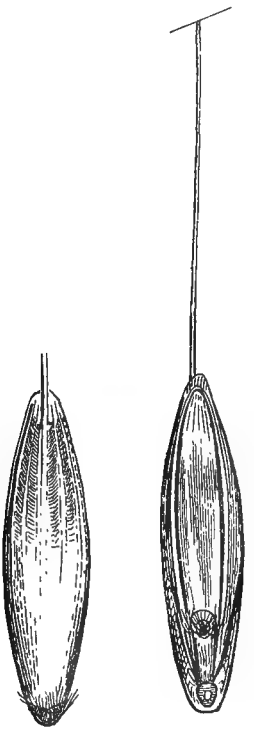


Fig. 30. "Seed" of *Agropyrum caninum.* ×5. Back and front views.

this species varies very much.) *Auricles prominent*, narrow and pointed; springing from greenish-white triangular areas at base of blade. Ligule very short, blunt and finely fringed. Abundant in Britain, and a most troublesome weed on cultivated ground.

Flowers about July; flowering culms 1½ to 3 feet high; inflorescence spikate. Spikelets in two rows, with the edges of

the paleæ turned towards the main axis, which is tough and notched. Spikelets of 4–5 flowers. The empty glumes are nearly equal, and 4–5 nerved.

"*Seeds*" boat-shaped, 7–12 mm. long; outer palea with a prominent dorsal nerve; rachilla stout, cylindrical, smooth (or sometimes hairy), widening above, with a concave apex. (Fig. 29.)

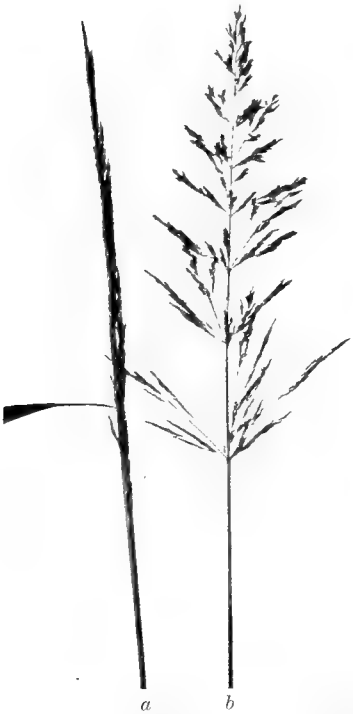


Fig. 31. Panicle of *Agrostis palustris*, (*a*) just after emerging from its sheath and (*b*) near the period of flowering. About $\frac{1}{3}$ nat. size.

Fig. 32. Panicles of *Agrostis stolonifera* (to the left), and *Agrostis vulgaris* (to the right). About $\frac{1}{2}$ nat size.

A common variety of this species—var. *aristatum*—has the dorsal nerve prolonged into an awn or awn-point, which is sub-terminal, and does not exceed the length of the outer palea.

A. junceum, Beauv., is a sea-shore variety of *A. repens*. Its leaf-blades are rigid and glaucous, and the lower ones are rolled and pointed.

Agropyrum *caninum*, Beauv. (Bearded Wheat-grass.) (Fig. 28.)

Though frequent in Britain this species is very much less common that *A. repens* from which it differs mainly in the following respects: it is a *tufted* perennial, *without rhizomes*; the empty glumes are usually only 3-nerved; the outer palea has a terminal

Fig. 33. *Agrostis alba*, L. var. *repens* showing creeping rhizomes.

awn longer than itself, and the rachilla of the "seed" is hairy. Fig. 30. It is a shade species.

Agrostis. British members of this genus may be identified by *the delicate spreading panicle; the very small one-flowered spikelets, and the empty glumes exceeding the length of the paleæ.*

Agrostis *alba*, L., var. *stolonifera*. (Fiorin or Creeping Bent-grass.) Fig. 32. Abundant in Britain. See also p. 134.

An *entirely glabrous* perennial, with numerous *creeping surface stolons*, rooting at the lower nodes. Sheaths split; *blades rolled* in

the shoot, varying much in relative length and breadth, but always thin, and acute at the apex; usually downwards rough; almost ribless. No keel to sheath or blade. Ligule *long*, erect, and rounded at apex; *no auricles*.

Flowers from July to September; culms from 1 to 2 feet high; panicle erect, delicate, and spreading when in flower. Spikelets numerous, small, and one-flowered. *Both paleæ are present*. Empty glumes acute and nearly equal.

"*Seeds*" 1·3–2·0 mm. long; outer palea delicate, awnless, and slightly notched at its apex. There is no rachilla, but a basal tuft of fine erect hairs may be present. Grain of butterscotch colour visible between the paleæ. The empty glumes

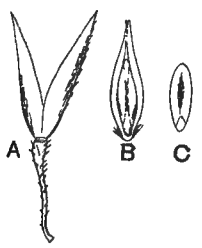


Fig. 34

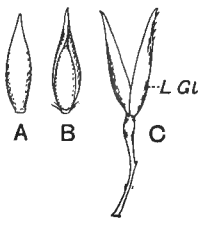


Fig. 35

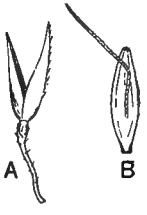


Fig. 36

Fig. 34. *Agrostis alba*, L. var. *stolonifera*. ×10. *A*. Empty glumes. *B*. "Seed." *C*. Naked grain.

Fig. 35. *Agrostis vulgaris*, With. ×10. *A*. Back view, and *B* front view of "seed." The dotted line indicates the position and form of the grain. *C*. The empty glumes.

Fig. 36. *Agrostis canina*, L. ×10. *A*. Empty glumes. *B*. "Seed" showing outer palea and dorsal awn.

may remain attached; the lower one has its keel minutely toothed along almost its entire length. (Fig. 34.)

Another form of this species known as *A. palustris* (Marsh Bent-grass) is a luxuriant variety found growing by the side of ditches and ponds. It has a larger and more spreading panicle. (Fig. 31.)

Agrostis *alba*, L. var. *repens*. (Black Bent-grass) = *A. nigra*, Withering. Very similar in foliage etc. to *A. stolonifera* but its panicle is more loose and spreading. It also creeps extensively by means of *stout underground rhizomes*—like those of Couch-grass. It is a troublesome weed on arable soils. (Fig. 33.)

Agrostis *vulgaris,* With. (Fine Bent-grass.) (Fig. 32.)

Perhaps only a smaller variety of *A. alba.* The main points of difference are: leaves usually narrower; ligule *short* and blunt. Panicle very fine and graceful—even more delicate than *A. alba*—and generally purple in colour. The lower empty glume is toothed only on the upper half of its keel. (Fig. 35.)

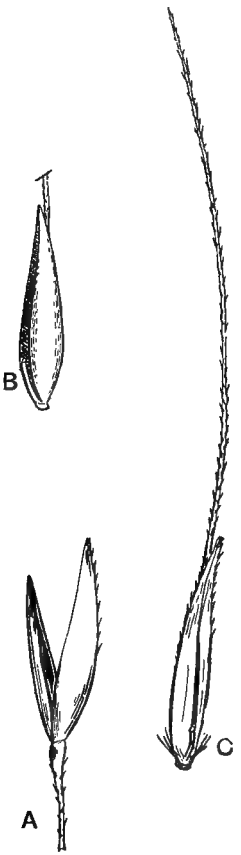


Fig. 37. *Agrostis Spica-venti,* L. × 10. *A.* Empty glumes. *B.* "Seed." *C.* "Seed" with awn fully shown.

Agrostis *canina,* L. (Brown Bent-grass.) Perennial.

Very near *A. alba* and *A. vulgaris,* but distinguishable from them by the following combination of characters: the ligule is long and acute and the lower leaves almost needle-like. The outer palea bears a fine dorsal awn as long as itself. *The inner palea is wanting.* (Fig. 36.)

Agrostis *setacea,* Curt. A perennial with needle-like leaves, and slender contracted panicle. The outer palea bears a bent basal or almost basal awn longer than itself. In Great Britain is only usually found in the S.W. counties of England.

Agrostis *Spica-venti,* L. An annual with narrow but expanded leaves. The panicle with its long, slender, spreading branches, and shining spikelets, has a graceful appearance. Not common.

The outer palea 2–3 mm. long—bears a fine, straight, sub-terminal awn from twice to four times its own length. Rachilla small and slender. (Fig. 37.)

Aira *cæspitosa,* L. (Tufted Hair-grass.) (Figs. 38 and 39.)

A perennial, abundant in Britain, growing in large *dense tufts* in moist or shady situations. Sheaths split, shoot rolled; leaf-blades expanded or slightly rolled, acutely pointed. Upper surface with

very *high, rough, and acute ridges* which are equal, and contrast greatly with the thin transparent tissue between. This transparent tissue consists of longitudinal rows of thin-walled motor cells. There is no mid-rib, and in dry weather the blade rolls up as the motor cells lose water and allow the ridges to come together. There are no auricles; the ligule is long and acute.

Flowers usually in July; culms $1\frac{1}{2}$ to 4 feet high. Panicle large and graceful—at first slightly drooping—later erect and spreading; spikelets numerous, 2–3 flowered, silvery-grey or purplish.

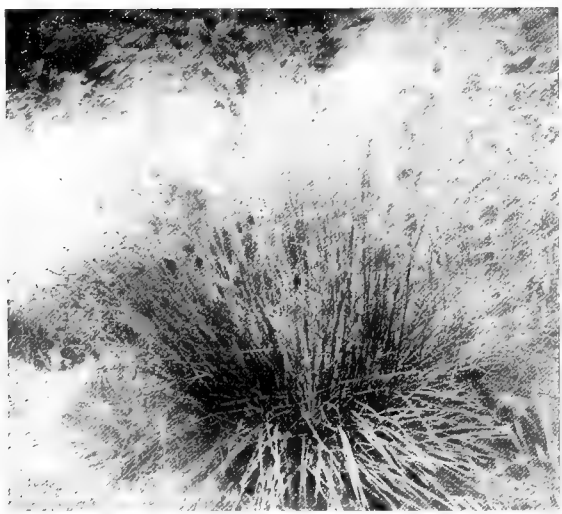


Fig. 38. A large dense tuft of *Aira cæspitosa*.

"*Seeds*" about 2·5 mm. long; outer palea membranous, white, and ragged at its apex, and bearing a fine, almost straight basal (or almost basal) awn seldom exceeding its own length. Rachilla relatively long, and bearing long white spreading hairs. There is also a basal tuft of white silky hairs. Colour variable. (Fig. 40.)

Aira *flexuosa*, L. (Wavy Hair-grass.) (Fig. 42.)

A perennial, with narrow leaves having their edges tightly rolled inwards, making them almost solid. Ligule prominent, broader than the base of the leaf. Flowers in July; culms from

12 to 18 inches high; panicle erect and spreading; spikelets erect, shining, containing two flowers. Generally distributed over Britain on heaths and upland pastures.

"*Seeds*" 4–5 mm. long, of pale to mid-brown colour when ripe; outer palea ragged or bifid at its apex, and bearing a twisted

Fig. 39. Panicle of *Aira cæspitosa*, about $\frac{1}{3}$ nat. size.

and "kneed" basal (or almost basal) awn distinctly longer than itself. A conspicuous tuft of white silky hairs surrounds the base of the "seed." Rachilla relatively short, also bearing white hairs. (Fig. 41.)

Aira *canescens*, L. (Grey Hair-grass.)

Needle-like leaves; awn basal, thickened at end, and bearing

a tuft of hairs in the middle. In Britain, only known to occur on the sandy shores of East Anglia.

Aira *caryophyllea,* L. (Silvery Hair-grass.) (Fig. 42.)

An annual, with rather rough needle-like leaves, growing about six inches high, and found mostly on poor uplands.

Panicle erect and spreading; spikelets containing two flowers, the empty glumes equal.

"*Seed*" dark-brown or almost black; about 1·5 mm. long, with a basal hair-tuft. Outer palea bifid at its apex, and bearing a dorsal (or almost basal) twisted and "kneed" awn about twice its own length. (Fig. 43.)

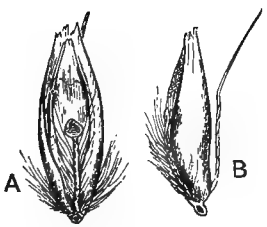


Fig. 40. "Seed" of *Aira cæspitosa.* ×10. *A.* Front view. *B.* Side view.

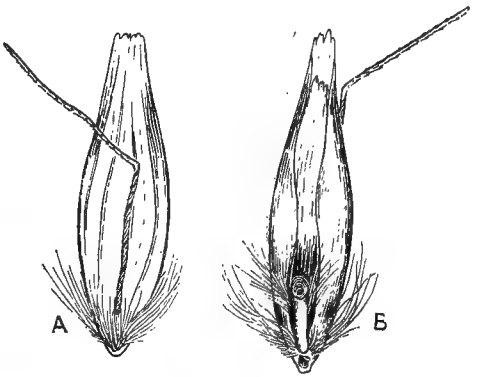


Fig. 41. "Seed" of *Aira flexuosa.* ×10. *A.* Back view, showing position of the awn. *B.* Front view.

Aira *præcox,* L. (Early Hair-grass.)

An annual, almost identical in structure and habitat with *A. caryophyllea.* It is however usually a smaller plant, and the branches of the panicle remain close to the main axis.

Alopecurus *pratensis,* L. (Meadow Foxtail.) (Figs. 44, 150.) Abundant in Britain in moist meadows and pastures (see p. 135).

A slightly stoloniferous, and entirely glabrous perennial, forming loose tufts of abundant dark-green foliage. Sheaths smooth, split; the lower ones often of a purplish colour near the ground, and becoming a dark chocolate colour as they age; the uppermost ones become inflated just before flowering, and remain

so afterwards. *Blade rolled in the shoot*, rather thin, broadest just above its base; acuminate above, and forming rounded collar-like ledges below where it joins the sheath; both surfaces dull. Ribs on upper surface low, flat and broad. Ligule variable in length, but always blunt. There is no keel to the sheath but a slight one is present on the lower half of the blade. *No auricles.*

Fig. 42. Plants of *Aira flexuosa* (left) and *Aira caryophyllea* (right). About ¼ nat. size. N.B. The photograph is of specimens which had been dried, and the bent condition of *A. flexuosa* is unnatural.

Flowers in April and May; culms smooth, 1 to 3 feet high; panicle cylindrical, spike-like, 1–3 inches long. Spikelets on very short branches, one-flowered, ovate. Flowers proterogynous.

The "seeds" consist of the entire ripened spikelets. Empty

glumes about 5 mm. long, equal, acute, united below, their keels fringed with long silky hairs. Outer palea acute, bearing a sub-dorsal (or almost basal) awn, *projecting more than half its length beyond the palea.* Inner palea wanting. The grain (caryopsis) is yellowish, ovate, somewhat flattened, and often bears remains of the stigma. (Fig. 45.)

Fig. 43. "Seed" of *Aira caryophyllea*, L. ×10. *A*. Side view, showing position of awn. *B*. Front view.

Alopecurus *agrestis*, L. (Slender Foxtail.) (= *A. myosuroides*, Huds.) (Figs. 46 and 47.)

A tufted annual, most common on stiff cultivated soils, where it becomes a troublesome weed. Flowers throughout the summer. It differs also from *A. pratensis* in the following respects: the leaf-blades have acute ribs on the upper surface; sheaths and flowering culms rough, the latter 1 to 2 feet high; the cylindrical panicles taper at each end, and are more slender than those of *A. pratensis*.

"*Seeds*" as in *A. pratensis*, but the empty glumes larger, about 6 mm. long, with the keels only slightly hairy; caryopsis also two or three times as large. (Fig. 48.)

Alopecurus *geniculatus*, L. (Floating Foxtail.) (Figs. 49 and 50.)

A semi-aquatic perennial, flowering about June. Culms 12–18 inches long, "kneed" at almost every node, and rooting at the lower ones. Blades relatively short and broad. *Ligule long.* Spikelets about half as long as those of *A. pratensis*. *Empty glumes blunt*, their keels fringed with hairs (Fig. 50). (A variety of this species with the stems swollen near the ground known as var. *bulbosus* is rare. *A. fulvus* Sm. and *A. alpinus* Sm. are also rare.)

Anthoxanthum *odoratum*, L. (Sweet-scented Vernal-grass.) (Fig. 51 *B* and *C*.) See also p. 138.

A small perennial, forming compact tufts, and producing culms from 12 to 18 inches high. Roots rather shallow. Sheaths split, with very slight keel, somewhat striated, sparsely hairy or glabrous. Blades thin, rolled in the shoot, of light or mid-green colour; varying much in shape, usually broadest in the middle and narrowing below; sub-acute apex. Ribs—though

distinct on upper surface—low, and flat. The hairiness of the blade varies much; hairs may be confined to the margins, and to the throat of the sheath, or both blade surfaces may be hairy. Ligule well developed, but blunt and very thin. No auricles are present, but the base of the blade forms ledges with hairy margins. Sweet scented. Abundant in Britain.

Fig. 44. Spike-like panicles of *Alopecurus pratensis*, L. showing four stages of development. Left to right, (*a*) emerging from the inflated sheath, (*b*) with stigmas just in the receptive condition, (*c*) with stamens fully protruded, and (*d*) the post-flowering condition. About $\frac{2}{3}$ nat. size.

Flowers in April and May; panicle close, and spike-like, 1 to 2 inches long. Spikelets one-flowered, 8–9 mm. long. Two pairs of empty glumes are present; the lower or outer pair unequal

and acute, slightly hairy, yellowing as they age; the inner pair nearly equal, hairy, of a rich brown colour when the "seed" is ripe. Two stamens only are present in each flower. Flowers protogynous.

The "seed" (3–4 mm. long) consists of the inner pair of glumes (covered with dark-brown hairs), and enclosing the paleæ and the caryopsis. The lower glume bears a straight dorsal awn, and the other glume bears a longer, "kneed," sub-dorsal or

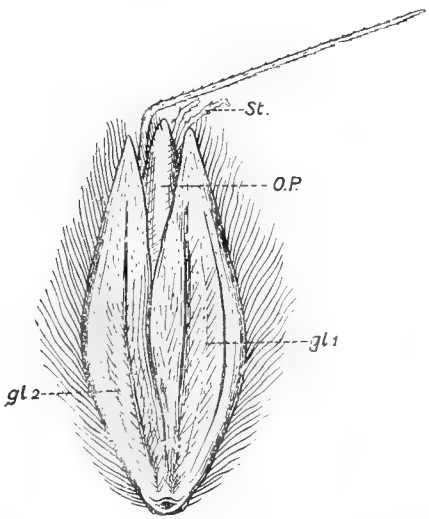


Fig. 45. "Seed" of *Alopecurus pratensis*, L. ×10. It consists of the empty glumes (*gl.* 1) and (*gl.* 2), and the outer palea (*O.P.*) enclosing the grain. *St.* remains of the stigmatic plumes.

almost basal awn. The upper margins of both glumes are silvery-white and membranous. The outer and inner paleæ are of a brownish colour, thin, smooth, and shining. (Fig. 52.)

A. Puelii, a closely allied annual species, only occurs as a weed of cultivation in Britain.

Arrhenatherum *avenaceum*, Beauv. (False or Tall Oat-grass.) (Fig. 53.) Common in Britain. See also p. 140.

A tall perennial, with loose, erect tufts of bitter foliage. Roots numerous and of *chrome-yellow colour*. Basal nodes of culms

often thickened, or bulbous, and sometimes coloured like the roots. Sheath split, with only a slight keel, usually glabrous but sometimes hairy, especially near the nodes. Blade rolled in the shoot, long, rather thin, and narrow in proportion to length; broadest in middle, acuminate above, tapering below;

a *b*

Fig. 46. Spike-like panicles of (*a*) Meadow Foxtail, and (*b*) Slender Foxtail. About nat. size.

upper surface almost ribless, usually hairy, and downwards rough near apex; lower surface slightly keeled at base of blade. There are no auricles and the ligule is blunt. A variety of this species with the lower internodes very much thickened is a troublesome weed on some cultivated soils. It is known as "Onion Couch." See Fig. 54.

Flowers usually in June; culms 2–4 feet high. Panicle large, 6–10 inches long, leaning slightly towards one side; the branches keep close to the main axis at first but spread at time of flowering. Spikelets 8–10 mm. long, containing two flowers, the upper one hermaphrodite, the lower one staminate. Empty glumes very

Fig. 47. *Alopecurus agrestis.* About ½ nat. size.

unequal, membranous, and acute; the upper and larger glume is three-nerved, and often of a purple colour; the lower glume has a dorsal nerve only. The "seeds" of this species are often "sooted" or "smutted" owing to the attacks of *Ustilago perennans*, one of the "smut" fungi.

The "seeds" consist of the spikelets minus the empty glumes;

their length without the awn varies from 6–10 mm. The outer palea of the lower flower bears a long (10 mm. or more) twisted and "kneed" dorsal awn. The outer palea of the upper flower usually bears only a short sub-terminal awn-point, but it may have a dorsal, twisted and "kneed" awn; its apex is ragged. Both of the outer paleæ are distinctly nerved, and the margins of both inner paleæ are delicately fringed. Each flower has a conspicuous basal tuft of white hairs. (Fig. 55.)

(N.B. The twisting of the awns is only apparent when the seed is ripe.)

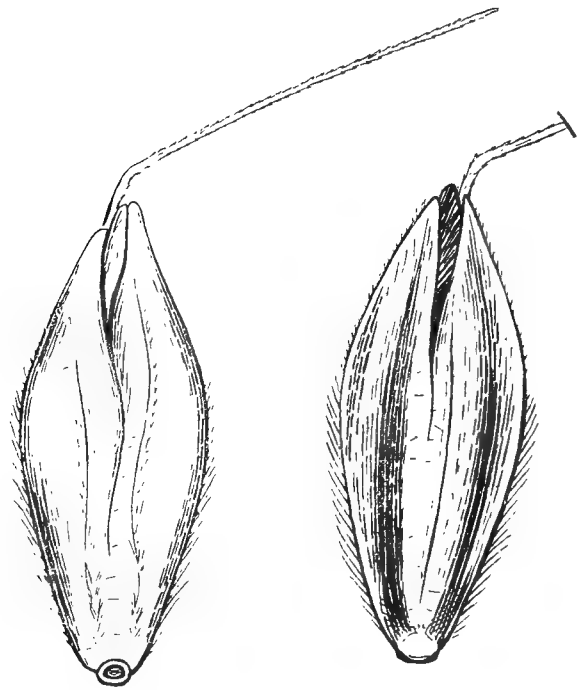


Fig. 48. "Seed" of *Alopecurus agrestis*, L. ×10. Two views.

Arundo *Phragmites*, L. (Common Reed.) (Fig. 56.) Common in Britain.

A perennial aquatic species with creeping rhizomes. Sheaths smooth, split, bearded at the throat, i.e. where sheath and blade meet. Leaves rolled in the shoot; blades about one foot long or

more, and often more than an inch broad, linear-lanceolate and acuminate; smooth on both surfaces, but with numerous, low, flat ribs on the upper side. *Ligule represented by a fringe of hairs.* No auricles. The loose sheaths allow the blades to turn away from the direction of the strongest prevailing winds.

Flowers about August; culms stout, erect, smooth, from 5 to 8 feet high. Panicle large, compound, with branches turned in the

Fig. 49. Two semi-aquatic grasses. *Alopecurus geniculatus*, L. (left), *Aira cæspitosa*, L. (right). About $\frac{1}{4}$ nat. size.

Fig. 50. "Seed" of *Alopecurus geniculatus*, L. $\times 10$.

same direction as the leaves; at first silvery-violet or chocolate in colour, but later on turning light-brown. Spikelets numerous, three-flowered, ovate-lanceolate at first, and spreading later. Empty glumes unequal, narrow, and acute, each bearing a nerve on either side of the central keel.

"*Seed.*" Outer palea 10–12 mm. long, including the long awn-a-a-a-a-a like taper-point. Inner palea half as long as the outer palea, a, a, a, a, a membranous and minutely fringed towards its apex. The rachilla la la la la la is covered with long silky hairs.

Avena. British species of this genus are recognised *by their open spreading panicles*, 2–5 *flowered spikelets* (if only two flowers

Fig. 51. Two of the earliest of British Grasses. *A*. Meadow Foxtail. *B*. Sweet Vernal-Grass (*Anthoxanthum odoratum*). *C*. Plant of the latter.

both are bisexual), *and the long dorsal and "kneed" awn on the outer palea*.

Avena *flavescens*, L. (Yellow or Golden Oat-grass.) (Fig. 57.) See also p. 139. Common in England, but much less so in Scotland and Ireland.

A tufted perennial, with numerous fibrous roots which are often of a yellowish colour. Shoot cylindrical. Sheaths split, covered with numerous silky and usually reflexed hairs. Leaf-blades rather thin, narrow, and acuminate; with *silky hairs on both surfaces*, but more especially on the upper surface which is also distinctly ribbed. *No auricles.* Ligule blunt, but distinct. The foliage is generally of a pale or mid-green colour.

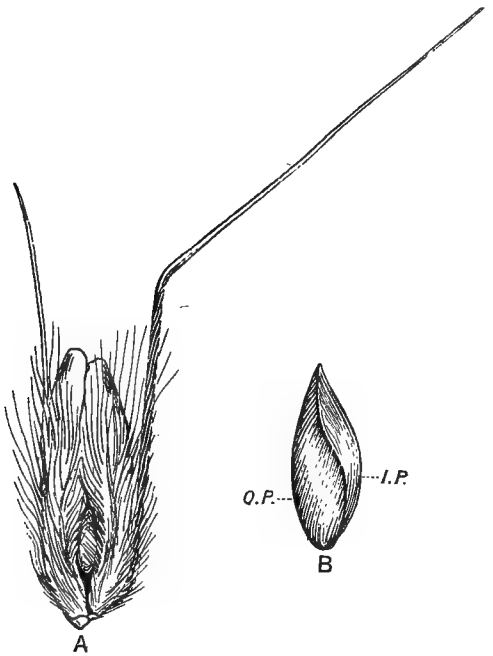


Fig. 52. "Seed" of *Anthoxanthum odoratum*, L. × 10. *A.* "Seed" consisting of the inner pair of hairy empty glumes enclosing the paleæ and grain. *B.* The outer palea (*O.P.*) and inner palea (*I.P.*) enveloping the grain.

Flowers about midsummer; culms erect about 15–20 inches high. Panicle symmetrical, open, and erect; of a golden-yellow hue, very delicate and graceful in appearance. Spikelets small, numerous, 2–3 flowered. Empty glumes very unequal, the upper one often nearly twice as long, and 3–4 times as broad as the other; both are very thin, acute and keeled, but the lateral nerves are indistinct.

"*Seeds.*" Outer palea 5–6 mm. long, yellow or straw coloured, or sometimes of a brownish hue, with a pointed bifid apex. The outer palea bears a sub-terminal or dorsal twisted and "kneed" awn, generally rather longer than itself. Inner palea 4–5 mm. long, membranous, very thin, without a marginal hair-fringe. Rachilla

Fig. 53. Three panicles of *Arrhenatherum avenaceum*, Beauv. About ½ nat. size.

rather long, outstanding, cylindrical and thickening towards the top, bearing long silky hairs. A tuft of silky hairs is also present at the base of the seed. (Fig. 58.)

Avena *pratensis*, L. (Perennial Oat-grass.) (Fig. 59.) Widely distributed though not abundant in Britain.

An entirely glabrous, tufted perennial. Blades folded in the

young shoot. Sheath split. Leaf-blades rather narrow, dry and scabrous on the upper surface; generally tending to fold or roll up, ribless, but keeled below. In outline they are very similar to those of *Poa pratensis*. Upper ligule long; ligule to basal leaves short; auricles wanting. Two or three varieties occur varying chiefly in the length or breadth of the leaf-blades.

Fig. 54. Tuft of *Arrhenatherum avenaceum*, Beauv. var. *bulbosum*. "Onion Couch."

Flowers about June; culms erect, smooth, finely striated, from 18–24 inches high. Panicle erect, rather close and almost simple. Spikelets large, oval, 3–6 flowered; empty glumes unequal, acute, and keeled, with a prominent nerve on either side of the keel. The upper and larger glume is of a purple colour below, and silvery-white and membranous above and along its margins.

"*Seed.*" Outer palea about 9 mm. long, white and membranous at its apex which is 2–4 toothed; bearing a slightly twisted and "kneed" dorsal awn. Inner palea very thin, flat and fringed. Rachilla long, slender, cylindrical, and bearing numerous long silky hairs. The base of the "seed" is surrounded by a large "brush" of hairs. (Fig. 61.)

A. pubescens, Huds. A marked variety of the above. The lower leaves and sheaths are distinctly hairy, and less harsh to the touch. The outer palea is rather shorter, and the rachilla longer and more feathered with hairs. The panicle also is more silvery in appearance.

Fig. 55. "Seed" of *Arrhenatherum avenaceum*, Beauv. ×10.
The grain is enclosed within the upper pair of paleæ.

Avena *fatua*, L. (Wild Oat.) (Fig. 60.) Abundant in Britain. A tall annual, occurring especially among cereal crops, forming close tufts. Shoot cylindrical, sheaths split, glabrous or occasionally with a few hairs. Leaf-blades linear, broad, acuminate, glabrous or slightly hairy. Ligule membranous, relatively short, and blunt. *Auricles wanting.*

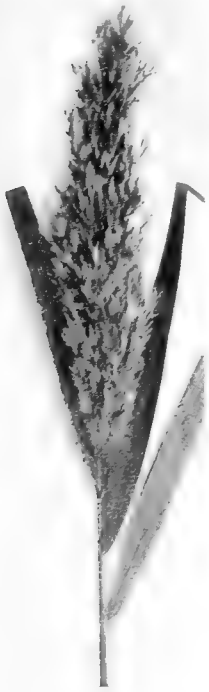


Fig. 56. Inflorescence of *Arundo Phragmites*. About $\frac{1}{4}$ nat. size.

Fig. 57. Panicles of *Avena flavescens*, L. *a*. Pre-flowering stage. *b*. In full flower. About $\frac{2}{3}$ nat. size.

Flowers in June or July; culms erect, 3–5 feet high. Panicle large, open, and spreading equally on all sides. Spikelets large, ovate-lanceolate, hanging, each of two to three flowers. Empty

glumes, smooth, papery, acute, and nearly equal. The lower glume has about seven conspicuous nerves, the upper one has from nine to eleven.

"*Seeds*" about 15 mm. long by 3 mm. broad, cylindrical, tapering at apex. The outer palea may be almost white, or yellowish, or some shade of brown, or even of a dark-slate colour; its basal part is covered with brown or yellow hairs, and it bears a twisted and bent dorsal awn of a rich brown colour (when ripe) and about 30 mm. long. Rachilla long, cylindrical, outstanding, and covered with fine long bristles. The grain closely resembles

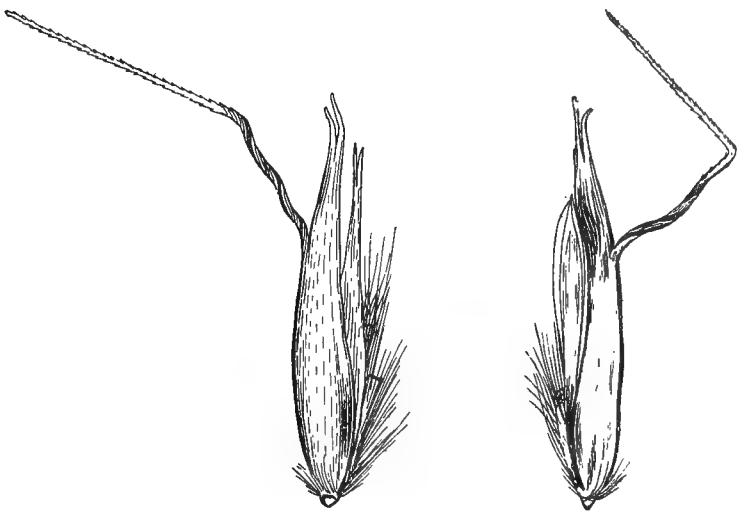


Fig. 58. "Seeds" of *Avena flavescens*, L. × 10. Two views

that of the cultivated oat. It is some 7 mm. long, distinctly grooved on its inner surface, and covered with fine hairs at its apex. (Fig. 62.)

A. strigosa, L. (Bristle-pointed Oat.) Very closely resembles the wild oat and is perhaps only a variety. Its panicle is less spreading, and more turned towards one side; the outer palea is terminated by two long straight bristles.

Brachypodium *sylvaticum*, Beauv. (Wood False Brome-grass.) (Fig. 66.) Common in Britain.

A tufted perennial growing in shade or semi-shade. Foliage

of a pale sap-green colour, making the plant very conspicuous. Shoot round, sheaths split and hairy. Blade thin, long, narrowing towards the base, and tapering above into a long point (Fig. 12): ribless, with scattered hairs. Ligule prominent, blunt, and ragged.

Flowers about midsummer; culms erect, 1–2 feet high. Inflorescence spikate, the spikelets being almost but not quite sessile

Fig. 59. Panicle of *Avena pratensis*. About $\frac{1}{2}$ nat. size.

Fig. 60. Panicle of Wild Oat, *Avena fatua*. About $\frac{1}{4}$ nat. size.

on the main axis. Spikelets long, cylindrical, somewhat drooping, with from 3 to 10 flowers. Empty glumes rather unequal, seven-nerved, and more or less hairy.

"*Seeds.*" Outer palea distinctly nerved above and hairy, 10

to 12 mm. long, boat-shaped, tapering into a long (9–13 mm.) rough terminal awn. Inner palea fringed on the upper half of the marginal ribs. Rachilla smooth or hairy, cylindrical, widened and concave at the top. (Fig. 63.)

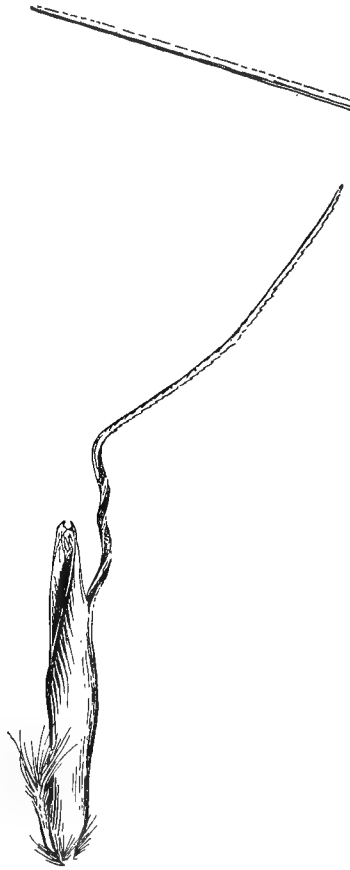


Fig. 61. "Seed" of *Avena pratensis*, L. ×5.

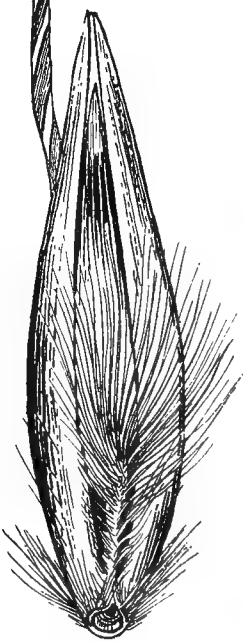


Fig. 62. "Seed" of *Avena fatua*, L. ×5.

Brachypodium *pinnatum*, Beauv. ¾ (Heath False Brome-grass.) In Britain, found only in the eastern and central counties of England.

This perennial plant is closely allied to the preceding species but may be distinguished by the following points: it prefers open situations, and has a slightly creeping habit; its leaves are firm, rough, rigid, and erect, and tend to roll up.

The "seed" is about 9 mm. long, or 11 mm. including the awn. The terminal awn or awn-point of the outer palea is not more than half the length of the latter. The outer palea and awn are usually smooth or only slightly pubescent. (Fig. 64.)

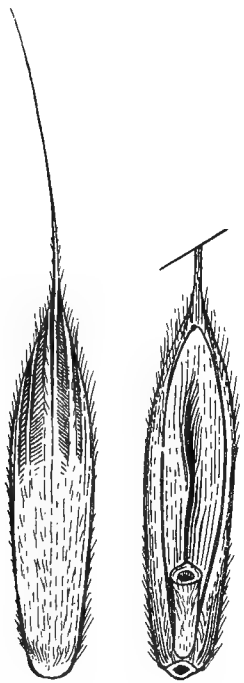


Fig. 63. "Seed" of *Brachypodium sylvaticum.* ×5. Back and front views.

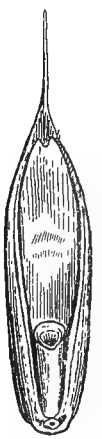


Fig. 64. "Seed" of *Brachypodium pinnatum.* ×5.

Briza *media,* L. (Quaking-grass.) (Fig. 65.)

A tufted or slightly creeping perennial commonly found on moors and poor soils. Shoots round; sheaths almost entire and smooth. Blades with very low flat ribs, and downwards rough on the upper surface. Ligules very short and blunt; no auricles.

Flowers about midsummer; culms from 12 to 18 inches high; panicle erect, spreading, triangular in outline. Spikelets containing 5–8 flowers, pendulous on the slender branches, broadly ovate, flattened, and variegated with green and brownish-purple. Empty glumes almost equal, broad, obtuse, and three-nerved.

"*Seed*" 2·5–3 mm. long, with outer palea inflated, blunt and round-backed. Grain dark-brown. (Fig. 69.)

Fig. 65. *Briza media*, L. About ½ nat. size.

Fig. 66. *Brachypodium sylvaticum*, Beauv. About ¼ nat. size.

Fig. 67. *Bromus arvensis*. About ¼ nat. size.

Briza *minor*, L. (Lesser Quaking-grass.)

A small annual, with erect culms from 3 to 10 inches high. Leaves thin, short, and broad. Ligule long, pointed, and arising

from the central portion of the sheath only. Spikelets usually pale green. Rare.

Bromus. British members of this genus may be recognised *by the rather large several-flowered spikelets on a distinctly branched panicle, and by the presence of an awn arising just below*[1] *the divided apex of the outer palea. The leaf-sheaths are entire*[2] *and usually hairy.* All our native species are inferior grasses and should be considered as weeds by the agriculturist.

Bromus *arvensis,* L. (Field Brome-grass.) (Fig. 67.)

An annual or biennial, with entire sheaths which are finely striated and hairy. Shoot section round; *keel slight*; blades thin, dry, acutely pointed, and hairy on both surfaces. There are no auricles, and the ligule is short, thin, and slightly ragged.

Flowers in May or June; culms from 1½ to 3 feet high, with considerably enlarged nodes. Panicle rather open and drooping. Spikelets linear-lanceolate, containing about nine flowers. Empty glumes rather unequal, practically smooth; the upper and larger one is seven-nerved, and its tip is midway between its base and the top of the outer palea of the fourth flower of the spikelet. The lower glume is three-nerved. (These last features will serve to distinguish it from *B. mollis.*) Both glumes have membranous

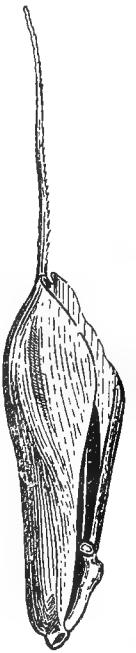


Fig. 68. "Seed" of *Bromus arvensis*, L. ×5.

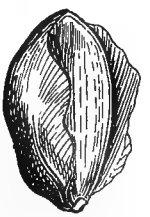


Fig. 69. "Seed" of *Briza media*, L. ×10.

[1] Except *B. erectus* and *B. giganteus* in which the awn may be considered as terminal.

[2] Except in *B. giganteus*, see p. 85.

margins, and their keels are slightly serrated on the upper half.

"*Seeds.*" Outer palea 7 to 12 mm. long, smooth or pubescent, broad and expanded above, seven-nerved, with membranous margins. Its apex is bifid, and it bears a fine, somewhat wavy and finely serrated sub-terminal awn, which is almost as long as

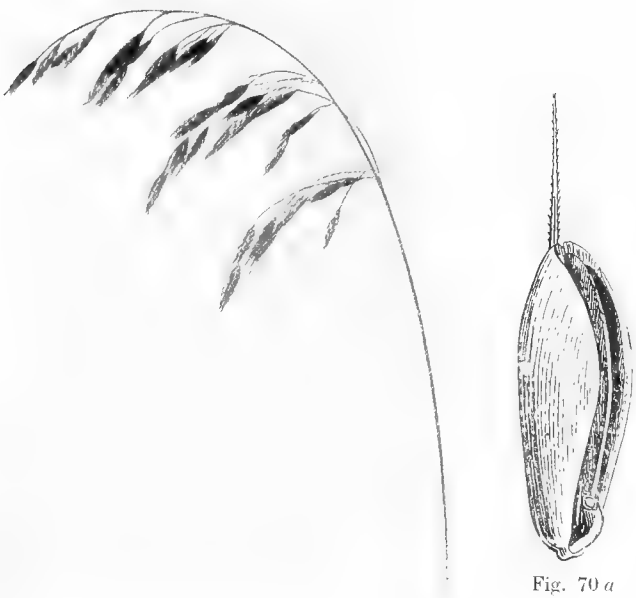


Fig. 70 *a*

Fig 70. *Bromus arvensis* var. *secalinus*. About ⅓ nat size.
Fig. 70 *a*. "Seed" of same. ×5.

the palea. Inner palea very thin, membranous, bearing a few white hairs at its margins. Rachilla cylindrical, pubescent or smooth, often bent or "bowed," and thickened upwards. (Fig. 68.)

Bromus *secalinus*, L. (Fig. 70.)

A cornfield variety of *B. arvensis*, from which it differs chiefly in the form of its spikelets which are more broadly ovate in

outline, and fewer flowered (about seven). The outer palea is also blunter and broader. Towards maturity the "seeds" tend to stand apart in the spikelet giving the latter a heavy appearance. (Fig. 70 *a*.)

Bromus *mollis*, L. (Soft Brome-grass.) (Fig. 71.)

This plant very closely resembles *B. arvensis*, and is generally considered as a variety of it. It is however a far more common

Fig. 71. *Bromus arvensis* var. *mollis*. About $\frac{2}{3}$ nat. size.

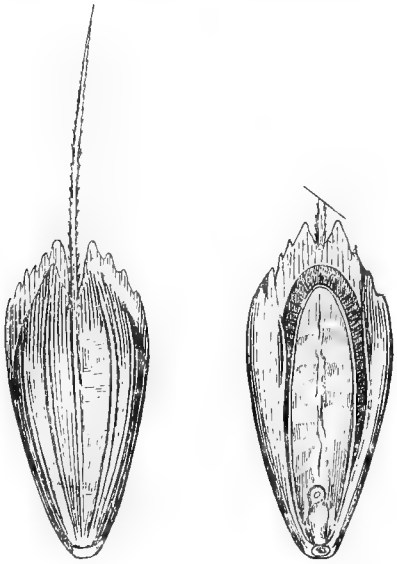


Fig. 72. "Seed" of *Bromus arvensis* var. *mollis*. ×5. Back and front views. The fine hairs on the outer palea cannot readily be shown on this scale.

form in Britain, being abundant as a weed in meadows, on waysides, and in open places generally. Its sheaths, blades, glumes, etc., are covered with longer and softer hairs than those of *B. arvensis*. It is distinguished mainly by the hairiness of its empty glumes, and also by the apex of the larger glume being midway between its base and the top of the outer palea of the sixth flower of the spikelet. There are other minor differences, e.g. the keels of the

empty glumes are not serrated above, and the lower glume is from 5 to 7 nerved. The outer palea is also usually more hairy, and broader. (Fig. 72.)

In all other respects the description given above of *B. arvensis* applies to this form also.

Fig. 73. Panicle of *Bromus sterilis*. About $\frac{1}{3}$ nat. size.

Bromus *racemosus*, L. (= *B. commutatus*, Schrad.) This is a more glabrous form of *B. mollis*. Its "seeds" are entirely glabrous except for the marginal hairs on the inner palea.

Bromus *sterilis*, L. (Barren Brome-grass.) (Fig. 73.)

An annual or biennial, growing about two feet high. Most common in waste places and near hedges. Sheaths entire, *keeled*, and striated. Blade rolled in the shoot, thin, dry, ribless, keeled

on lower half, and acutely pointed. Both sheaths and blades are softly downy or pubescent. Ligule white, conspicuous, *deeply toothed or ragged*. Auricles absent. Abundant in Britain.

Flowers about May and June. Panicles loose, open and drooping, from 6 inches to nearly a foot long. Spikelets large, linear-lanceolate, 5–12 flowered. Empty glumes unequal, acute; the upper one three-nerved.

Fig. 74

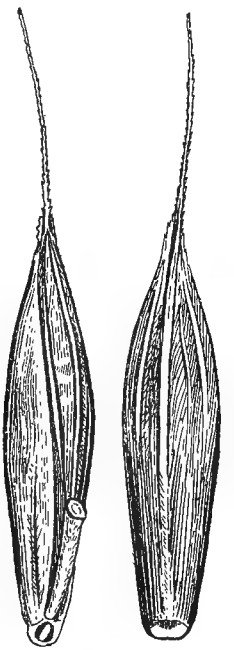


Fig. 75

Fig. 74. "Seed" of *Bromus sterilis*, L. ×5. The barbed awn if fully shown would much exceed the length of the outer palea.

Fig. 75. "Seed" of *Bromus erectus*, L. ×5. Side and back views.

"*Seed.*" Narrow linear-lanceolate in form, tapering at both ends and often slightly "bowed." Outer palea from 14 to nearly 20 mm. in length, free from hairs but scabrid (rough); bifid at apex, seven-nerved, the dorsal nerve prolonged into a fine, rough, sub-terminal awn, usually longer than the palea. Inner palea

membranous, its margins fringed with hairs. The outer palea is of a red-brown colour when the seed is ripe. Rachilla long, cylindrical, rough, and thickening towards the top. (Fig. 74.)

Fig. 76. *Bromus erectus.* About ½ nat. size.

Fig. 77. *Bromus asper*, Murr. About ¼ nat. size.

Fig. 78. "Seed" of *Bromus asper.* ×5.

Bromus *erectus,* Huds. (Upright Brome-grass.) (Fig. 76.) Chiefly found in the southern and eastern counties of England.

A tufted perennial, usually growing on poor soils in open situations. Shoot section oval, sheaths entire, with long scattered hairs. Blades thin, dry, almost ribless, with hairy margins, often partially rolled or folded up. The hairs on all parts of

the plant are rather long and tend to point upwards. On the Continent it is considered worth sowing on poor chalk soils.

Flowers about midsummer; culms from 2 to 3 feet high; panicle erect and rather close. Spikelets erect, 4–8 flowered, lanceolate in outline, of a brownish-purple hue. Empty glumes narrow-lanceolate, with serrated keels.

"*Seeds.*" Outer palea from 9–12 mm. long, scabrid or hairy, with membranous margins above; the central nerve (keel) is conspicuous from the base to the top, and prolonged into a straight, stiff, terminal awn, shorter than the palea. From 4–6 lateral nerves usually appear at the top of the outer palea. Inner palea acutely pointed. Rachilla long, cylindrical and pubescent. (Fig. 75.)

Bromus *asper,* Murr. (Wood Brome-grass.) (Fig. 77.)

A tufted annual, or biennial, growing in shade. Shoot round; sheaths entire and covered with long, scattered, *reflexed hairs.* Blade long and drooping, tapering at both apex and base; hairy, keeled below, almost ribless above. Small auricles present; ligule short and toothed. Frequent in Britain.

Flowers in June or July; flowering culms from 3–5 feet high; panicle large, open, and drooping. Spikelets about an inch long, linear-lanceolate, usually with from six to ten flowers. Glumes very unequal, acute, the upper and larger one three-nerved, and its keel finely serrated.

"*Seeds.*" Outer palea 10–14 mm. long, rough with short, white bristly hairs; three nerves conspicuous especially above, the central one prolonged into a straight rough sub-terminal awn about half the length of the palea. Inner palea with distinct marginal nerves fringed with fine hairs. Rachilla long, cylindrical or somewhat flattened, outstanding, hairy, or sometimes nearly smooth. (Fig. 78.)

Bromus *giganteus,* L. (Tall Brome-grass.) = **Festuca** *gigantea,* Vill. (Giant Fescue-grass.) (Fig. 79.)

An erect *glabrous* perennial growing in shade. Shoots round, *sheaths split.* Leaves broad, acute, flat and almost ribless above, keeled below. Ligule short, reddish-violet; auricles greenish-white. Generally distributed over Britain.

Flowers about July; culms from 3–4 feet high, with striated

sheaths. Panicle large, loose, inclined to droop. Spikelets ovate-lanceolate, 4–6 flowered. Glumes unequal, acute, three-nerved. *In most of its characters this plant more closely approaches the Fescues than the Bromes.*

"*Seeds.*" Outer palea about 7 mm. long, with five indistinct nerves, scabrid (slightly rough), its upper margins

Fig. 79. *Bromus giganteus*, L. About $\frac{1}{4}$ nat. size.

Fig. 80. "Seed" of *Bromus giganteus*. ×5. In the natural state the awn is not curved back as shown in the figure.

membranous. The fine *terminal* (or only slightly sub-terminal) awn is serrulate (barbed), and longer than the palea itself (12–20 mm.). The rachilla is rather long, cylindrical, and rough. (Fig. 80.)

B. madritensis, and *B. maximus* are rare species (p. 188).

Bromus *inermis,* Leyss. (Awnless Brome-grass.) (Fig. 81.) See p. 141.

This is not a native of Britain but is sometimes grown as a forage crop on poor soils in this country under the name of Hungarian Forage-grass. It is a perennial *with long stout rhizomes* which enable it to endure drought and to spread rapidly

Fig. 81. Panicle of *Bromus inermis.* About ⅓ nat. size.

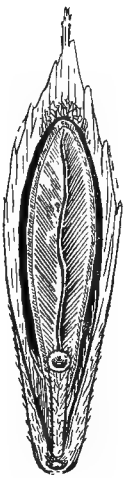


Fig. 82. "Seed" of *Bromus inermis.* ×5.

in loose soils. The whole plant is entirely *smooth and glabrous* and its foliage is of a rather dark-green hue. Sheaths entire, with a slight keel or none. Blades rolled in the shoot, numerous, broad, acuminate, almost ribless above, and but slightly keeled below. There are no auricles, but greenish-yellow triangular areas are conspicuous at the base of the blades. Ligule membranous, very short and blunt.

Flowers about the latter part of May or early in June. Culms erect, 2 to 3 feet high. Panicle about 6 to 8 inches long, becoming moderately open at time of flowering, and of a silvery-grey hue when seed is ripening. Spikelets large, linear-lanceolate, containing from four to six flowers. Empty glumes unequal, lanceolate and acute, the upper and larger one two-nerved; both have prominent keels.

"*Seeds*" "barge-shaped," 9–12 mm. long, and about 2·5 mm. broad. Outer palea with rounded-off keel, and 2–3 rather indistinct nerves on either side; glabrous, or with a few short silky hairs. The dorsal nerve (keel) may project beyond the apex as a short awn-point. Inner palea very thin and membranous, except at the marginal folds where ridges (nerves) occur with a hairy fringe. Rachilla cylindrical, thickening upwards and evenly covered with silky hairs. Caryopsis 7–9 mm. long and about 1·8 mm. broad, pointed below, and rounded at the top end which is densely covered with hairs. The grain is very much flattened, and has a shallow longitudinal cavity on its ventral surface with a fine ridge running along its middle. (Fig. 82.)

Fig. 83. "Seed" of *Bromus Schraderi*. ×4.

Bromus *Schraderi*, Kunth. (Schrader's Brome-grass.) See also p. 142.

Like the last species this is not a British plant, but is sometimes grown as a forage crop. A rather coarse perennial grass growing in irregular tufts. Sheaths entire, keeled, the lower ones densely covered with fine silky hairs, the upper ones more or less glabrous. Young shoots flattened; blades folded, long, very acuminate, and rough. The lower surface of the blade has a prominent keel, and is slightly hairy; the upper surface is more densely hairy. Ligule membranous, white, prominent but blunt. Auricles wanting.

Flowers in June. Culms two feet or more in length, standing out obliquely from the ground. Panicle 6–12 inches long, moderately close in structure. Spikelets large, long, narrow-ovate containing four or five flowers. Empty glumes rather

unequal in length, the upper one longer and nearly twice as broad as the other. Both glumes have prominent keels and nerves.

"*Seeds*" large and usually well filled; 14–22 mm. long and about 2·6 mm. across broadest part. Outer palea straw-coloured, acutely keeled and ending in a short terminal and barbed awn-like point. The lateral nerves number five or six on either side of the keel, and are sometimes scabrid. The keel is markedly scabrid near the awn-point. The margins of the outer palea are slightly rolled back. The inner palea is about 10 mm. long, folded at the margins to entrap the grain, and fringed with hairs at the folds. The rachilla is cylindrical, stout, thickening upwards, and usually rough. The grain is about 7 mm. long, and 1·7 mm. broad. It is hard and glutinous, and has a shallow longitudinal groove in front, and a few hairs at the upper end. (Fig. 83.)

Fig. 84. Panicles of *Calamagrostis lanceolata* (left) and *C. Epigeios* (right). About $\frac{1}{3}$ nat. size.

Calamagrostis *Epigeios,* Roth. (Wood Small-reed.) (Fig. 84.)

A perennial growing in moist shade. Sheaths striated, split. Young shoots round, blades narrow, acuminate and acute. Ligule long with bifid apex. No auricles. Most common in the south of England.

Flowers in July; culms 3 to 5 feet high. Panicle erect, and rather close except during flowering. Empty glumes equal, narrow, and acute, with dorsal nerve only, enclosing one flower.

"*Seeds.*" Outer palea about 3 mm. long, deeply bifid at apex. Awn dorsal, slender, about as long as the palea. At

the base of the "seed" is a tuft of fine silky hairs longer than the outer palea.

Calamagrostis *lanceolata*, Roth. (Purple Small-reed.) (Fig. 84.)

Very similar to the last species. It is chiefly distinguished by its looser and more spreading panicle, and its sub-terminal awn-points which are less than half the length of the outer palea. Not common.

C. stricta is very rare. In bogs and moors.

Catabrosa *aquatica*, Beauv. (Whorl-grass.)

A small aquatic perennial occasionally found in shallow water. Stems procumbent, often creeping and forming adventitious roots at the nodes. In deeper water the stems float. Blades short, broad, blunt, flaccid, and ribless, of a light-green colour. Not common in Britain.

Flowers about June. Panicle erect and spreading, from four to six inches long. Spikelets small, numerous, and two-flowered. Empty glumes much smaller than the palea, very unequal, membranous and blunt. Outer palea with a distinct lateral nerve on either side of the keel, and with a notched apex. Inner palea divided at the top, with marginal nerves. Rachilla long, cylindrical and outstanding.

Cynodon *Dactylon*, Pers. (Creeping Finger-grass.)

A prostrate and creeping perennial growing on sandy sea-shores. It occurs on the southern coast of England. Flowering culms 3 to 6 inches high; inflorescence digitate, purplish, of from 3–5 slender spikes each from 1 to 1½ inches long. Spikelets compressed, one-flowered. Empty glumes about equal, acute. Outer palea awnless, hairy on its dorsal nerve and at the margins. Flowers in July and August.

Cynosurus *cristatus*, L. (Crested Dog's-tail.) (Figs. 85, 157.) See also p. 142.

A small perennial grass growing in close tufts. The young shoots may be either partially flattened or nearly cylindrical. Sheaths split (though this is not always obvious when young), and almost keelless, becoming of a canary-yellow or yellow-brown colour at the base as they age. Blades normally short, dark green in colour, the margins upturned and forming a semi-cylindrical trough towards the base; apex acuminate; the lower surface

smooth, glossy, with a fairly prominent keel; the upper surface distinctly ribbed and dull. There are no auricles, and the ligule is extremely short and blunt. The entire plant is glabrous. Abundant in Britain.

Fig. 85. Spike-like inflorescences of *Cynosurus cristatus* shown in full flower. About twice natural size.

Fig. 86. "Seed" of *Cynosurus cristatus*. × 10. Front view.

Flowers late in June or early in July. The culm is thin, smooth and wiry, from nine to fifteen inches high. Panicle spike-like, 1 to 2 inches long, simple, bearing the spikelets in clusters on its wavy axis. About one-fourth of this axis (rachis) is left exposed owing to the clusters of spikelets being all turned towards one side. Spikelets, 3–5 flowered, each subtended by a group of

several imperfect or modified flowers. Empty glumes narrow, acute, and equal, with rough keels, but without lateral nerves.

"*Seeds.*" These vary in colour from a bright canary-yellow to a deep brown. Many are often also of a light fawn colour. Length about 3–4 mm.; breadth ·6 to ·8 mm. The margins of

Fig. 87. *Dactylis glomerata.* Form of panicle shown in the pre-flowering and flowering stages. About ½ nat. size.

the outer palea overlap at its apex and form a point which may sometimes be prolonged into an awn-point. The upper part of the outer palea is very scabrid as are also its margins in front. The inner palea is held in very tightly by the outer palea, and both are covered with fine but conspicuous dots. The rachilla varies much in length but is usually short. It is cylindrical, rather outstanding, and

thickened at the top, almost "knobbed" (except in the case of the uppermost "seed" of each spikelet). It has a small circular cavity at its top. (Fig. 86.)

Cynosurus *echinatus*. L. (Rough Dog's-tail.)

A tufted annual, rare, and perhaps only introduced into Britain. Flowering culms 1 to 2 feet high. Ligule of upper leaf is very long. Panicle oval in outline, about $\frac{3}{4}$ inch long. The outer palea bears a slender terminal awn about as long as itself.

Flowers about June.

Fig. 88

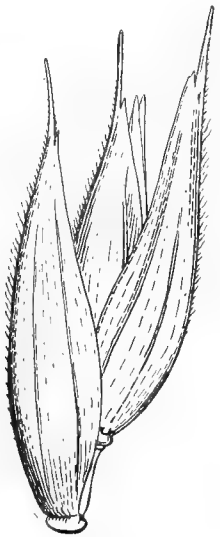


Fig. 89

Fig. 88. "Seed" of *Dactylis glomerata*. ×10. Front view.

Fig. 89. Three attached "seeds" of *Dactylis glomerata*. ×10. The proportion of such attached "seeds" is especially high in immature samples. Usually only the lowest pair of paleæ contain a grain.

Dactylis *glomerata*, L. (Cock's-foot.) (Fig. 87.) See p. 145.

A coarsely-tufted perennial growing on almost every type of soil. The plant is entirely glabrous though it may often be rough to the touch. Its foliage is dull and varies much in colour—from a light green to a deep bluish-green hue. Sheaths entire, very sharply keeled both at back and front. Leaves folded in the flattened shoots; blade partly conduplicate, long, and tapering into an acute

apex; its edges finely serrated, ribless above, and strongly keeled throughout its length below. Ligule long, white, and membranous. Auricles absent. Abundant throughout Britain.

Fig. 90. Two aquatic grasses. *Glyceria aquatica*, Sm. (left). *Digraphis arundinacea*, Trin. (right). About ¼ nat. size.

a *b*

Fig. 91. Two sea-coast grasses. *a*. Spike of *Elymus arenarius*. *b*. Spike-like inflorescence of *Psamma arenaria*. About ⅓ nat. size.

Flowers late in May or early in June. Culms from two to three feet high, the upper sheaths and blades of the culm very harsh to the touch. The panicle consists of clusters of spikelets arranged on contracted or shortened branches, thus giving it a close, dense, heavy appearance. Spikelets three to five flowered.

Glumes nearly equal, strongly keeled and pointed, with scarious margins; the lower one distinctly hairy on the keel, and to a lesser extent on the margins; the upper glume less hairy.

"*Seed.*" Outer palea of a light straw colour, varying from 4 to 9 mm. in length (usual length 5–6 mm.), terminating in a curved point sometimes one-third the length of the palea. The upper part of the keel of the outer palea is either distinctly hairy

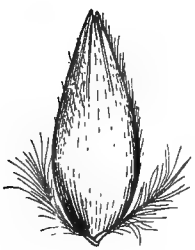


Fig. 92. "Seed" of *Digraphis arundinacea.* × 10.

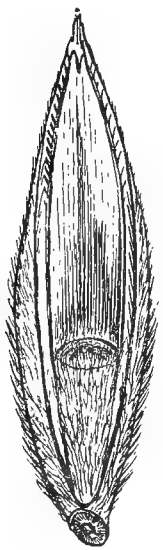


Fig. 93. "Seed" of *Elymus arenarius.* × 5.

or serrated. Inner palea 4–6 mm. long, thin and membranous. Rachilla cylindrical, enlarged above. The "seeds" frequently remain attached in twos or threes as in the spikelet. (Figs. 88 and 89).

Digraphis *arundinacea,* Trin. (Reed-grass.) (Fig. 90.)

A semi-aquatic, and entirely glabrous perennial. The creeping rhizomes frequently bear pink or deep red scales (rudimentary leaves). Shoots cylindrical; sheaths split, with the thin membranous margins much overlapping. Leaf-blades long and often an inch

wide at the broadest part which is about the middle of the lower half of the blade; firm, flat, almost ribless above. The mid-rib is prominent and forms a keel below. Ligule long and either rounded off or torn. There are no auricles, but the base of the blade forms ledge-like projections. Common in Britain.

Fig. 94. Panicle of *Festuca elatior* sub-sp. *arundinacea*. About $\frac{1}{3}$ nat. size.

Fig. 95. "Seed" of *Festuca elatior* sub-sp. *arundinacea*. $\times 10$.

Inflorescence a plume-like panicle, rather close at first but spreading at the time of flowering which is usually in July. Flowering culms 3–5 feet high; spikelets numerous, one-flowered, and green, white, or purplish. Empty glumes almost equal, and acute.

"*Seeds*" about 3 mm. long. Outer palea very glossy, and either white, or yellow, or sometimes dark coloured. At the base of the paleæ are a pair of linear hair-tufts. These are shorter than the outer palea which is awnless and hairy at its margins. The upper margins of the inner palea are also fringed with hairs. (Fig. 92.)

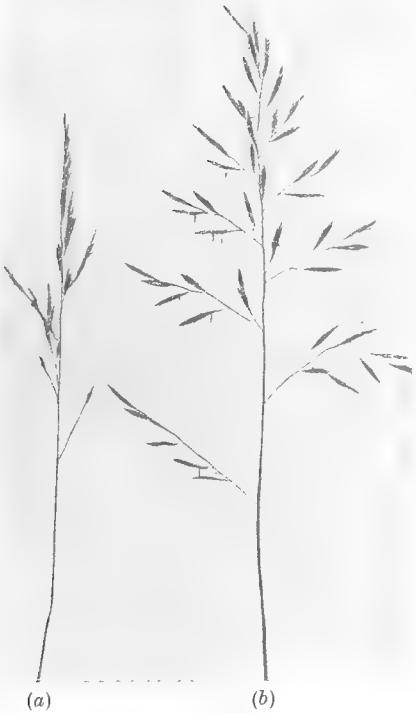


Fig. 96. Panicles of (*a*) *Festuca rubra genuina* and (*b*) *Festuca pratensis*. About ½ nat. size.

Fig. 97. "Seed" of *Festuca elatior* sub-sp. *pratensis*. × 10.

Elymus *arenarius*, L. (Sand Lyme-grass.) (Fig. 91.)

A perennial, with long and numerous rhizomes, chiefly found on sandy sea-shores. It has been extensively sown for binding loose or blowing sand on parts of the English and Dutch coasts.

Shoots round; sheaths split; leaf-blades long, firm, folded or rolled inwards, with spinous points. The inner or upper surface of the blade has deep grooves and flat-topped prominent ribs; the lower surface is ribless and smooth. Ligule very short and blunt. Auricles distinct.

Fig. 98. *Festuca Myurus.* About ¼ nat. size.

Fig. 99. "Seed" of *Festuca Myurus.* ×10.

Flowers about July; culms from 2 to 5 feet high. Inflorescence spikate, from 4 to 10 inches long. Spikelets of 3 or 4 flowers, arranged in pairs at each notch of the rachis. Empty glumes usually three-nerved, narrow, acute, nearly equal, and more or less woolly.

"*Seeds*" about 14 mm. long (varying from 10–18 mm.). Outer

palea five-ribbed, hairy or velvety, taper-pointed, the central nerve ending in a spur-like point. Inner palea with delicately fringed marginal ribs, and a bifid apex. Rachilla cylindrical, stout and hairy. (Fig. 93.)

Fig. 100. Tuft of *Festuca ovina*, L. var. *vulgaris* Koch. About $\frac{1}{3}$ nat. size. To the right are shown two panicles in the viviparous condition.

Fig. 101. Tuft of *Festuca ovina*, L. var. *tenuifolia* Sibthorp. About $\frac{1}{2}$ nat. size.

Festuca. All the British species of this genus have *split sheaths, more or less spreading panicles, 3 to 12 flowered spikelets, and the outer palea terminates in an awn or awn-point* (except in *F. ovina tenuifolia*).

Festuca *elatior*, L., sub-sp. *arundinacea*, Hackel. (Tall Fescue.) (Fig. 94.) See also p. 147. Frequent throughout Britain.

A deeply-rooted glabrous perennial, forming rather coarse

tufts—especially in moist situations. Shoots cylindrical; sheaths split, red or pink at the base. Leaf-blades rolled in the shoot, dark-green, firm, long, acuminate; the upper surface dull, harsh, with prominent ribs; the lower surface smooth and glossy, distinctly keeled at the base. White lines are seen between each rib when the leaf is held up to the light. Auricles often mere ledge-like projections. Ligule much reduced and blunt.

Flowers early in July; culms from 3 to 5 feet high. Inflorescence a compound panicle, large, spreading, and the upper portion somewhat drooping towards one side. Spikelets 5–10 flowered. Glumes unequal, the upper and larger one three-nerved.

"*Seeds.*" Outer palea 5–9 mm. long, boat-shaped, round-backed, and indistinctly five-nerved, the dorsal nerve terminating in an acute point, or even an awn-point. The nerves are often finely serrated. Inner palea acutely pointed. Rachilla cylindrical and outstanding, smooth or rough. The ripe "seed" has a dull grey-brown appearance. (Fig. 95.)

Festuca *elatior*, L., sub-sp. *pratensis*, Hackel. (Meadow Fescue.) (Fig. 96.) Frequent throughout Britain. See p. 148.

Both in habit and foliage this plant resembles the last variety, but it is of smaller size. The flowering culms are from 18 inches to 2 feet high, and the panicles are less branched than in the preceding form. The spikelets and "seeds" are also very similar, but the latter are shorter (about 5–6 mm. long), slightly broader, and usually without the acuminate apex of the "seeds" of Tall Fescue. When well ripened the "seeds" are also of a paler appearance than those of the tall variety. (Fig. 97.)

Festuca *loliacea*, Curt., is probably only a form of Meadow Fescue, in which the inflorescence is reduced to a spike of spikelets. It is otherwise indistinguishable from the normal form of *F. pratensis*. The two empty glumes at the base of each spikelet readily distinguish it from the Rye-grasses.

Festuca *gigantea*, Vill. See **Bromus** *giganteus*.

Festuca *Myurus*, L. (Rat's-tail Fescue) = *F. bromoides*, Sm. (Fig. 98.)

An annual, occurring chiefly in waste places and as a roadside weed. Leaf-blades permanently folded, bristle-like, dark-green.

Auricles distinct. The inner surface of the blade is ribbed and hairy. Frequent in Britain.

Flowers about the middle of June. Panicle rather close and one-sided. Spikelets 5–6 flowered. Glumes acute, very unequal, the upper and larger one three-nerved.

"*Seeds.*" Very slender, about 6 mm. long without the awn. (15–20 mm. or more including the awn.) Outer palea gradually tapering into a fine roughish awn nearly twice its own length. Rachilla small and cylindrical. (Fig. 99.)

Festuca *ovina*, L. (Sheep's Fescue.) Abundant in Britain.

A fibrous rooted and tufted perennial, with permanently folded leaves; very abundant on poor dry soils, limestone hills, etc. Flowers early in June. At high elevations and under moist conditions Sheep's Fescue frequently passes into the viviparous state. Instead of the normal development of sexual organs, the flowers grow out into leafy buds having rudimentary roots at their base. These are capable of directly propagating the plants when they fall to the ground. See Fig. 100. This phenomenon is also met with in some of the Poas, especially *Poa alpina*.

Many varieties have been described, but most of them are separated by only slight and variable features. Possibly the forms of Red Fescue are also to be considered as only distinct varieties of *F. ovina*. The following distinct varieties are of economic importance[1].

Festuca *ovina*, L., var. *vulgaris*, Koch. (Common Sheep's Fescue.) (Fig. 100.) See p. 150.

All the leaves are permanently folded and grow in dense tufts. Short stiff erect auricles at juncture of sheath and blade. Ligule obsolete or wanting. Flowering culms about 6–9 inches high, erect, and rather rough and angular just below the panicle. The panicle is short, close, and secund (one-sided). Spikelets nearly erect, about six-flowered. Empty glumes unequal, the upper and larger one three-nerved.

"*Seeds.*" Outer palea either smooth, rough, or hairy, 3–4 mm. long, ending in an awn-point which is usually less than half the

[1] It is very probable that the numerous intermediate forms which cannot be satisfactorily grouped in the main types here described are the result of the repeated cross-fertilisation of these types.

length of the palea. Rachilla cylindrical, rough or smooth, outstanding. (Fig. 102.)

Festuca *ovina*, L., var. *tenuifolia*, Sibthorp. (Fine-leaved Sheep's Fescue.) (Fig. 101.)

In this variety the leaves are still finer and more needle-like than in the normal form, and the flowering culms are only from 4 to 6 inches high. The "*seeds*" are from 2 to 4 mm. long, and of a light golden-brown colour. The outer palea is simply acute—usually having no awn-point. In other respects the "seeds" are similar to those of the var. *vulgaris*. (Fig. 103.)

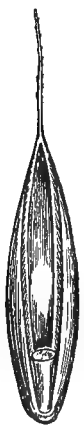


Fig. 102

Fig. 103

Fig. 102. "Seed" of *Festuca ovina* var. *vulgaris*. × 10.

Fig. 103. "Seed" of *Festuca ovina* var. *tenuifolia*. × 10.

Festuca *ovina* L., var. *duriuscula*, Koch. (Hard Fescue.) (Fig. 105.) See p. 150.

This may be considered as a robust variety of Sheep's Fescue. It is more commonly met with on richer and moister soils, and is either tufted or slightly creeping. Its basal leaves are permanently folded, dark-green in colour and rather fleshy. The leaves of the flowering stems tend to remain open and flat.

Flowers early in June. The culms reach a height of 1 or 2 feet, and the panicle is more spreading than in *F. ovina vulgaris*. The stem is also smooth just beneath the panicle. The spikelets are from five- to seven-flowered. Empty glumes unequal, the upper and larger one three-nerved.

"*Seed.*" The outer palea is round-backed (without a keel), about 4–5 mm. long (in some forms 6 mm. long), and terminates in an awn-point generally about half as long as itself. Rachilla cylindrical and outstanding. The outer palea and rachilla may be either smooth or rough, or even hairy. (Fig. 106.)

Festuca *rubra*, L. (Red Fescue.) (Figs. 96 and 104.) Common in Britain. See p. 151.

Sub-species *eu-rubra*, Hackel. *Ovary glabrous.*

Var. 1, *genuina*—with rhizomes.

Var. 2, *fallax*—without rhizomes, growing in fairly compact tufts.

Sub-species *heterophylla*, Hackel. *Top of ovary pubescent.*

In this variety the intravaginal shoots are much more numerous than the extravaginal and the upper leaves of the culm are distinctly expanded.

Fig. 104. *Festuca rubra*, L. var. *genuina*, Hack. About $\frac{1}{4}$ nat. size.

Fig. 105. *Festuca ovina*, L. var. *duriuscula*, Koch. About $\frac{1}{4}$ nat. size.

The following remarks apply to the genuine creeping variety, var. 1, *genuina*. This plant is closely allied to Hard Fescue. It differs chiefly in its habit of extensively creeping by means of well-developed rhizomes. Its basal sheaths are also red or pink in colour.

"*Seed.*" The outer palea is 4–5 mm. long, of a pale straw colour, tinged with red, and usually smooth. Rachilla cylindrical, smooth, and enlarged above. In some forms the palea may be 6 mm. long, and the outer palea and rachilla rough or hairy. The awn-point varies considerably in length in different forms but it never exceeds half the length of the outer palea. (Figs. 107 and 108.)

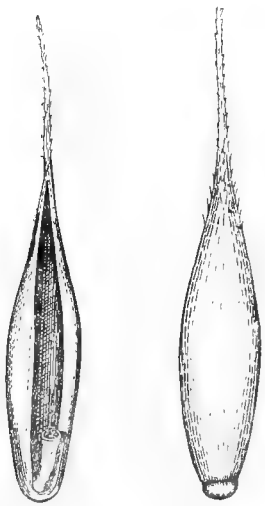


Fig. 106. "Seed" of *Festuca ovina* var. *duriuscula*. × 10. Front and back views.

Fig. 107. "Seed" of *Festuca rubra* var. *genuina*. × 10.

Fig. 108. "Seed" of *Festuca rubra* var. *fallax*. × 10

Festuca *sylvatica*, Vill. (Reed Fescue.)

Festuca sylvatica is thinly scattered over the British Isles—chiefly in moist mountain woods. The leaf-blades are broad, acute and rough. Flowering culm from 2 to 3 feet high. Panicle lax, of long slightly drooping branches. Spikelets 3–5 flowered. Glumes very narrow. Outer palea three-nerved, acute, but not awned. (Fig. 109.)

Glyceria *aquatica*, Sm. (Reed Sweet-grass.) (Figs. 90 and 110.)

A large aquatic perennial, entirely glabrous, though very harsh to the touch, chiefly found by the side of streams, ditches, etc.

Stems somewhat creeping and rooting at the nodes. Young shoots compressed and with prominent keels. Sheaths entire, glabrous but rough, of a spongy texture owing to air-cavities within. Blades often an inch or more in width, folded in shoot, broadest near base, tapering very gradually to an acute apex; smooth or rough, ribless above, and keeled on the lower surface. Yellowish triangles at base. Ligule membranous, and usually short. No auricles. Frequent in Britain.

Flowers about July; culms varying from 3 to 6 feet high. Panicle erect, spreading, large and graceful. Spikelets numerous, ovate, 4–10 flowered. Glumes unequal, blunt, and without lateral nerves. Flower without a "web" at its base.

"*Seeds.*" Outer palea 3–4 mm. long, rounded off at apex, awnless, and seven-nerved, the dorsal nerve minutely toothed. Rachilla cylindrical and outstanding. The "seed" is entirely free from hairs and is of a golden-brown colour. (Fig. 111.)

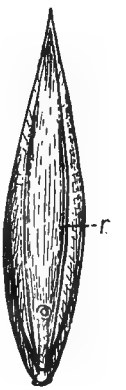


Fig. 109. "Seed" of *Festuca sylvatica*. × 10. Note the very prominent marginal ribs (*r*) of the inner palea.

Glyceria *fluitans*, Sm. (Floating Sweet-grass.) (Fig. 110.)

A perennial and somewhat creeping semi-aquatic species closely allied to the last, but capable of growing in drier situations. Young shoots flattened; sheaths entire, keeled, striated, with large air-cavities. Blade soft, thin, broad and blunt, with numerous low flat ribs above, and a very fine keel below extending to the apex. At the base of the blade are two conspicuous yellow areas of a triangular shape. Ligule prominent, membranous, acute or rounded off. Auricles absent. Frequent in Britain.

Flowers late in June; culms 18 to 24 inches high. Inflorescence a simple panicle or even nearly spikate; lax, slender, and frequently a foot or more in length. The branches are very widely spread apart during flowering, but are close to the main axis before and afterwards. Spikelets few, long, narrow, containing from six to nearly twenty flowers. Glumes very unequal, the upper one the larger; both membranous and without lateral nerves. Paleæ without a "web" at their base.

"*Seeds*" about 4 to 5 mm. long, broader and stouter than *G. aquatica*. Outer palea awnless, seven-nerved, with scarious margins above. Rachilla cylindrical, with a large "knob" at its top. The whole "seed" is free from hairs, but the outer palea and nerves are scabrid (rough). (Fig. 112.)

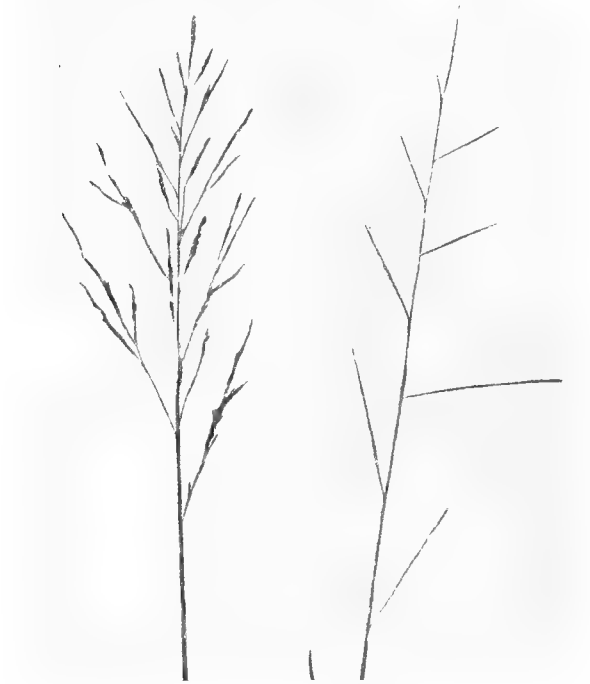


Fig. 110. *Glyceria aquatica* (left) and *Glyceria fluitans* (right). About $\frac{1}{4}$ nat. size.

Holcus *lanatus*, L. (Yorkshire Fog.) (Fig. 113.)

A tufted or sometimes slightly stoloniferous perennial found on all types of soil but growing most luxuriantly where moisture is plentiful. Abundant in Britain, as a weed in pastures, meadows, etc.

The sheaths and leaves are densely covered with short soft

hairs, giving the plant a velvety touch, and the foliage is of a pale greyish-green colour. Sheath split, with a slight keel; the veins of the basal sheaths of a pink colour. Blades rolled in the shoot, thin, dry, and almost ribless. Ligule distinct, but blunt and hairy. Auricles absent.

Flowers in June or July; culms from 1 to 2 feet high. Panicle at first green and close; at flowering time open, spreading, and usually having a pinkish tinge. Spikelets two-flowered, the lower flower bi-sexual, the upper one staminate. Glumes hairy, of nearly equal length; the upper and broader one tipped with an awn-like point. Both glumes are sharply keeled; the upper one has a lateral nerve on either side of its keel, situated nearer to the margin than to the keel.

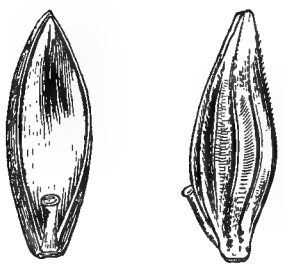


Fig. 111 "Seed" of *Glyceria aquatica*. ×10. Front and side views.

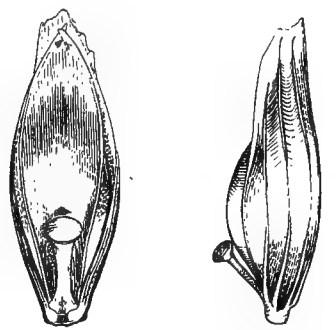


Fig. 112. "Seed" of *Glyceria fluitans*. ×10. Front and side views.

"*Seed.*" The outer palea of the lower flower is oval in form, smooth and awnless. At its base are frequently a few straight silky hairs, and its rachilla is long, slender and cylindrical. The outer palea of the upper flower bears a sub-terminal awn which is about half as long as the palea and becomes curved and hook-like when mature.

The "seed" may consist of the whole spikelets, about 4 mm. long by 2 mm. broad; or the product of the two flowers may separate from the empty glumes (in which case the "seed" consists of the paleæ of the lower flower enclosing a grain, and carrying the upper barren flower on their rachilla); or the ripened "seed"

of the lower flower may separate both from the glumes and the upper flower. The outer palea of the ripe "seed" is almost transparent, shining, and about 2 mm. long. (Fig. 114.)

Holcus *mollis*, L. (Creeping Soft-grass.) (Fig. 115.)

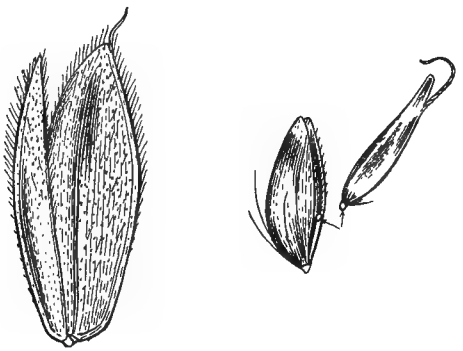
A perennial, very closely allied to *H. lanatus*, and flowering about the same time. It is however less common, and occurs

Fig. 113. Panicles of *Holcus lanatus* showing the position of the branches and spikelets at the pre-flowering and full-flowering stages. About $\frac{2}{3}$ nat. size.

chiefly in moist shady situations. It is distinctly stoloniferous, with slender and decumbent creeping stems rooting at the nodes. Its foliage is less softly hairy than *H. lanatus*, and the flowering culms are more slender and have reflexed hairs at the nodes. The upper flower of the spikelet is occasionally perfect and fertile. In addition to the above differences it may be distinguished from

H. lanatus by (1) both its empty glumes being acute at the top, and rather larger, (2) the lateral nerves of the upper glume being closer to the keel than to the margin, and (3) the awn of the upper flower being more dorsally situated and rough (a microscopic character) throughout its entire length, and bent—but not curved back—when mature. These differences will of course serve to distinguish the "seeds." (Fig. 116.)

Hordeum. *In this genus the inflorescence is spikate. The spikelets are one-flowered, and are arranged in alternating groups of threes on opposite sides of the rachis.*



A *B*

Fig. 114. *A*. "Seed" of *Holcus lanatus* consisting of the entire spikelet. *B*. Contents of the spikelet *A*. The imperfectly developed upper flower readily separates (as shown) from the rachilla of the lower pair of paleæ. The grain is enclosed by the latter and is a very common impurity in many kinds of commercial seeds. It may either remain attached within the glumes or become free from them. × 10.

Hordeum *murinum*, L. (Wall Barley.) (Fig. 117.)

A closely tufted annual with abundant light-green foliage. Sheaths split, slightly keeled, hairy (at least the lower ones). Blade rolled in the shoot, broadest about its middle, acuminate, rather thin; both surfaces dull and hairy, ribless above, slightly keeled below. Ligule short and blunt. Auricles large, white, pointed and overlapping. Common in Britain as a weed in waste places.

Inflorescence and "Seeds."

Flowers in June; culms 1 to 2 feet high. Inflorescence a spike of spikelets. Spikelets one-flowered, arranged in alternating triplets on the flattened sides of the notched rachis. The three

spikelets usually adhere when ripe. *The central spikelets* have linear-lanceolate glumes, which are fringed and end in a straight rough awn. The outer palea bears a terminal awn which is longer than the glumes. The inner palea has a long slender rachilla. Central flowers bi-sexual. (Fig. 118.)

Fig. 115. *Holcus lanatus* (left) and *Holcus mollis*, a dried specimen (right). About $\frac{1}{3}$ nat. size.

The lateral spikelets are borne on distinct pedicels, and the glumes are fine and bristle-like. The outer palea bears a terminal awn longer than the glumes. Rachilla fine, shorter than that of the central flower. Lateral flowers staminate. As in *H. pratense* the "seed" consists of the three united spikelets—the central one only enclosing a grain.

H. maritimum, With., is a sea-coast form of *H. murinum*.

Hordeum *pratense*, Huds. (Meadow Barley-grass.) (Fig. 117.)

A small tufted annual or perennial, preferring stiff clays and moist soils generally. Frequent in England ; rare in Scotland. Of little agricultural value. Sheaths split, the lower ones hairy, but the upper ones often glabrous. Blades rolled in the shoot, *firm*, dry, hairy above, *almost glabrous and glossy below*. Ligule short; auricles small, narrow and pointed or even reduced to mere ledges.

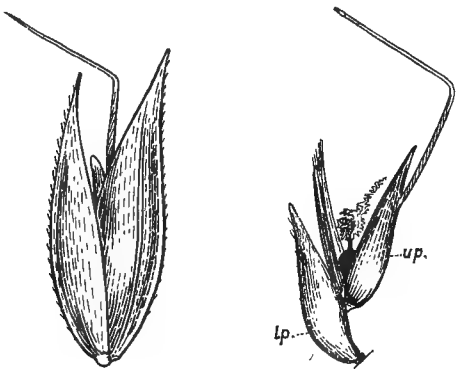


Fig. 116. *A*. "Seed" of *Holcus mollis* consisting of the entire spikelet. × 10. *B*. Contents of the spikelet *A*. The lower pair of paleæ (*lp.*) contain a grain; *up.* upper pair of paleæ showing the remains of stigma on the undeveloped ovary. × 10.

Flowers early in July; culms usually about 18 inches high. The spike of spikelets is from 1 to 2 inches long. The flower of each central spikelet is bi-sexual, the lateral flowers staminate only. The glumes of all the spikelets are bristle-like.

The "*seed*" consists of the three united mature spikelets. The outer palea of the central flower is three-nerved, and the middle nerve terminates in a serrated awn rather longer than the outer palea. The rachilla of the central flower is very fine, cylindrical, and about half as long as the inner palea.

H. sylvaticum, Huds. (Wood Barley-grass.) A not very common perennial.

Flowers about midsummer; culms about 2 feet high; spike about 3 inches long, lax, i.e. the spikelets are distinctly separated on the rachis. In this species the flowers of the central spikelets are staminate or rudimentary, while each lateral spikelet contains one bi-sexual flower.

Fig. 117. *Hordeum murinum* (left) and *Hordeum pratense* (right). About $\frac{3}{5}$ nat. size.

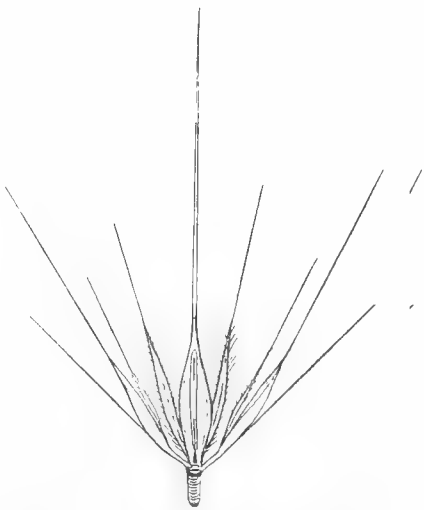


Fig. 118. A "triplet" of spikelets of *Hordeum murinum.* Nat. size. Only the central spikelet, which lies between the two dilated and fringed glumes, contains a grain.

Kœleria *cristata,* Pers. (Crested Hair-grass.) (Fig. 119.)

A small perennial forming dense tufts of rather stiff foliage, principally found on dry soils near the sea. Sheaths split and hairy. Blades rolled in the shoot, narrow, and pubescent or downy on

both surfaces. Panicle close, erect, oval in outline, and from 1 to 2 inches long. Spikelets silvery, flattened, two-flowered. Glumes unequal, acute, completely enclosing the two flowers.

"*Seeds.*" Outer palea about 4 mm. long, acute, three-nerved, the central nerve minutely toothed above. Inner palea with fringed margins, divided at the top. Rachilla relatively long, cylindrical and often covered with short hairs. (Fig. 120.)

Fig. 119. Tuft of *Kœleria cristata*, Pers. About ¼ nat. size.

Fig. 120. "Seed" of same. Side view. × 10.

Lolium *perenne*, L. (Perennial Rye-grass.) (Figs. 121 and 122.) See also p. 152.

A fibrous rooted, tufted perennial, abundant on most types of soil throughout the British Isles. The whole plant is glabrous. Young shoots usually rather flattened—sometimes almost cylindrical. Sheaths split (not obvious while plants are young), the lower ones pink or red near the ground. Blades usually of a dark-green colour, smooth and glossy below; dull and with distinct ribs above. The sheath is without a keel, and the blade though somewhat conduplicate is only slightly keeled below. Auricles small; ligule short and blunt.

Flowers early in June; culms from 1 to 2 feet high. Inflorescence spikate, compressed, almost erect. Spikelets sessile, borne singly, and alternating in two opposite rows with their edges next the rachis. From six to ten flowers are usually present in each spikelet. Only the outer empty glume is present[1], and the inner edge of the spikelet is partially pressed into a groove in the rachis. Empty glume

[1] Two empty glumes are present however in the terminal spikelet of *Lolium*.

five-nerved, and shorter than the spikelet. Outer palea smooth, five-nerved, awnless. Inner palea with the marginal nerves finely fringed.

"*Seed.*" The "seed" is barge-shaped, flattened, and from

Fig. 121. Left to right—*Lolium temulentum*, *L. italicum*, *L. perenne* and *Agropyrum repens* for comparison. About ½ nat. size.

Fig. 122. *Lolium perenne* (left) and *L. italicum* (right) with enlarged spikelet of the latter. About ¼ nat. size.

5 to 8 mm. long. Outer palea smooth, with a rounded or simply pointed apex where the central nerve is just noticeable. The rachilla is flattened and usually pressed close to the inner palea; its upper transverse section is either elliptical or rhomboidal in

outline. The naked grain is oblong-elliptical, with a shallow groove. (Fig. 123.)

Lolium *italicum*, Braun. (Italian Rye-grass.) (Figs. 121 and 122.) See also p. 155.

This variety is distinguished from the above chiefly by: (1) its more rounded shoot section, the leaves being rolled in the shoot; (2) its more distinctly tufted habit, and broader leaf-blades; (3) and its awned outer palea. It also usually

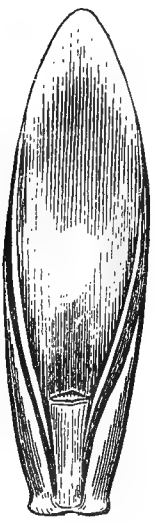
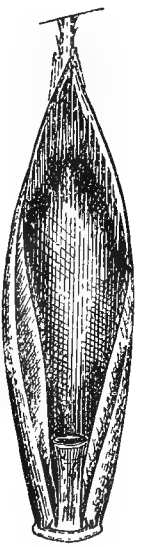


Fig. 123. "Seed" of *Lolium perenne*. ×10.



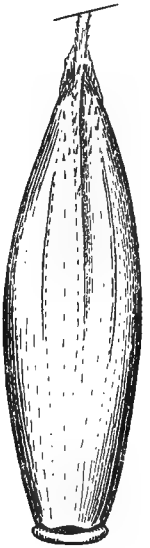


Fig. 124. "Seed" of *Lolium italicum*. Front and back views. ×10.

behaves as a biennial, and is more luxuriant in growth. In most other respects it is similar to *L. perenne*.

"*Seed.*" Very similar in size, etc., to those of Perennial Rye-grass but not so much flattened. The rachilla may be flattened or almost cylindrical. The terminal awn is usually longer than the outer palea. It is not at all uncommon for the "seeds" to shed their awns at the ripening period. (Fig. 124.)

L. woldicum is a rapid growing annual variety of Italian Rye-grass.

Lolium *temulentum*, L. (Darnel or Bearded Rye-grass.) (Fig. 121.)

An annual, sometimes found as a weed in cornfields. It is practically indistinguishable from Italian Rye-grass by the foliage.

Flowers about July; culms about 2 feet high. Inflorescence similar to that of *L. italicum*, but the spikelets contain only four or five flowers, and the empty glume is longer than the spikelet and has only three distinct nerves. A very small inner glume

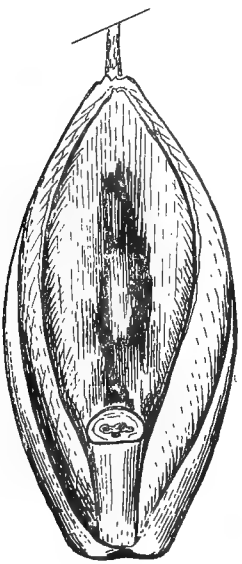


Fig. 125. "Seed" of *Lolium temulentum*. ×10.

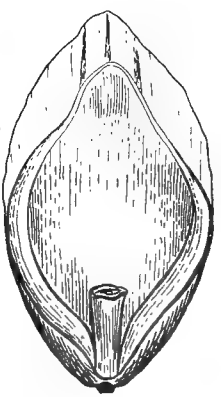


Fig. 126. "Seed" of *Melica nutans*. Front view. ×10.

may sometimes be present. Outer palea seven-nerved, bifid at its apex, and bearing (in the ordinary form) a sub-terminal rough awn from once to twice the length of the outer palea. Another form without awns is sometimes described as *L. arvense*.

The "*seeds*" are from 6 to 7 mm. long (excluding the awn), smooth, and very stout (about 2·5 mm. thick). Rachilla stout, round, and smooth. (Fig. 125.)

Melica *nutans*, L. (Mountain Melick.) (Fig. 127.)

A rather rare perennial, occurring only in shady places at fairly

high altitudes. Shoots quadrangular in cross-section. Sheaths entire. Blades rolled in the shoot, long, narrow, thin, dry, flaccid, and of a light-green colour; sparsely hairy, showing ribs on lower surface only. Ligule distinct.

Fig. 127. *Melica uniflora* (left) and *Melica nutans* (right). About $\frac{1}{3}$ nat. size.

Fig. 128. *Molinia cærulea*. About $\frac{1}{3}$ nat. size.

Flowers in May or June; culms from 1 to 2 feet high. Inflorescence racemed, of about ten spikelets on short branches. Spikelets ovate, pendulous, containing two perfect flowers and one imperfect flower. Empty glumes reddish-brown, five-nerved.

"*Seed*" 4–6 mm. long. Outer palea broad, rounded at the apex, awnless, distinctly 5–7 nerved. Rachilla somewhat flattened

and smooth. Grain elliptical in outline, flattened; about 2·5 mm. long, shining, and of a dark-brown colour. (Fig. 126.)

Melica *uniflora,* L. (Wood Melick.) (Fig. 127.)

A perennial species occurring in similar situations to the last species, but at lower elevations, and is more frequent in the British Isles.

Sheaths and blades as in *M. nutans,* but the ligule is practically wanting, and a slender bristle projects from the sheath near the point of insertion of the blade.

Flowers about June; culms from 1 to 2 feet high. Inflorescence a simple panicle or raceme, with only a few spikelets on long, slender, and somewhat nodding branches. Spikelets ovate, containing one perfect and one rudimentary flower. The empty glumes and paleæ are similar to those of *M. nutans.* Outer palea 4–5 mm. long.

Milium *effusum,* L. (Spreading Millet-grass.)

Occurs in damp shady woods in many parts of the British Isles. A somewhat creeping glabrous perennial. Sheaths split; leaf-blades broad, flat, of a glossy light-green colour. Ligule long and membranous. Auricles absent.

Flowers about June; culms from 3 to 4 feet high. Panicle large, erect, open and spreading. Spikelets on long slender branches, numerous, small, ovate, and one-flowered. Glumes equal, broad, membranous and three-nerved.

"*Seeds.*" Outer palea membranous, smooth, glossy, awnless and nerveless; about 3 mm. long, light-coloured. Inner palea glossy, without marginal hairs. No rachilla. (Fig. 129.)

Molinia *cærulea,* Mœnch. (Purple Melick-grass.) (Fig. 128.)

This plant is common on damp moors, peaty soils, woods, etc. in Britain. It is a perennial, *with tough cord-like roots,* and forms conspicuous tufts. Sheaths smooth and split. Leaf-blades rolled in the shoot, long, narrowing below, and tapering above to a long fine point; thin, dry, almost ribless, and more or less hairy on the upper surface. There are no auricles and the ligule is either very short or represented by only a tuft of hairs.

Flowers about July; culms usually 2–3 feet high but varying much with the situation. Panicle erect, long, and close. The slender branches arise in alternate tufts on the wavy rachis.

Spikelets numerous, small, erect, two- or three-flowered, of a green, or more frequently a purplish colour. Glumes unequal, and smooth.

"*Seeds.*" Outer palea 3–4 mm. long, acute, three-nerved and smooth, often of a purple colour. Inner palea with marginal nerves not fringed. The two paleæ stand rather widely apart at the top. Rachilla long, cylindrical, slender, and bent or "knobbed" at the top. (Fig. 130.)

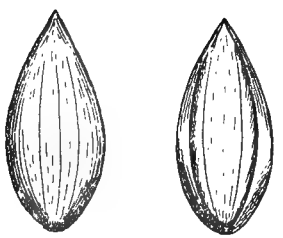


Fig. 129. "Seed" of *Milium effusum.* × 10. Left. Back view, showing fine nerves of the outer palea. Right. Front view, showing the inner palea.

Fig. 130. "Seed" of *Molinia cærulea.* × 10. Side view.

Fig. 131. "Seed" of *Nardus stricta.* × 5.

Nardus *stricta,* L. (Moor Mat-grass.) (Fig. 132.)

A tufted perennial, common on dry moors and sandy heaths. *Its roots are tough and stringy.* Sheaths smooth. Leaves bristle-like, hard, rigid, and almost solid. Ligule small and blunt. No auricles.

Flowers about July, the culms being 6 inches or rather more in height. Spikelets sessile on the erect spike, one-flowered, lanceolate-pointed, all turned towards one side. *Empty glumes wanting, or one rudimentary glume only.*

"*Seeds*." (Fig. 131.) Outer palea very narrow, slightly twisted, and tapering off into an awn-point. Total length of "seed" from 8–12 mm. The naked grain tapers off to a point at each end.

Fig. 132. Tuft of *Nardus stricta*, L.

Fig. 133. Two spike-like inflorescences of *Phleum pratense*, L. showing variation in length.

Fig. 134. "Seed" of *Phleum pratense*, L. × 10. The right-hand figure shows the caryopsis free from the paleæ.

Phalaris *arundinacea*. See **Digraphis** *arundinacea*.

Phalaris *canariensis*, L. (Canary-grass.)

A native of S. Europe: occurs as a weed of cultivation in Britain. It is also sometimes cultivated for its seed which is used for caged birds. It is from 2–3 feet high, with an ovoid spike-like panicle

1–1½ inches long. The spikelets are one-flowered, on very short branches, and densely imbricated in the panicle. There are usually two pairs of empty glumes; the outer pair very much compressed, the keels white and almost winged, bordered by a broad green line. The inner pair are smaller and lanceolate. The paleæ are acute, awnless, shining and more or less pubescent in the green state.

Phleum *pratense,* L. (Timothy or Cat's-tail.) (Fig. 133.) Abundant in Britain. See p. 157.

A tufted perennial, most common on soils of a peaty or tenacious character. The plant is entirely glabrous, and its stems are generally more or less enlarged at the base, especially when the soil is dry or hard. Sheaths split, the older ones of a pale chocolate colour when decaying near the ground. Blades rolled in the shoot, normally short, and acute; those on the culms usually erect. Both sheath and blade are of a light-green colour; there is a slight keel to the blade, but none on the sheath. Auricles absent. Ligule white, membranous, blunt, usually longer than broad.

Flowers in July or later; the culms vary much in height, but are usually from 1½ to 2½ feet high. The nodes of the culm are short and often of a deep violet hue. The cylindrical spike-like panicle varies in length from 1 to 6 inches, but is generally about 2 inches long. Spikelets numerous, one-flowered, and borne upon very short branches. Glumes equal, broad and obtuse, each with a prominent keel which terminates in a rough awn-like point not half as long as the glumes. The glumes are covered with very fine short hairs, and their keels are fringed with short, stiff, white hairs.

"*Seeds*" about 1·5 mm. long and 0·8 mm. broad. The paleæ are silvery-white, thin, membranous, and finely nerved. The caryopsis (naked grain) easily separates from the paleæ, and is spherical-ovoid in shape, of a pale yellow-brown colour, and its surface is finely reticulated. (Fig. 134.)

Phleum *alpinum,* L. (Alpine Cat's-tail.) A perennial found in the Highlands of Scotland. It is distinguished from other British species of this genus by the glume awn-points which are more than half the length of the glumes.

Phleum *arenarium,* L. (Sea Cat's-tail.) Frequent in many places on sandy shores of the British Isles. An annual, seldom exceeding 15 inches in height. It may be readily distinguished from *P. pratense* by the following points: its spike-like panicle tapers distinctly below; the glumes are lanceolate in form, acutely pointed but without awn-points, and their inner margins are fringed with fine hairs.

The "*seeds*" may be distinguished by their smaller size, and by the absence of a central point or spur at the top of the outer palea. Flowers about July.

Fig. 135

Fig. 136

Fig. 135. "Seed" of *Poa alpina.* × 10. Note the absence of a "web"; the numerous long hairs on the ribs, and the membranous margins of the outer palea.

Fig. 136. "Seed" of *Poa annua.* × 10. Note the relatively stout and prominent rachilla, and the absence of a "web."

Poa. *The common British species of this genus have numerous 2–8 flowered spikelets in spreading panicles. The outer paleæ have no awns or awn-points.*

Poa *alpina,* L. (Alpine Poa.)

A perennial, occurring on the Highlands of North Britain. Shoots much compressed, blades short, broad, and bluntly pointed. Ligule of upper leaf long and pointed, sheaths entire. Flowers in May or June; culms about 6–12 inches high; panicle rather close and erect; spikelets 3–5 flowered, the flowers without "webs."

"*Seeds.*" Outer palea 3–4 mm. long, its upper margins membranous, and its apex acute; very distinctly keeled, and hairy—especially on the lower part of the keel and marginal ribs. No intermediate nerves between keel and marginal ribs. Rachilla cylindrical, smooth or hairy. (Fig. 135.)

Poa *annua,* L. (Annual Meadow-grass.) (Fig. 144.) See p. 158.

A little tufted annual abundant on gravel paths and waste places generally. Its foliage is entirely glabrous and of a dull pale-green colour. Young shoots flattened. Sheaths split and keeled. Blades conduplicate, keeled below, ribless above, broadest

near base and tapering to a rather blunt point. The blades are rather limp and often waved or puckered. Ligule relatively long, white and conspicuous. No auricles.

Flowers throughout most of the year. Culms ascending, from 2 inches to a foot high. Panicle 1 to 2 inches long, erect, spreading, triangular in outline, one-sided, the rachis and branches smooth. Spikelets small, ovate-lanceolate, 3–6 flowered. Glumes rather unequal, three-nerved.

"*Seeds.*" Outer palea 2–3 mm. long, five-nerved, with membranous margins above, smooth, except for a fringe of fine silky hairs on the lower half of the keel and lateral nerves. Rachilla cylindrical, outstanding. The "web" is absent. (Fig. 136.)

Poa *bulbosa,* L. (Bulbous Poa.)

A small tufted and glabrous perennial about 6 inches or less in height. Blades short. Shoots round. Ligule long, acute. The base of the stems and lower sheaths are much swollen. Food materials are stored in these bulbous stems and they also assist in the propagation of the plant.

Flowers in May; culms smooth. The panicle consists of rather few, ovate, 3–4 flowered spikelets. Glumes equal, three-nerved. Outer palea ovate-acute, five-nerved. A "web" is present at the base of the paleæ. Occurs chiefly near the coasts in the eastern and southern counties of England.

Poa *compressa,* L. (Flat-stemmed Meadow-grass.) (Fig. 137.)

A rather frequent perennial on dry soils and rocky situations throughout Great Britain. Sheaths split[1] most of the way down, sharply keeled, firm, and much compressed. Blades folded in the shoot, usually short and narrow. Ligule short and blunt. No auricles. The whole plant is generally glabrous and spreads by underground rhizomes. It is cultivated in N. America under the name of Canadian Blue-grass, but it is of little agricultural value in this country.

Flowers about July; culms about 12 inches long, ascending, very hard, much compressed, with very short purple nodes. Panicle small, 1–2 inches long, erect, unilateral, with short branches. Spikelets small, ovate, 4–7 flowered. Glumes almost equal, three-nerved, sometimes of a purplish hue.

[1] Entire while young.

"*Seeds*" 1·5 to 2·5 mm. long. Outer palea *three-nerved*, each nerve hairy on its lower half. The inner palea is fringed with finer and more numerous hairs than in *Poa pratensis*, and the outer palea also spreads more widely open. Rachilla smooth, cylindrical, outstanding. A delicate "web" of white hairs is present at the base of the paleæ in "uncleaned" samples. (Fig. 138.)

Fig. 137. Panicle of *Poa compressa*. About ½ nat. size.

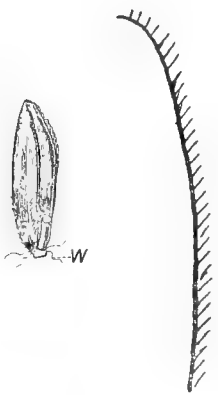


Fig. 138. "Seed" of same. ×10. To the right is shown the appearance of the hair fringe on the margins of the inner palea when highly magnified. W. the "web."

Poa *distans*, L. (Reflexed Meadow-grass.) A somewhat rare perennial with culms from 12-18 inches high. Flowers about July. The rachis of the panicle is rough, and its lower branches become obliquely bent downwards after flowering. Spikelets linear-lanceolate, 4–7 flowered. The outer palea five-nerved, and without a "web" at its base.

Poa *maritima,* Huds. (Sea Poa.) A somewhat creeping perennial, frequent on the shores of the British Isles. Blades short and narrow, frequently rolled up. Flowers about July; culms usually less than a foot high. Panicle erect, rather close, its rachis and branches smooth. Outer palea five-nerved, without a "web" at its base.

Fig. 139. "Seed" of *Poa nemoralis.* ×10.

Fig. 140. Panicle of the same. About ½ nat. size.

Poa *nemoralis,* L. (Wood Meadow-grass.) (Fig. 140.) See p. 159.

A tufted or slightly creeping glabrous perennial, frequent but not abundant in the British Isles, and confined to shady places. Sheaths split, smooth, and without a prominent keel. Blades

rolled in the shoots, smooth, thin, long, narrow, limp and ribless. Ligule very short or wanting. No auricles.

Flowers about midsummer; the culms erect, from 18 inches to 2 feet high. Panicle rather open, spreading, or slightly nodding. Spikelets ovate, 2–5 flowered. Glumes almost equal, three-nerved.

Fig. 141. Panicles of *Poa pratensis* (left), and *Poa trivialis* (right).

"*Seeds*" 2–3 mm. long. (Fig. 139.) Outer palea five-nerved (the intermediate nerves indistinct), with membranous margins above, and rather acutely pointed. The lower half of the central and marginal nerves hairy, the other nerves without hairs. Rachilla

cylindrical, rough or pubescent (a microscopic feature). A well-developed "web" is present in "uncleaned" samples. Seen in bulk the "seed" has a paler appearance than that of *P. pratensis* or *P. trivialis*.

Poa *pratensis*, L. (Smooth-stalked Meadow-grass.) (Figs. 5 and 141.) See p. 159.

A common species throughout the British Isles in pastures, meadows, and on road-sides. It is a perennial, and creeps extensively by extravaginal rhizomes. Young shoots flattened, with

Fig. 142. "Seed" of *Poa pratensis*. ×10. To the right is shown the appearance of the hair fringe on the margins of the inner palea when highly magnified. (Compare with *Poa compressa*, Fig. 138.)

Fig. 143. "Seed" of *Poa trivialis*. ×10.

rounded-off keels. Sheaths entire. Blade dark-green, conduplicate, short or long, with almost parallel margins suddenly narrowing and curving upwards to an abrupt blunt point; ribless above, distinctly keeled below. The flanking lines of motor cells can usually be readily seen, one on each side of the mid-rib. Ligule short and blunt, sometimes almost obsolete. No auricles. The whole plant glabrous.

There are several distinct forms of this species differing much in regard to the width and stiffness of the blades. The above description applies to the form most frequently met with (var.

vulgaris, Döll.), having rather broad, expanded, and moderately stiff leaves. Two other quite distinct forms are: (*a*) var. *latifolia*, Koch, with short broad leaf-blades of a bluish-green colour, and (*b*) var. *angustifolia*, Smith, with long narrow leaf-blades which are permanently folded, stiff and erect.

Flowers late in May or early in June, the culms smooth, from 1 to 2 feet high. Panicle erect, and spreading at time of flowering.

Fig. 144. *Poa rigida* (left) and *Poa annua* (right). About $\frac{1}{3}$ nat. size.

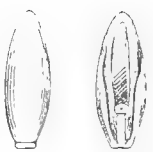


Fig. 145. "Seed" of *Poa rigida*. × 10. Back and front views.

Spikelets from three- to five-flowered, ovate. Glumes rather unequal, the upper one three-nerved.

"*Seeds*" 1·5–2·5 mm. long. (Fig. 142.) Outer palea blunt and often ragged at the apex, *five-nerved*, the lower half of the central and marginal nerves hairy, the intermediate nerves glabrous. Rachilla cylindrical and smooth. A well-developed "web" is present at the base of the paleæ. In cleaned commercial samples of the "seed" both this "web" and the hairs of the nerves are almost

completely removed. In bulk the "seed" almost always has a darker brown appearance than that of *P. trivialis*.

Poa *rigida*, L. An annual, frequently found in rocky situations, on old walls, etc. Flowers in July, the culms seldom more than 6 inches high. Panicle secund. Spikelets about seven-flowered. Glumes without lateral nerves. Paleæ not "webbed" at the base. (Figs. 144 and 145.)

Poa *trivialis*, L. (Rough-stalked Meadow-grass.) (Fig. 141.) See p. 161.

A perennial, abundant in moist pastures etc. throughout the British Isles. Whilst young it forms tufts (and remains tufted if grown under dry conditions), but later, and especially in the presence of moisture, it covers large patches of ground by forming roots and tufts of foliage at the nodes of its numerous thin stolons. Young shoots compressed. Sheaths entire, sharply keeled, those of the young foliage smooth, but those of the flowering culms rough (upwards). Blade conduplicate, broadest near base, and tapering gradually to a sub-acute point. Upper surface dull, ribless. Lower surface keeled and glossy. Ligule of the uppermost leaf long and glossy. No auricles.

Flowers about midsummer; the culms erect, from 1 to 2 feet or more in height. Panicle erect, with rough spreading branches. Spikelets ovate, 2–5 flowered, but usually with two or three flowers. Upper empty glume slightly larger than the other glume and three-nerved. Both glumes have scarious margins and are sharply keeled; the keels are distinctly toothed.

"*Seeds*" 1·8 to 2·5 mm. long, and narrower than those of *P. pratensis*. Outer palea acute at the apex, five-nerved; only the dorsal and marginal nerves are prominent, which gives a sharply triangular cross-section to the "seed." Hairs may be present on the lower half of the dorsal nerve (keel), but none are present on the remaining nerves. The "web" at the base of the paleæ is less copious than that of *P. pratensis*. Commercially cleaned "seeds" are usually quite free from hairs except for a trace of the "web." (Fig. 143.)

Psamma *arenaria*, Beauv. (Sea Mat-grass.) (Fig. 146.)

A perennial, frequent on our sea coasts. It has extensively creeping rhizomes and is therefore useful as a sand-binder. Leaf-

blades erect, long, narrow and rolled; rough on the upper surface, glabrous below. Ligule long and divided. No auricles.

Flowers in July, the culms about 2 feet high. Panicle erect, spike-like, tapering above and below. Spikelets 10 mm. or more in length, narrow, one-flowered. Glumes rather unequal, narrow and acute.

Fig. 146. *Psamma arenaria*, showing inflorescence and a portion of the rhizome. About ¼ nat. size

Fig. 147. "Seed" of *Psamma arenaria*, side view. × 5.

"*Seed.*" Outer palea five-nerved, the central nerve minutely toothed, and slightly projecting beyond the apex of the outer palea. A basal tuft of long silky hairs is present. Rachilla slender, round, with fine silky hairs. (Fig. 147.)

Sesleria *cærulea*, Ard. (Blue Moor-grass.) (Fig. 148.)

A small perennial, uncommon in this country except on the upland limestone regions of North Britain. Its leaves are flat, hard, rigid, and of a glaucous blue. Flowers in April or May, the culms being from 6 inches to a foot high; entire sheaths. Panicle ovoid and spike-like, three-fourths of an inch or less in length.

Fig. 148. *Sesleria cærulea*. About ½ nat. size.

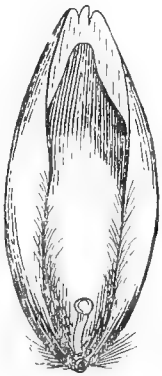


Fig. 149. "Seed" of *Triodia decumbens*, front view. ×10.

Spikelets 2-3 flowered. Glumes nearly equal, broad; the upper half of their keels rough.

"*Seeds.*" Outer palea about 4 mm. long, five-nerved, the central nerve ending in a short awn-point; the remaining nerves forming four teeth at the apex of the outer palea. Inner palea bifid at the top, and its marginal ribs fringed.

Triodia *decumbens,* Beauv. (Heath-grass.)

Rather common on heaths and barren land in the British Isles. A small perennial *with stringy roots.* Sheaths hairy, flattened. Blades rather long, narrow and acute, hairy. Ligule represented by a tuft of hairs. Flowers about July, the culms from 6–12 inches high. Panicle close, of a few simple branches. Spikelets few (seldom more than six), rather large, three or four-flowered. Empty glumes equal, three-nerved, acutely pointed, smooth.

"*Seed*" about 6 mm. long. Outer palea round-backed, indistinctly nerved, with a tuft of short white hairs at its base, and three-toothed at its apex. Rachilla cylindrical. (Fig. 149.)

PART II

AGRICULTURAL SECTION

CHAPTER VIII

THE AGRICULTURAL VALUE AND CHARACTERISTICS OF THE GRASSES SOWN ON THE FARM

The agricultural value of any fodder plant is not an easy matter to decide since it is affected by so many different circumstances. Other things being equal it will of course depend upon (1) *the Yielding Capacity of the plant*, and (2) *the Nutritive Value of its produce*. But both these factors are extremely variable.

The yield is obviously partly correlated with the relative size of the plant, and also partly with its capacity to re-start growth immediately after being grazed or cut. But the yield of the same species varies so greatly with the soil and other circumstances that it is impossible here to do more than indicate what the relative productiveness is when the plants are grown under the most suitable conditions. This is approximately given in Table II, on p. 175.

With regard to the important question of the *nutritive value* of our grasses we must admit that at present our knowledge is most inadequate. Although a considerable number of chemical analyses of the separate species have been made, they have, unfortunately, not been carried out with sufficient uniformity to render the results strictly comparable.

The composition of plants varies so considerably with the different stages of their development, and also probably with the

nature of the soil, that it is necessary to grow, and also harvest them under uniform conditions, if we wish to compare the composition of one with another.

Even then it must be borne in mind that the composition and nutritive value of the plant are by no means the same thing, since it is not the amount of food substances present, but *the actual amount of digestible food present* which matters to the animal. The proportion of total food present which is digestible (coefficient of digestibility) varies not only with each species, but also with each stage of development attained by the plant (see p. 182).

It is to be hoped that in the near future this matter may be fully investigated by some botanist working in connection with a chemist and making use of direct feeding experiments. Meanwhile we must remember that although the nutritive value of a plant is a very important point in determining its agricultural value, it is far from being the only one. Whatever nutritive value a forage plant may possess it is useless to the farmer unless its produce is eaten and relished by live stock. A plant may possess considerable agricultural merit even though either its yield or nutritive value are only moderate. It may be capable of growing under circumstances where better plants would entirely fail, and therefore under such conditions it becomes the more valuable plant.

It must in fact be acknowledged that each of our cultivated grasses has a special value of its own for particular circumstances of soil, climate, and agricultural requirements. Our aim therefore should always be to place each species under the conditions for which it is best adapted, for by so doing its greatest agricultural value will be realised. In the present chapter these special conditions and requirements are as far as possible indicated for each species.

Agrostis alba, L. var. *stolonifera*.

For Botanical description see p. 54.

Fiorin or Creeping Bent-grass is widely distributed throughout the temperate regions of the world and thrives more especially where the rainfall is heavy or the soil is inclined to be wet. On dry soils its produce is very scanty. As its propagation

depends upon the spread of its surface-creeping stolons it naturally succeeds best on moist soils. On such land—especially when its fertility is low—it can be recommended for either pasture or meadow, but on the more fertile well-drained soils it is probably best to replace it entirely by such superior grasses as Meadow Foxtail and Timothy. It attains full development by the second year after sowing, but it is entirely unsuitable as a rotation grass because of its creeping habit. It is one of the hardiest of our grasses and its value lies mainly in its power to thrive at high elevations and on water-logged soils where few other plants of agricultural worth will do well. A further useful feature is that it continues to vegetate in the late autumn and winter months and thus affords pasturage when this is most needed.

Commercial samples of seed are seldom satisfactory. It is imported from Central Europe and frequently consists of a mixture of varieties or types, e.g. *A. vulgaris*, *A. canina*, etc. (see Figs. 35 and 36). These varieties are much inferior for the purpose of cultivation. In addition to the frequent admixture of these varieties the seed often contains large proportions of fine sand and worthless chaff. Other natural impurities often present are seeds of Yarrow, Timothy, and *Poa* sps., *Agrostis Spica-venti*, and *Aira cæspitosa*. The two last are harmful weeds (see Figs. 37 and 40).

Well-dressed seed will contain less than six per cent. of sand and chaff and not more than one per cent. of weed seeds. The *Purity* should reach 85 to 90 per cent. and the *Germination* 70 to 80 per cent. in 28 days. Samples with a Germination Capacity of over 90 per cent. are now frequently met with.

Alopecurus pratensis, L.

For Botanical description see p. 59.

Meadow Foxtail is indigenous to most North Temperate regions and thrives even at high altitudes, enduring cold better than most other valuable forage plants. It is especially suitable for soils rich in humus and for moist rich clays, and on such soils it is certainly one of the most valuable grasses either for grazing or meadow land. On poorer soils, especially if they are subject to

drought, it is of little use. It is one of the first species to commence growth in the spring (flowering usually in April in England), thus affording early grazing which is always especially welcome. Both "top" and "bottom" growth are produced and owing to its slightly creeping habit the plants mix well with other species. Complete development is generally attained by

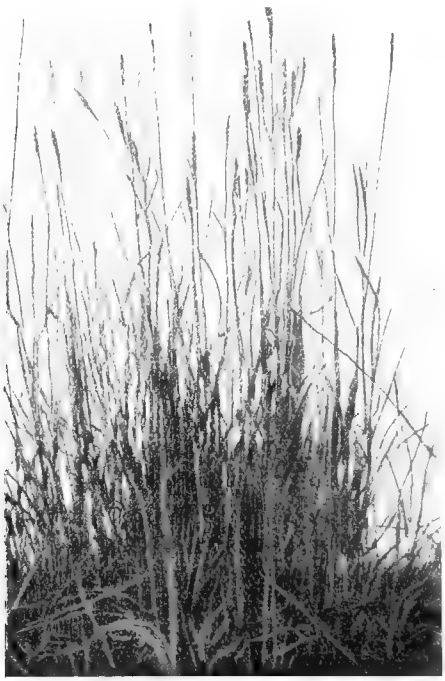


Fig. 150. Meadow Foxtail, showing its habit of growth.

the third season after sowing and it may therefore be used for leys of four or more years' duration as well as for permanent grass on the types of soil indicated above.

In productiveness—even under favourable conditions—it is probably behind Cock's-foot, Tall Oat-grass and the Rye-grasses, but in quality it is unsurpassed. Its hay is free from coarseness and the proportion of leaves to flowering stems is very high.

Meadow Foxtail thrives under irrigation, in water meadows, and on sewage farms. Under liberal treatment a large growth of aftermath is quickly produced. Its ability to thrive in shade makes it especially useful for parks and other semi-shaded grounds.


Fig. 151


Fig. 152


Fig. 153


Fig. 154

Fig. 151. "Seed" of *Rumex crispus*, L. Curled Dock.
Fig. 152. „ *R. acetosa*, L. Sorrel Dock.
Fig. 153. „ *R. acetosella*, L. Sheep's Sorrel.
Fig. 154. The same, freed from the perianth. Each ×10.

Seed is imported into Britain from Finland, Sweden, Holland, etc. That obtained from the North of Europe is usually of the best quality. As imported it generally contains a high proportion of chaff and weed seeds. The proportion of chaff is sometimes

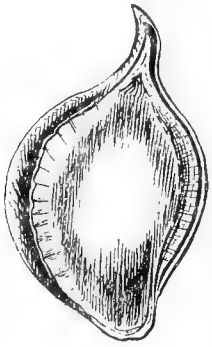


Fig. 155. *Ranunculus repens*, L. Creeping Buttercup. ×10.


Fig. 156. *Rhinanthus Crista-galli*, L. Yellow Rattle. ×4. Sometimes present in Meadow Foxtail Seed.

abnormally high owing to the presence of the larvæ of a species of Midge (*Cecidomyia* sp. closely related to the Wheat Midge *C. tritici* or possibly the same) which attacks the young and developing ovary of the flower, thus preventing the formation of the grain.

The seeds of Hard Fescue and various Poas are generally present. One worthless grass seed (*Aira cæspitosa*) is an almost constant impurity owing to the fact that these two plants thrive under similar conditions of soil, etc. and the seeds are harvested together. Other impurities are *Rumex acetosa*, *R. acetosella*, *Holcus lanatus*, *H. mollis*, *Ranunculus repens*, *Alopecurus agrestis*, etc. (see Figs. 40, 48, 114, and 152–155, and Chap. VII).

Modern cleaning machinery, however, can by successive operations remove all or nearly all these impurities. Properly cleaned samples should not contain more than five to ten per cent. of chaff, and less than one per cent. of Tufted Hair-grass, etc.

The *Germination* should reach 60 per cent. in seven days and 75 to 85 per cent. in eighteen days. Samples giving a germination of over 90 per cent. are now sometimes met with.

Anthoxanthum odoratum, L.

For Botanical description see p. 61.

Sweet-scented Vernal-grass is indigenous to the temperate parts of Europe and Asia, and has been introduced into North America. It thrives on a great variety of soils and within wide limits of altitude and appears to be little affected by extremes of temperature, moisture or drought. Although it thrives best in deep rich soils it nevertheless succeeds in growing on the poorer and drier types of land where the better kinds of agricultural grasses would fail.

This plant was formerly much over-rated in value as a forage grass. The presence in it of a substance known as *coumarin* gives the plant a characteristic fragrant smell especially when made into hay. Chiefly for this reason it was supposed to be a valuable constituent of the meadow. When masticated it is found to possess a rather disagreeable bitter taste both in the fresh and dried condition, and cattle are certainly not at all fond of it. Its relative yield is also very small. Owing to these facts and the high price of its seed it cannot be recommended for ordinary farming purposes. Its most valuable characters are its extreme hardiness, its earliness (flowering in April) and its undoubted permanence. It is essentially a "bottom" grass and grows well in shade. These points indicate that its main use lies, not as

purely a pasture or meadow grass, but as a principal constituent of the turf of shaded park land and pleasure grounds, especially where the elevation is high or the soil poor or variable. Its rich green foliage also adds to its value for this purpose. It is less suitable however for playing grounds as its rather broad, soft, hairy leaves hold dew and moisture too readily and the plant does not produce a turf that will "wear" well.

Commercial Seed.

Practically all our seed has hitherto come from Central Europe and as it is mostly hand-collected its cost is high. Sheep's Sorrel (*Rumex acetosella*) and Woodrushes (*Luzula campestris*, mostly) are the usual weed impurities (see Figs. 153, 154 and 175). The seed of a closely allied species known as Puel's Vernal-grass (*A. Puelii*, Lam.) is occasionally used as an adulterant or even entirely substituted for the real article. This plant is an annual and quite useless for cultivation. The seeds of *A. Puelii* are covered with hair which is paler in colour and less silky than in *A. odoratum* while the awns are slightly longer and finer.

Well cleaned samples of Sweet Vernal-grass seed will not contain more than five per cent. of chaff and less than one per cent. of weed impurities. The *Purity* of good samples should exceed 90 per cent. and the *Germination* should reach 70 to 80 per cent. in 20 days.

Avena flavescens, L.

For Botanical description see p. 68.

Yellow Oat-grass is indigenous to the temperate parts of Europe and Asia and to northern Africa. It is much less frequent in Scotland and Ireland than in England where it is common in the drier pastures and meadows. It thrives at high altitudes and is a good drought-resisting plant. Its most luxuriant growth is attained on moderately moist calcareous or marly soils, but even under the best conditions its yield is only moderate. Full development is reached by the second or third year after sowing. It is essentially a "bottom growth" grass and the bulk of its yield is produced in the middle of summer in Britain. Its produce is entirely free from coarseness and both cattle and sheep are fond of it. Owing to the high price of its seed its use is necessarily restricted,

but for the formation of pasture or meadow on soils for which it is adapted a small quantity should certainly be sown.

Commercial Seed.

The seed is difficult to harvest and to clean, and most samples contain much chaffy material. Even well-dressed lots often contain 20 or 30 per cent. Seeds of the Ox-eye Daisy (*Chrysanthemum leucanthemum*) and *Aira flexuosa* occur as impurities. (See Figs. 41 and 158.) Seed of the latter plant is sometimes entirely substituted for that of Yellow Oat-grass. *Aira flexuosa* has no agricultural value though it may be useful for golf-links, etc. at high elevations. Its seed is plentiful and cheap in comparison with that of *Avena flavescens.*

Good samples of Yellow Oat-grass seed will possess a *Purity* of 75 to 80 per cent. and the pure seed will give a *Germination* of from 60 to 80 per cent. in 18 days. The weed seeds present should not exceed one or two per cent. by weight, the remaining impurities consisting of chaff principally.

Avena elatior, L. = *Arrhenatherum avenaceum*, Beauv.

For Botanical description see p. 63.

Tall or False Oat-grass is indigenous to the whole of Europe and Western Asia except the extreme north. It is common throughout Britain especially as a hedge-plant on the lighter types of soils. It is less frequently met with in open situations or on old pastures and meadows. Though it thrives best on good loams or marls it will give good results on all soils which are not liable to excessive wetness. It is one of our best drought resisting grasses and succeeds even on dry soils though on such its yield is naturally reduced. Its development after sowing is very rapid; a good yield is obtained in the first season, and its maximum growth is reached by the second year. Its duration is however correspondingly short as it tends to die out after four or five years on most soils. These qualities make it especially suitable for leys of from two to four years' duration or for temporary pasture or meadow. It is one of the most valuable of rotation grasses on light soils; at the same time it may be used with advantage in mixtures for permanent grass as its rapid development quickly leads to the formation of a productive turf;

other more permanent species must however form the bulk of a mixture for such a purpose. In a meadow its abundant "top growth" contributes very largely to the yield, while its aftermath is so considerable as to frequently afford a second cutting. It is perhaps less suitable for permanent pasture. Owing to its slightly bitter taste and rather coarse tufts it should never be grown alone but always mixed with a suitable proportion of clovers and "bottom" grasses. The merits of this plant have for many years been recognised on the Continent and it is largely grown there, especially in France, where it is called "Fromental" or French Rye-grass.

The variety *bulbosum* (Onion Couch) has the lower internodes of the stem greatly thickened. These bulb-like stems form rootlets and separate at the nodes, thus forming an efficient mode of propagation. On some arable soils it is a troublesome weed and very difficult to eradicate. (Fig. 54.)

Commercial Seed.

The seed of Tall Oat-grass is seen to be comparatively expensive when the number of seeds per pound is taken into consideration. Most of it is obtained from France. The *Purity* of good samples should be about 90 per cent. Of usual impurities, the Brome-grasses (*B. erectus*, *B. arvensis*) and *Avena pratensis* are the worst and should not exceed one per cent. of the bulk (see Figs. 61, 68 and 75). Other impurities are seeds of Cock's-foot, Rye-grass and Yellow Oat-grass which are of course useful. Even well-cleaned samples will generally contain from five to eight per cent. of chaff.

The pure seed should give a *Germination* of 60 per cent. in seven days, and from 85 to 90 per cent. in eighteen days.

Bromus inermis, Leyss. Awnless Brome-grass; Hungarian Forage-grass.

For Botanical description see p. 87.

This plant though not a native of Britain is indigenous to a large part of Europe and Northern Asia. It is a tall growing perennial, extensively creeping by means of its numerous, long, underground rhizomes. If sown in the spring it produces a fair crop in the first year, and attains its full development during the second or third season.

It is especially able to propagate itself rapidly on the lighter and looser types of soil, and in Hungary it has been extensively grown on dry soils either alone or in mixtures for hay. On heavy land it does not grow freely, and on all fertile soils more valuable grasses should be used.

On poor soils which are loose in texture and subject to drought it is a useful plant and if sown in conjunction with such plants as Cock's-foot, Tall Oat-grass, Kidney Vetch, Sainfoin, etc. good crops may be obtained for such conditions. It is not suitable for alternate husbandry because it is difficult to eradicate.

"*Seed.*" The usual impurities in the seed consist of chaffy material, though other Bromes are sometimes present. The *Purity* should reach 90 per cent., and the *Germination* 80 to 90 per cent. in eighteen days.

Bromus Schraderi, Kunth. Schrader's Brome-grass (= *B. unioloides*).

For Botanical description see p. 88.

This plant is grown to some extent upon dry soils on the Continent, and in dry climates such as Australia and elsewhere. It is a short-lived perennial and grows in distinct massive tufts. On soils which are rather poor and thin it is capable of giving good yields, but it should always be mixed with other drought resisting species as it does not cover the ground evenly by itself. If allowed to flower it becomes coarse but when regularly mown or grazed this objection disappears.

Good seed should have a *Purity* of from 95 to 100 per cent., and the *Germination* should reach about 90 per cent. in 20 days.

Cynosurus cristatus, L.

For Botanical description see p. 90.

Crested Dog's-tail is found throughout the whole of Europe and Asia except the extreme north. It thrives at high altitudes, and on a great variety of soils. It is abundant in Britain not only on dry hilly pastures and downs, but also on heavy clays. It withstands both cold and drought well, remaining green even in dry summers and throughout the winter months. Its development is rather slow but its permanence is quite reliable on the majority

of soils. Very little growth takes place during the first year after sowing, and full development is not attained until the third season. Its tufts are small and compact and most of the leaves are formed near the ground. It is therefore essentially a "bottom" grass capable of forming a compact turf and is especially suitable for permanent grazing land. It is also suitable for temporary pasture of four or more years' duration, as well as for garden lawns, cricket grounds, etc. Its nutritive value is said to be high, and it certainly forms a large percentage of the herbage in several of our most famous grazing districts and on many celebrated natural sheep pastures. Sometimes—owing to its ready production of seed—it tends to spread and occupy too large a proportion of the ground. In such cases it is advisable to graze heavily until the end of June so as to keep down the flowering culms while they are in a succulent condition. Its most rapid growth takes place about midsummer. As very little "top growth" is produced its contribution to a hay crop is small and it should be omitted from mixtures for meadow land.

Fig. 157. A tuft of Crested Dog's-tail. Note the short basal leaves and the numerous wiry culms.

Commercial Seed.

Most of the seed formerly came from the Continent—especially Holland. In recent years, however, the North of Ireland has become one of the main sources of our supply. It frequently contains numerous kinds of weed seeds, e.g. *Crepis virens*, *Holcus* sps., *Lapsana communis*, *Poa annua*, *Festuca Myurus*, *Sonchus*

arvensis and *S. oleraceus*, *Prunella vulgaris*, *Chrysanthemum leucanthemum*, *Aira caryophyllea*, etc. (see Figs. 43, 99, 114, 158 to 164, and 170). Most of these can be removed by modern machinery and samples containing more than one per cent. should be rejected.

Fig. 158 Fig. 159 Fig. 160

Common impurities in Crested Dog's-tail Seed.

Fig. 158. *Chrysanthemum leucanthemum*, L. Ox-eye Daisy.
Fig. 159. *Crepis virens*, L. Smooth Crepis.
Fig. 160. *Poa annua*, L. Each × 10.

Small seeds of Rye-grass and Cock's-foot, and seeds of Timothy, and Hard Fescue commonly occur as impurities.

Fig. 161. "Seeds" of the Common Sowthistle (*Sonchus oleraceus*, L.). × 6.

The chaff should not exceed one per cent. by weight, and the *Purity* should easily reach 97 to 99 per cent. The *Germination* of good seed will reach 50 to 60 per cent. in seven days, and 85 to 90 per cent. in 21 days. Sometimes 28 days are required to ascertain its full germination capacity.

Fig. 162. "Seeds" of the Prickly Sowthistle (*Sonchus asper*, Hoff.). ×6.

Fig. 163. "Seeds" of the Field Sowthistle (*Sonchus arvensis*, L.). ×6.

Dactylis glomerata, L.

For Botanical description see p. 93.

Cock's-foot is indigenous to the temperate parts of Europe and Asia and is abundant throughout Britain. It has been introduced into North America where it is known as "Orchard-grass." It will grow well on a great variety of soils and at high elevations.

Although it gives its greatest yields on good loams and clays it is one of the best plants for moderately poor and dry soils. Providing the soil is sufficiently deep to allow its roots to descend it can withstand long spells of drought.

When sown in the spring Cock's-foot developes fairly rapidly, usually giving a small or moderate yield in the first season, and attaining its full development by the second or third year.

Fig. 164. "Seeds" of Nipplewort (*Lapsana communis*, L.). ×6.

Fig. 165. "Seeds" of the Creeping Thistle (*Cnicus arvensis*). ×6.

When growing alone (unless sown very thickly) it forms large coarse tufts which do not cover the surface evenly, and for this reason it should always be grown with other species which mix well with it. It grows fairly early in the season and produces a large amount of both "top" and "bottom" growth.

Its rapid development, early and late growth, and large produce, combined with its drought resisting power, make it one of the most valuable of grasses for either permanent pasture or meadow. It is also very suitable for leys of two or more years' duration, and for alternate husbandry generally. All superficial objections to its

coarseness disappear when the plant is sown with others in suitable proportions, and when proper attention is given to grazing and mowing. When abundant in a meadow the crop should be cut by the time this plant is in flower. No other permanent grass after cutting yields a larger or more valuable aftermath.

Commercial Seed is imported into Britain from New Zealand, America, Denmark, Sweden, France, etc. where crops are specially grown for seed production. New Zealand and Danish seed is usually of the best quality, and the supply from these sources is increasing.

The most common weed impurities are *Bromus mollis*, *Holcus lanatus*, *Lapsana communis* and Docks (*Rumex crispus*, etc.). Other weed seeds to look for are *Plantago lanceolata*, *Anthemis arvensis*, *Ranunculus* sps. (see Figs. 72, 114, 151, 155, 164, and 166). Sometimes seeds of Rye-grasses, Tall Fescue, Meadow Fescue, etc. are present either as natural impurities, or possibly as adulterants.

Good samples contain not more than three to eight per cent. of chaff, and at least 90 per cent. of pure seed. Good seed will give a *Germination* of from 60 to 70 per cent. in seven days and 90 to 95 per cent. in from 15 to 21 days.

Festuca elatior, sub-sp. *arundinacea*, Hackel.

For Botanical description see p. 99.

Tall Fescue is indigenous to the temperate parts of Europe and Asia. It is commonly met with on tenacious clay soils and in wet marshy places. It forms much larger and more distinct tufts than Meadow Fescue; its leaves and stems are much longer and coarser, and it produces more "top growth." Its full development is reached by the fourth year after sowing. Although its produce is too coarse for it to be largely used under ordinary conditions its value becomes at once apparent on soils of the extreme types. It will thrive on poorly drained clays, fen lands, and other soils which are too wet for our superior grasses. At the same time its deeply penetrating roots enable it to withstand long spells of drought. Providing the soil is sufficiently deep to allow its roots to descend into it this plant will grow well even on light loose soils and remain fresh and green through the driest

summers. Under all such extreme conditions of soil and climate it may well be used as a constituent for permanent grass.

Commercial Seed.

The best agricultural type of Tall Fescue is grown from seed hitherto obtained from the Rhenish provinces of the Continent. The supply from this source is limited, and sometimes seed of the New Zealand Reed Fescue (*F. littoralis* Br.) is imported under the name of Tall Fescue. This plant is altogether unsuitable for cultivation owing to its extremely coarse reedy nature, and probably some of the objection which has been raised against Tall Fescue has been due to the use of this variety. The seeds of New Zealand Reed Fescue are larger and paler in colour than those of genuine Tall Fescue; the outer palea is distinctly 5-nerved, and is covered all over with microscopic hairs, while the rachilla and base of the "seed" are clothed with longer hairs.

The usual impurities found in seed of Tall Fescue are seeds of Cock's-foot (of equal value), chaffy material, and the sclerotia of Ergot (*Claviceps purpurea*). The last is the most serious impurity. *Bromus arvensis* and *Holcus* sps. also occur. The proportion of chaff is frequently high, sometimes reaching 10 or 20 per cent. or even more. Good samples will have a *Purity* of about 90 per cent. and contain not more than five to seven per cent. of chaff. The *Germination* of good seed should reach 60 to 70 per cent. in seven days, and 85 to 90 per cent. in twenty-one days.

Festuca elatior, L. sub-sp. *pratensis*, Hackel.

For Botanical description see p. 100.

Meadow Fescue is indigenous to the same geographical areas as Tall Fescue. It is common—though not abundant—in Britain, and has been introduced into North America. It is most usually found in moist pastures and meadows situated on good soils. Though it thrives best on clays and marls it will also succeed on calcareous and even sandy soils providing they are sufficiently moist. A good and regular supply of moisture is one of the chief conditions for its successful growth. It is much more resistant to cold than to drought.

The development of Meadow Fescue is rather slow, and a full yield is not obtained before the second or third year after sowing.

It forms fairly compact tufts and produces rather more "bottom" than "top" growth. On good soils a large yield of nutritious produce is obtained. For permanent grass on all moist fertile soils it should be included in the mixture, as well as for leys of three or more years' duration. It is suitable for irrigation and water-meadows. As the stems harden and lose much of their nutritive value soon after flowering it should be cut previous to this stage. Under favourable conditions a considerable aftermath is rapidly produced.

Commercial Seed.

Meadow Fescue seed is imported principally from North America and Denmark.

Fig. 166. Seed of *Plantago lanceolata*, L. Rib-grass.

Fig. 167. Seeds of *P. aristata*, Mx. Bracteate Plantain.

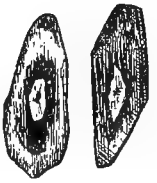


Fig. 168. Seeds of *P. Rugelii*, Dcne. Pale Plantain.

Each × 10.

Commercial samples were formerly often adulterated with seeds of Perennial Rye-grass, but this seldom happens now. The most common weed seed impurities are *Bromus arvensis*, *B. secalinus*, *Plantago aristata*, Mx., and *Polygonum Persicaria*, L. These seeds are harvested with those of Meadow Fescue and it is difficult to completely remove them. In well cleaned bulks only small amounts of these weeds will be found and the total impurities including broken seeds and stems should not exceed two per cent. Good seed gives a *Germination* of about 80 per cent. in four days and 90 to 95 per cent. in twelve days. New seed with a germination capacity of nearly 100 per cent. is frequently met with.

Festuca ovina, L.

For Botanical description see p. 101.

Sheep's Fescue and its varieties are indigenous to most of the temperate regions of the world. All the varieties are perennial. The common form, var. *vulgaris*, forms compact tufts and seldom grows more than a few inches high. It grows well at very high altitudes and in dry climates, and is one of the hardiest of our grasses. It is abundant in Britain, especially upon natural upland sheep pastures where it often forms the principal constituent of the herbage. Although its produce is small it is nutritious and sheep thrive where it abounds. Wherever the conditions are favourable the plant propagates itself by shedding its seeds and there is seldom any need for sowing it. The true seed is difficult to obtain commercially, and what little is procured is mainly used in the formation of lawns—a purpose for which this plant is very suitable. The variety *tenuifolia* has leaves which are extremely short and fine (bristle-like), and it is especially valuable for the production of lawns of the finest nature.

Commercial Seed.

Good samples of the above varieties should have a *Purity* of 80 to 90 per cent., and the pure seed should give a *Germination* of 70 to 80 per cent. in twenty-one days. The impurities usually consist in the main of chaffy material especially in the case of the fine-leaved variety.

The variety *duriuscula*—known as Hard Fescue—is the most useful form of *F. ovina* for permanent pasture. It is larger and more vigorous in growth than the ordinary type, and is a useful "bottom" grass on almost all kinds of soils. It withstands both cold and drought extremely well and thrives in exposed situations and at high altitudes. Under such conditions, and on poor dry soils, it should be freely used when forming grazing land. Its value for meadow land is comparatively small, and it should only be sown sparingly on fertile soils which will support more heavily yielding grasses. Its maximum development is attained by the second or third year after sowing.

Commercial Seed.

Hard Fescue seed is obtained chiefly from the Continent.

The weed impurities to be looked for are *Aira flexuosa*, *Festuca Myurus*, *Bromus mollis*, and *Rumex acetosella* (see Figs. 41, 72, 99 and 153). From three to eight per cent. of chaff usually remains even in well-dressed samples. The *Purity* should reach 90 to 95 per cent., and the pure seed give a *Germination* of 60 per cent. in seven days, and 80 to 90 per cent. in twenty-one days.

Very frequently the seed of Chewing's variety of Red Fescue is sold as Hard Fescue. The former is more easily produced and is considerably cheaper, but it is doubtful whether the plant is so hardy or permanent in Britain as genuine Hard Fescue.

Festuca rubra, L.

For Botanical description see p. 102.

Red Fescue and its varieties have a similar geographical range to Sheep's Fescue, and are also of perennial growth. The creeping variety (*genuina*, Hackel) forms loose tufts of herbage with its creeping rhizomes. It withstands cold, drought, and shade well, and thrives at high altitudes. It forms a good "bottom" grass on soils of the poorer description, especially on loose sands whether wet or dry. But it should never be sown for any agricultural purpose on good fertile soils. It becomes fully developed by the second year after sowing. Its creeping habit gives it some value as a sand-binder on railway slopes, etc. For lawns, golf-links, etc. on dry open soils it is an excellent constituent of the turf, wearing well, and adding a rich green colour.

Commercial Seed.

Genuine seed of Creeping Red Fescue is very difficult to obtain commercially. The kind almost always sold at the present day under the name of Red Fescue is the variety known as Chewing's New Zealand Fescue (see Fig. 108). This is the variety *fallax*, Hack., which is without creeping rhizomes. Although Chewing's variety is perennial, and has rich green foliage, it does not possess the special value of the creeping variety for the purposes indicated above. It is to be hoped that more attention will be given in the future to the production of seed of the creeping variety. The variety *heterophylla* is very similar in habit of growth, etc. to Chewing's Fescue and neither of them is of much agricultural value in Britain.

The *Purity* and *Germination* of good samples of Creeping Red Fescue should be similar to the figures given for Hard Fescue.

Seed of Chewing's Fescue should have a purity of 90 to 95 per cent. Chaff, and seeds of Perennial Rye-grass usually form the chief impurities. The weed seeds to be looked for are *Holcus* sps., *Hypochœris radicata* (Cat's-ear), and *Festuca Myurus* (see Figs. 99, 114 and 169). Its germination is extremely variable even with seed of good weight and appearance. The germination capacity often falls off to a serious extent in the course of a few months, even under good storage conditions. Good new seed should germinate 50 per cent. in seven days and about 90 per cent. in twenty-one days, but frequently the germination capacity is as low as 40 per cent. All samples should be tested before sowing.

Fig. 169. *Hypochœris radicata*, L. Cat's-ear. ×5.

Glyceria aquatica, Sm.

This large perennial grass is frequently found by the side of streams, on wet ground, etc. and is readily eaten by cattle. On land liable to floods, water-meadows and wet places generally it might be worth sowing. The seed could be easily produced by seedsmen, if there was a reasonable demand for it.

Lolium perenne, L.

For Botanical description see p. 113.

Perennial Rye-grass is indigenous to the temperate parts of Europe and Asia, and it has become naturalized in many other parts of the world. It is abundant all over Britain in pastures, meadows, and waste places. Although this plant will grow on almost any kind of soil it only really thrives on moist fertile land. Rich loams and clays are most suitable for it, and on these it forms a thick even turf, withstands drought well, and is quite permanent. On looser and drier soils it generally fails to form a compact turf and soon dies out. Its permanence thus varies very much with the nature of the soil and climate. Perennial Rye-grass developes very rapidly after sowing. When sown in the spring a good crop is obtained the first season, and its full yielding capacity is reached by the second year. The ground is

thus quickly covered with a thick growth of "bottom" grass. During the early part of the nineteenth century, and before the merits of other grasses were well understood, this plant was probably over-estimated in value. Moreover as it was the only grass of which seed could be readily obtained it was frequently the only one sown in conjunction with clovers for permanent pasture. This excessive use, and the fact that it rapidly died out on some soils, led to its being wholly condemned by some authorities as soon as the seed of other perennial grasses became available. It was said that it crowded out better plants, that it rapidly exhausted the soil, and that it was only a biennial, or short-lived perennial, and therefore wholly unsuitable for permanent pasture.

Subsequent experiments and observation have shown that this wholesale condemnation was without justification. That it makes very great demands upon the soil and requires liberal manurial treatment is perfectly true; but this is also true of most plants which develop rapidly and produce heavy and nutritious crops. This quick and reliable growth of perennial Rye-grass is in fact one of its most valuable characters. On stiff clays where the surface is wet in winter, and dry and hard in the summer, it is often difficult to get most useful grasses to establish themselves. Seedlings which are slow in growth get in a state of stagnation in winter on such land, whilst in hot weather they become scorched off especially when the surface cracks as is commonly the case. But when some perennial rye-grass is sown it grows so quickly that the surface becomes effectively covered and protected against the danger of cracking during the first season—one of the most critical periods. Used in moderation it does not crowd out other plants but actually protects them and favours their later development. In this way it makes the formation of grass land comparatively easy and certain even under rather unfavourable conditions. While the wholesale use of perennial Rye-grass is undoubtedly a wrong practice, and at the present time unnecessary, it is equally an error to omit it from mixtures for permanent grass altogether. For upon the soils most adapted for grass it is quite permanent, and taking all points into consideration it is perhaps unsurpassed as a pasture grass in Britain. In several of our best grazing districts it forms a large proportion of the herbage.

Even on soils upon which it will not persist it is worth while including a fair proportion of seed. Its rapid covering of the ground prevents the invasion of weeds, and gives profitable returns during the first year or two, after which its gradual disappearance makes way for the spread of the more slowly maturing plants. For temporary pastures, and leys of two or more years' duration it is most suitable. It is on the whole more adapted for grazing than meadow land, and withstands the treading of animals better than most other plants. For ordinary lawns where extreme fineness is not essential it answers well, especially if sown very thickly; but for this purpose it is always advisable to mix other finer growing grasses with it.

Commercial Seed.

Perennial Rye-grass was the first grass seed gathered separately for agricultural purposes, and it appears to have been sown in England nearly 300 years ago. Rich moist soils, e.g. fen soils, and fertile loams, are the most suitable for seed production. The first cutting is usually made into hay, and the second crop reserved for seed. The bulk of our seed is grown in the north-west of Ireland; smaller amounts are produced in the south of Scotland, and in the Fen districts of England. After being cleaned by the merchant it is generally graded according to its bushel weight. The common grades are 20, 22, 24, 26, and 28 pounds weight per bushel of seed. The heaviest grades are often sold under the name of Pacey's Rye-grass. Sometimes the smaller heavy seeds are taken out and sold as "Small Seeded Perennial," or as "dwarf" perennial Rye-grass. These are however merely distinctive trade terms and do not represent any essential difference of variety.

The proportion of chaff present varies of course with the bushel weight. Seed weighing 28 pounds per bushel is practically free, while 20-pound seed usually contains about 10 to 15 per cent. of chaff, the other grades having intermediate amounts.

The common weed impurities are *Holcus* sps., *Bromus mollis*, *Festuca Myurus*, *Ranunculus* sps., and *Plantago lanceolata*. Yorkshire Fog is often especially abundant when the bushel weight is low. Seeds of Hard Fescue and *Trifolium minus* are also common impurities (see Figs. 72, 99, 114, 155 and 166).

Good seed should weigh at least 24 pounds per bushel, and have a *Purity* of 96 to 99 per cent. The pure seed should germinate 70 to 80 per cent. in four days, and from 90 to 96 per cent. in 14 days.

Lolium italicum, Alex. Br.

For Botanical description see p. 115.

Italian Rye-grass is not found growing in the wild state, but appears to have originated in Lombardy as a cultivated variety of perennial Rye-grass. Since 1830 its cultivation has spread throughout the whole of Europe. Although of South European origin it withstands cold well, and no other grass developes so rapidly in our northern climate. When sown in the spring it attains its maximum growth in the same year, but generally dies off after the second season. When however the conditions are favourable it only dies out gradually, and it may continue to occupy the same ground for several years if it is allowed to shed some seed. Its rapid and heavy production make very great demands upon the soil, and its full capabilities can only be realised on soils which are rich, deep, and moist. It thrives well on black fen lands, and on clays which are not too stiff. On poor dry soils its yield falls off to insignificant proportions. Italian Rye-grass grows in compact erect tufts and does not spread well over the surface of the ground. It grows up with great rapidity after cutting and is on the whole less suitable for grazing than for mowing. It is probably the best of all grasses for irrigation on good warm soils, and on sewage farms enormous yields are obtained. Under such liberal treatment several cuttings may be taken during one season. It is however in alternate husbandry that this plant is of the greatest service. For leys of one or two years' duration it can either be sown alone, or along with Red Clover or other quickly-maturing plants. For this purpose it is superior to perennial Rye-grass not only on account of its higher yield, but also because of its greater nutritive value. For leys of more than two years' duration it must be sown less freely, and other more permanent plants should be given a due place. But even for permanent grass this plant may with advantage be sown sparingly (3 to 4 pounds per acre) in order to ensure a rapid soil covering. If

thus used in moderation it in no way prevents the proper development of the more permanent plants, but rather indirectly favours their growth.

A variety known as Westernwolths Grass (*L. woldicum*) originating from Holland is now being grown in this country. It differs from ordinary Italian Rye-grass in its strictly annual growth. When sown in the spring on good land and liberally dressed with soluble artificial manures heavy crops may be cut the same year. It is also useful for renovating patchy clover leys. Its seed is indistinguishable from that of Italian Rye-grass, though it frequently contains distinctive impurities.

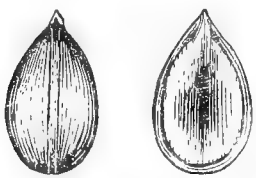


Fig. 170. *Prunella vulgaris*, L. (Self-heal.) Two views.

Fig. 171. *Myosotis arvensis*, Hoff. (Common Forget-me-not.)

Fig. 172. *Sherardia arvensis*, L. (Field Madder.)

Each × 10.

Commercial Seed.

Italian Rye-grass seed is obtained mainly from France and the north of Ireland. French seed as imported almost always contains many weed seeds, and unless thoroughly re-cleaned is therefore unfit for sowing. It usually possesses a higher germination energy than Irish seed, and has also been supposed to produce plants which mature earlier. There is probably however little to choose between the resulting plants as regards earliness or productiveness. Like perennial rye-grass the seed is graded according to its bushel weight, and the usual grades offered on the market weigh 16, 18, 20, and 22 or 23 pounds per bushel.

Seed of the last-mentioned weight is quite free from chaff, while 16-pound seed will contain from 15 to 20 per cent.

The impurities to be looked for are the same as those mentioned under perennial Rye-grass. In French seed the following also

are frequent: Ox-eye Daisy (*Chrysanthemum leucanthemum*, L.), Forget-me-not (*Myosotis arvensis*, Hoff., etc.), Nipplewort (*Lapsana communis*, L.), Black Medick (*Medicago lupulina*, L.), and Field Madder (*Sherardia arvensis*) (see Figs. 158, 164, 171 and 172). Good seed should have a bushel weight of at least 20 pounds and the *Purity* and *Germination* should be equal to the figures given for perennial Rye-grass.

Phleum pratense, L.

For Botanical description see p. 121.

Timothy or Cat's-tail grass is indigenous to most of Europe and temperate Asia; also to parts of Northern Africa and to North America. It is common all over Britain especially on moist soils. It is a hardy species, resists cold well, and succeeds at high elevations; but it thrives best at low levels and on moist loams and clays. On wet, marshy or peaty land it often grows with extraordinary luxuriance but is then rather coarse. When properly established Timothy withstands drought moderately well, but it is quite unsuitable for sandy soils and dry land generally. In the United States of America it is very largely grown by itself for hay, and it is said to have been introduced from that country into England as an agricultural crop by an agriculturist named Timothy Hansen, about the middle of the eighteenth century.

Its development from seed is rapid and under suitable conditions the maximum yield is reached by the second year. It is not however a long-lived perennial and frequently tends to die out after the third or fourth season. Rather loose tufts are formed which do not cover the ground well by themselves, and it produces quite as much "top" as "bottom" growth.

It is perhaps more adapted for hay than for grazing, but for the former purpose it should always be cut before the flowering stage is reached. If not cut until after flowering its produce becomes very hard and fibrous (especially the stems) and unsuitable as food for cattle. Timothy is a late-growing grass, the bulk of the crop being formed after midsummer, but it produces a large yield of heavy hay of high nutritive quality. The amount of aftermath is relatively small, especially if the first crop is cut late.

For the formation of permanent grass, or for leys of two or

more years' duration Timothy may always be sown with advantage on clays and other good moist soils.

Commercial Seed.

Timothy-grass readily produces large quantities of seed and it is (per million seeds) the cheapest of all grass seeds. Most of our seed is imported from North America, but some of it is produced on the Continent and also in Scotland. It may easily be obtained quite free from impurities, but some samples contain such weeds

Fig. 173. "Seed" of *Hieracium Pilosella*, L. Mouse-ear Hawkweed (with the pappus shortened).

Fig. 174. *Potentilla monspeliensis*, L. Upright cinquefoil.

Fig. 175. *Luzula campestris*, Br. Field Woodrush.

Each × 10.

as *Plantago Rugelii*, Dcne., *P. major*, L., *Prunella vulgaris*, L., *Rumex* sps. (Docks), *Potentilla monspeliensis*, and *Lepidium apetalum*, etc. Alsike and White Clovers, Crested Dog's-tail, *Agrostis* sps. and *Poa* sps. also are commonly present (see Figs. 151 to 154, 168, 170 and 174).

The *Purity* should reach at least 97 to 99 per cent., and the *Germination* 70 to 80 per cent. in four days and 90 to 96 per cent. in ten days.

Poa annua, L.

For Botanical description see p. 122.

Annual Meadow-grass is most abundant in the temperate parts of the northern hemisphere but is also indigenous to many other parts of the world. It is very common in Britain. It is of little value to the farmer on account of its small produce and short length of life. Occasionally it is found as a constituent of pastures and when constantly grazed and prevented from flowering it tends to become more permanent. It is possible to form lawns

of a very fine character and of a pleasing green colour from a pure seeding of this plant though the turf will not stand hard wear. For this purpose the soil must be in a fine condition and the seed thickly sown. The seed is not usually to be bought on the market, but sufficient for this purpose may be gathered by hand. When used for a lawn the plants must be prevented from seeding by the constant use of the mower.

Poa nemoralis, L.

For Botanical description see p. 125.

Wood Meadow-grass is indigenous to most of Europe and the temperate parts of Asia. It is frequent in Britain in woods and moist shady places on all kinds of soil. It is a perennial, and produces a considerable amount of "bottom" growth on good soils. On this account it might be more frequently included in mixtures for permanent grass if the seed could be more easily obtained. The seed is however expensive, and it is therefore only commonly used with other grasses for lawns and ornamental grounds. As the leaf-blades are narrow and of a rich green colour it is admirably adapted for this purpose, especially where there is much shade.

Commercial Seed. Owing to its high cost the seed is liable to adulteration. Sometimes the cheaper seeds of *Poa pratensis* or other species of Poas are mixed with it, and occasionally *Poa flava*, L. (Foul Meadow-grass) from North America has been entirely substituted for it. The usual weed impurities present are *Aira cæspitosa*, *A. flexuosa*, *Hieracium Pilosella* and *Luzula* sps. (see Figs. 40, 41, 173 and 175). Of cultivated plants the seeds of Hard Fescue, Fine-leaved Fescue and Cock's-foot occur.

In properly cleaned samples there should not be more than five to ten per cent. of chaff, or more than one per cent. of weed seeds. The *Germination* should reach 40 to 50 per cent. in seven days, and 70 to 85 per cent. in 28 days.

Poa pratensis, L.

For Botanical description see p. 127.

Smooth-stalked Meadow-grass is indigenous to the whole of Europe and Northern Asia. It forms a large proportion of the herbage on the prairies of North America, and is also largely

cultivated there under the name of Kentucky Blue-grass. It is also found in Australia and other parts of the southern hemisphere. It is abundant in Britain in meadows, pastures, on roadsides, etc. Its numerous and widely-creeping rhizomes enable it to withstand extremes of heat and cold better than most other useful grasses, and this fact no doubt partly accounts for its wide distribution.

Poa pratensis thrives better upon soils which possess a loose texture than upon those which are heavy and compact. Its development from seed is slow, and in the first year only small tufts of herbage are formed. During the second season the underground rhizomes spread considerably and its maximum growth is attained by the third year. When this stage is reached it is capable of covering the ground fairly evenly with a fine growth of "bottom" grass.

This plant can be most usefully used as a constituent of permanent pasture on soils which are loose or light, and of only medium quality. Its growth commences early in the spring especially upon warm dry soils. As a meadow plant it is less valuable and its aftermath is small. On more fertile and moister soils *Poa trivialis* is much to be preferred for either pasture or meadow. Its nutritive value appears to be below that of most pasture grasses. For alternate husbandry it is unsuitable owing to its slow development and creeping habit.

Poa pratensis can be usefully employed as a constituent of the turf for lawns, especially for those on dry soils, or which are required to "wear" well under hard usage.

Commercial Seed.

The seed is obtained mostly from North America, and owing to its relative cheapness it is seldom adulterated. In some years when it is scarce the seeds of the closely allied *Poa compressa*, L. (Flat-stemmed Poa or Canadian Blue-grass) are either mixed with it or wholly substituted. Compare Figs. 138 and 142.

The proportion of chaff sometimes reaches 20 per cent. or more, but in well-cleaned samples it should not exceed five to seven per cent. The usual weed impurities are various Sedges (*Carex* sps.), Mouse-eared Chickweed (*Cerastium vulgatum*, L.), Shepherd's Purse (*Capsella Bursa-pastoris*, L.) and Sheep's Sorrel.

The *Purity* should not be less than 90 per cent.

Both the germination and the germination energy are very variable and usually fall off very rapidly after one or two seasons. A *Germination* of 30 per cent. in seven days, of 50 per cent. in fourteen, and of 70 to 80 per cent. in twenty-eight days is very good. The seed germinates much better in light than in darkness, and it should therefore be simply rolled in on a fine firm surface rather than covered with soil.

Poa trivialis, L.

For Botanical description see p. 129.

Rough-stalked Meadow-grass is indigenous to most of Europe and Northern Asia, and has been introduced into America. It is abundant in Britain in pastures and meadows on all good soils. It withstands cold moderately well and can grow at high elevations. It grows most luxuriantly where the climate and soil are moist, e.g. in the west of Britain, upon wet clays, deep fen soils, etc. In dry situations or in seasons of drought the plants become much dwarfed, and the foliage turns red. This happens because the thin creeping stolons are very shallow rooted, and the plant is dependent upon surface moisture for its growth. As soon as rain falls however it is capable of rapid recovery from the effects of drought.

The development of this species is more rapid than that of *Poa pratensis*. Under favourable conditions it gives its maximum yield by the second season. Owing to its extensively branching stolons it is capable of producing a dense mat-like covering of bottom herbage which effectively fills in the spaces between other plants. This habit of growth aids in the conservation of surface moisture, and also prevents the establishment of weeds. For these reasons it is worth while including some seed in all mixtures for permanent grass upon all but very dry soils. But it should be most largely used for permanent pasture or meadow in wet districts and upon moist soils. In favourable situations it produces a considerable bulk of "top" grass which makes hay of the finest quality, though the aftermath is not usually large.

Poa trivialis may also be sown for temporary pastures and leys of three or more years' duration. It succeeds well in shady places,

and grows to perfection in water meadows, and under irrigation. Its nutritive value is high and no kind of grass is more readily eaten by cattle. It forms a most valuable constituent for the turf of ordinary lawns, but it will not withstand hard wear.

Commercial Seed.

Rough-stalked Meadow-grass seed is imported chiefly from Denmark.

Adulteration is now rarely attempted though other Poas may occasionally be mixed with it. Well-cleaned seed should not contain more than five to seven per cent. of chaff, or one per cent. of foreign seeds. The usual weed impurities are: *Holcus* sps. and *Alopecurus geniculatus*, L. (Floating Foxtail-grass). (Figs. 50 and 114.) The *Purity* should reach at least 90 per cent., and the *Germination* 60 to 70 per cent. in seven days, and 85 to 95 per cent. in twenty-one days.

CHAPTER IX

THE VALUATION AND PURCHASE OF GRASS SEEDS

In the purchase and use of grass seeds special care is necessary, not only because they are generally expensive, but more especially because different samples of the same species are extremely variable in composition and vitality. Yet in many cases low-grade samples cannot be readily distinguished from high-class seed by a mere casual examination. A brief account of the method of determining the value of samples will therefore be useful to all purchasers.

The *value of any sample of seed* may be ascertained by an examination of the following points:

1. Its *Genuineness*, i.e. trueness as to the variety required.
2. Its *Purity*, i.e. the percentage of pure seed in the sample, and the nature of the impurities present.
3. The *Germination Capacity* of the pure seed.
4. The *Germination Energy*, or rate of germination, and to a less extent by—
5. The *Absolute Weight* of a given number of seeds, and
6. The *Volume Weight*, e.g. Weight per bushel.

1. **Genuineness.** Cases of entire substitution of an inferior or lower-priced species do not as a rule occur at the present time. Nevertheless whenever the supply of seed of a particular species falls short of the demand, as is frequently the case, there is always the liability of an inferior allied species being substituted for the required article.

Thus *Poa compressa* may be sold as *Poa pratensis*, or *Poa flava* as *Poa nemoralis*, etc. In all cases of doubt some of the seed should be sent to a reputable seed-testing station.

2. **Purity.** All foreign matter present may be grouped under two heads: (*a*) *adulterants*, and (*b*) *impurities*.

By the term *adulterant* is meant any ingredient which has been intentionally mixed with the pure seed. Seed which is scarce or high-priced is more liable to adulteration than cheap seed, e.g. *Aira flexuosa* may be introduced into bulks of *Avena flavescens*, or *Poa pratensis* into *Poa nemoralis*, etc. Again, a cheaper and heavier seed may be introduced to increase the bushel weight of another species. On the whole however it must be said in fairness to the seed trade that wilful adulteration is a thing of the past, and the above points are only mentioned here that purchasers may be prepared for any isolated case of ignorance or fraud with which they may be troubled.

Impurities are ingredients which either occur naturally, or get into the pure seed more or less by accident, and in many cases cannot be entirely separated from it. They consist of:

(*a*) *Chaffy material, sand, earth, etc.*

(*b*) *Seed of other cultivated plants.*

(*c*) *Weed seed.*

It is of importance to note that *the value of a sample is often more affected by the nature of the impurities than by their actual proportion in the sample*[1]. A mere statement that a sample contains say 90 per cent. of pure seed is of little value apart from a knowledge of what the impurities consist. A certain proportion of chaff is almost always present, and as a matter of fact this must be the case with certain species in which some of the chaff is adherent to the well-filled seeds, e.g. in Cock's-foot. Such non-living impurities only reduce the value of a sample by replacing

[1] See Bibliography, No. 2.

so much of the pure seed. The presence of seeds of other cultivated plants may or may not reduce the value of a sample, but *the presence of weed seeds, especially of noxious kinds, is always objectionable.* The presence of even small proportions by weight of weed seed should not be ignored, because the actual number represented may be enormous. The following list taken at random will make this clear.

The presence of one per cent. by weight of:	Represents approx. per lb.
Yorkshire Fog (*Holcus lanatus*, L.) (in glumes)	... 9,000 seeds
„ „ „ „ „ (without glumes)	... 13,000 „
Ox-eye Daisy (*Chrysanthemum leucanthemum*, L.)	... 11,000 „
Chickweed (*Stellaria media*, Cyrill.)	... 12,000 „
Mouse-ear Chickweed (*Cerastium vulgatum*, L.)	... 35,000 „
Docks (*Rumex* sp.)...	... 3,000 „
Sheep's Sorrel (*Rumex acetosella*, L.)	... 10,000 „
Creeping Buttercup (*Ranunculus repens*, L.) ...	... 3,000 „
Slender Foxtail (*Alopecurus agrestis*, L.) ...	... 2,500 „
Wavy Hair-grass (*Aira flexuosa*, L.)	... 8,000 „
Tussock Grass (*Aira cæspitosa*, L.)	... 25,000 „

This short list will serve to show that only one per cent. of weed seed in a sample may produce serious results for the purchaser. For example, if we assume that a mixture of grass seeds contains the above weeds in equal proportions, *but not exceeding one per cent. by weight of the entire bulk*, then each pound of the mixture will contain about 12,000 weed seeds. Since something like 30 pounds of grass seed per acre is usually sown for permanent pasture it follows that such a mixture would introduce some 360,000 weed seeds to the same area, i.e. nearly 80 to each square yard.

A reference to Chap. VIII will show what are the usual impurities to look for in any kind of seed, and also what percentage of pure seed may be reasonably expected in each case. By means of the illustrations of weed impurities given on pages 137, 144–146, 149, 156 and 158, and by reference to the descriptions of grass seeds given in Chaps. VI and VII, most of the harmful impurities may be identified.

3. **Germination.** Even when a sample is reasonably pure the vitality of the seed may for various reasons be low. For instance, the seed may be imperfectly or irregularly matured, it

may have suffered from exposure during harvesting or through faulty storage. Or again it may have been kept over for one or more seasons and so have lost some of its original germinating power. At the same time the difference in colour and general appearance between such seed and that which is practically perfect may be so slight, that only those accustomed to constantly handling seeds might have any suspicion about it. It is therefore of the highest importance to have the germination tested.

At properly equipped seed-testing stations the germination of the pure seed is usually determined on four lots of 100 seeds each in suitable germinating dishes, placed either in a greenhouse or specially ventilated incubator, and under suitable conditions as regards temperature and moisture supply. A temperature of about 20° C. is most suitable for the Rye-grasses, Oat-grasses, Meadow Foxtail, and Timothy. For the Fescues, Cock's-foot, Crested Dog's-tail and most other common species a temperature of from 20°–23° C. gives the best results. Such tests should extend over a period of 14 days for Rye-grasses and Timothy; for 28 days in the case of *Poa pratensis*, *Poa nemoralis*, and *Agrostis* sps.; and for 21 days for most other kinds. It should be understood, however, that the tests in the case of good samples may often be concluded in somewhat less than the times here given. The germination to be expected of good samples under the above conditions is stated in Chap. VIII.

4. **Germination Speed or Energy** is the rate at which the pure seed germinates. Rapid, vigorous germination indicates new, well-matured, healthy seed, while a slow germination is typical of the reverse conditions. To indicate the relative vigour or energy of a sample it is customary to give the percentage of growth made in about one-fourth the time allowed for a full test. For Timothy three days should be allowed; for Rye-grasses, Meadow Fescue, and Tall Oat-grass four or five days; and for most other grasses seven days.

5. **Absolute Weight and Bushel Weight.** When grass seeds are very thoroughly cleaned not only are most of the weed impurities and chaffy materials removed, but also a large proportion of the half-filled and immature seeds are taken out. A thousand pure seeds of such a sample will weigh more than a thousand taken

from a less thoroughly cleaned sample. This test of absolute weight is therefore an indication of quality. In the same way the bushel weight indicates roughly the extent to which the chaff and light seeds have been removed. The bushel weights of good samples are given for each species in Table II, p. 175.

Real Value. Provided a sample is free from noxious weed seeds its "*real value*" or "*cultural value*" for practical purposes may be said to depend upon the proportion of pure and germinating seed it contains. Thus the "*real value*"

$$= \frac{Purity \times Germination}{100},$$

which gives the percentage of pure and germinating seed present. For example, a sample of Cock's-foot seed having a purity of 90 per cent., and a germination capacity of 85 per cent. will—if the growth is normal—have a "real value" of $\frac{90 \times 85}{100} = 76{\cdot}5$ R.V.

By employing such a method as this, samples which possess different values for purity and germination may be compared upon a common basis with one another. The "real value" figure reveals the amount of useful seed present in a given bulk, which is a very important point when making up seed mixtures. Thus in the above example of Cock's-foot seed, each 100 pounds of the bulk contains only 76·5 pounds of useful seed.

Comparison of Seed Prices.

The "real value" also shows what the relative cost of any sample should be. If we know that Cock's-foot seed with a "real value" of 90 per cent. can be purchased at 1*s.* 2*d.* per pound the cost of the 76·5 seed should not be more than $\frac{14 \times 76{\cdot}5}{90} = 11{\cdot}9d.$, say 1*s.* per pound.

It should always be borne in mind that the actual price of seed is determined, not by the value of the plant to the farmer, but by (*a*) the cost of its production, and (*b*) cost of cleaning; and also by (*c*) the relation of supply and demand, i.e. the condition of the market. Since the prices fluctuate considerably no useful purpose would be served by quoting prices here. The latest price lists of merchants should be consulted.

It may be pointed out however that the only sound basis for comparing the cost of the seed of different species is to calculate the cost of a given number—say one million—of pure and germinating seeds of each kind. This is so because of the widely different numbers of seeds weighing one pound in the case of different species, and also because of the varying quality of samples. For high-class samples of good bushel weight the price per million germinating seeds may be found as follows:

$$\frac{[1]\textit{Total No. of seeds per pound} \times \textit{Real Value}}{100}$$

$$= \textit{Number of pure and germinating seeds per pound}$$

and

$$\frac{\textit{Price per pound (in pence)}}{\textit{Millions of pure and germinating seeds per pound}}$$

gives the cost per million germinating seeds.

For example, a sample of Meadow Foxtail seed having a "real value" of 80 per cent. costs say 1*s.* 6*d.* per pound. The number of pure and germinating seeds per pound will be

$$\frac{[1]500{,}000 \times 80}{100} = 400{,}000$$

and the cost per million germinating seeds will be

$$\frac{18 \text{ (pence)}}{0{\cdot}4 \text{ million}} = 45 \text{ pence or } 3s.\ 9d.$$

The following are useful rules for seed purchasers:

1. Buy each species required in a separate parcel.
2. *Purchase by weight*—not by measure—even if the bushel weight is given.
3. Insist upon a guarantee as to genuineness, purity, and germination from the seedsman.
4. Submit carefully drawn samples to a recognised botanist, or better still to a properly equipped seed-testing station, for a report upon the "real value."
5. Take special notice of the nature of the impurities present. If they consist of such land-fouling weeds as Wild Carrot, Docks, Thistles, Yorkshire Fog, Slender Foxtail, etc. even to the extent of one per cent. it is unwise to sow the seed.

[1] The approximate total number of seeds per pound in samples of good quality is given in Table I, page 174.

6. Avoid generally all seeds of low quality, since they are almost invariably higher priced *per their "real value"* than the best samples.

Pedigree of Seeds.

The foregoing remarks are concerned with the quality of the seeds themselves and *do not take their pedigree into consideration.*

The question of pedigree in forage plants has not yet received the attention it deserves, but it is undoubtedly as important as in the case of most other farm crops. It would probably be possible to obtain "*pure lines*" of each species which would excel present mixed stocks in such important points as yield, nutritive quality, earliness, durability, etc. The seed of such stocks would of course have a correspondingly higher value.

It is also highly desirable that *pure stocks of our native British grasses* should be raised, and it may here be noted that a beginning in this direction has already been made by the Plant Breeding Institute at Cambridge. At present the great bulk of our grass seeds are produced elsewhere than in the United Kingdom, and it is very questionable whether seed from these exotic sources produces plants which are as hardy, permanent, and otherwise valuable in our climate as the truly indigenous plants would be.

CHAPTER X

THE SPECIFICATION AND COMPOUNDING OF GRASS SEED-MIXTURES

Although a few grasses which mature rapidly, such as Italian Rye-grass, may be profitably grown by themselves, it is generally found more serviceable to sow several species together in a mixture with clovers and other plants. This is especially so when land is being laid down for a long ley or to permanent grass. *The advantages of growing such a combination of species are many*, the most important of which are as follows.

(1) Rapidly maturing species can be sown with those permanent kinds which are naturally slow of development. In this way the ground can be quickly covered, weeds largely excluded, and crops secured from the first; whilst the permanent sorts gradually come forward and occupy the place of the short-lived kinds as the latter die out. (See Diagram on p. 170.)

(2) Generally speaking, the larger the variety of plants associated, the greater the number of individuals that can grow on a given area. Tall and low-growing plants, tufted and creeping forms, can be associated with advantage as regards yield, etc., and the surface can be more evenly and densely covered by a mixed vegetation.

(3) Species which vegetate early can be associated with those which are more prominent at later periods of the season.

(4) Leguminous plants—on account of the nitrogen fixing bacteria contained in their root-nodules—can be associated with grasses to the great advantage of the latter.

(5) A mixed vegetation gives more regular and certain crops than a simpler type. In abnormal seasons, though some of the species may suffer others will probably be favoured.

The making up of such mixtures is a matter which requires a considerable amount of experience and care. Probably on no other subject directly connected with practical farming has such widely differing views been held. This has been so—partly because of the lack of carefully conducted experiments, and partly because of the almost infinite variety of soils and climatic conditions, to say nothing of other variable factors. By some it has been held that the selection of species for the formation of grass land is almost a matter of indifference since the soil and after treatment will ultimately determine the character of the turf produced; whilst others have advocated a rigid selection of species for each geological formation, and in strictly definite proportions, as if the ultimate results could be secured by careful calculations beforehand.

Whilst such slavish adherence to a particular mixture for a given type of soil is quite unnecessary, it is equally foolish to be indifferent in the choice of species to meet a given set of circumstances. Our object is to obtain a much larger yield of more valuable produce than would be obtained if nature were left to

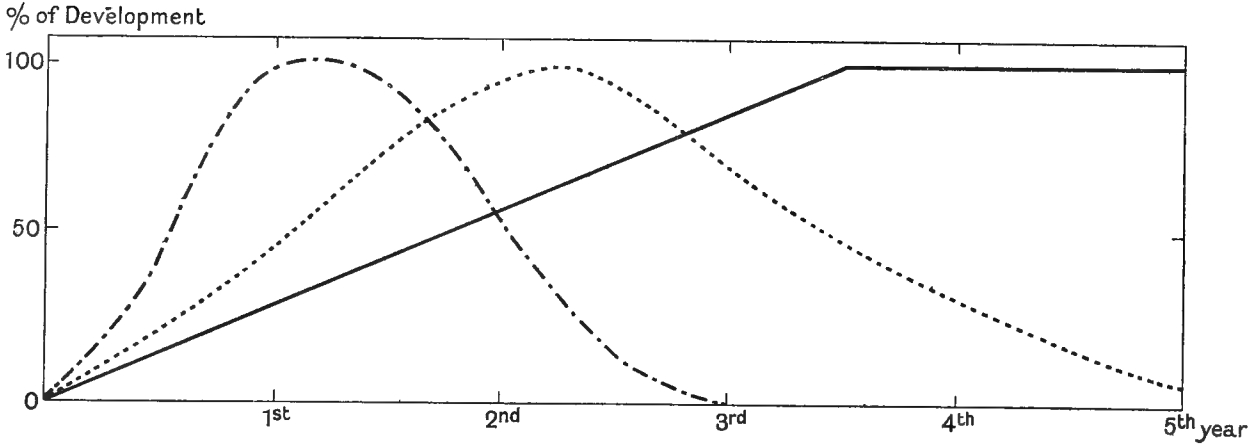


Diagram showing the relative positions occupied by different types of plants during the early stages of the formation of grass land from a seeds-mixture.

The approximate rate of development and of disappearance of the biennial species such as Italian Rye-grass, Red Clover, etc. is shown thus — — — —; and of the short-lived perennials, e.g. Timothy, Tall Oat-grass, Alsike, etc. thus - - - - - -.

The gradual development of the more permanent species like Meadow Foxtail, Rough-stalked Meadow-grass, etc. is indicated by the thick black line.

The endemic (native) species usually begin to compete with the sown plants and to invade the area more or less successfully before the end of the second season. The specially critical period is from the end of the second to the end of the fourth year, that is, before the permanent plants have fully established themselves.

itself, but experience shows that this is most readily accomplished when we work in harmony with the natural conditions by which we are faced.

The most critical period in the life of a pasture is generally from the second to the fifth year after sowing. One reason for this is that the initial fertility of the soil has become more or less depleted by that time. Another cause is the gradual dying out or even total disappearance of some of the short-lived species sown. Moreover the truly perennial species which remain have to meet with keen competition from the in-coming indigenous species of the neighbourhood[1].

It should be remembered that different localities and varying elevations possess distinct climatic conditions, and associated with these conditions are specialised forms of indigenous plants. These plants, e.g. grasses, are those varieties or biologic forms which are most adapted to their special habitat, and have therefore proved most successful in the struggle for existence. Native grasses like Fiorin, Crested Dog's-tail, Sweet Vernal-grass, and the various forms of Sheep's Fescue, etc. commonly compete very successfully with their commercial counterparts (*generally the product of foreign-grown seeds*) and so gradually take possession of the ground from the second year onwards until a certain semi-natural stable condition has been reached. It is therefore probably true that when land is sown down to permanent grass the proportions of the species in the original mixture sown and in the resulting turf ten years later are very seldom anything like the same.

This modification of the turf generally occurs most rapidly on soils of the extreme types (very dry or wet) and at high elevations.

On all fertile soils at low elevations in this country the in-coming indigenous species will—under good farming conditions—be of the better and more useful kinds.

Whilst the foregoing facts do not constitute a sufficient reason against the sowing of suitably selected mixtures of seeds, it is obvious that *they form the strongest possible argument in favour of the production and propagation of races of our own native grasses.* Until this is done it cannot be maintained that we are dealing with the problem of grass production on really scientific lines.

[1] See Bibliography, No. 28.

Specification of Seed-Mixtures.

In the description of each plant given in Chap. VIII we have seen that each species possesses certain characters of its own which give it some special use or value to the agriculturist. It is by utilising these characters under circumstances which most favour their development, and where they are most needed, that the greatest return is obtained from each kind. If these points are carefully considered, the farmer will be able himself to decide what kind of mixture will be most likely to meet his requirements, instead of leaving so important a matter to be settled by the seedsman or some other person who is less able to understand the special local conditions to be met.

To answer the question *Which species shall be sown?* we should consider:

(1) *The character of the Soil and Climate.*

While no special attention need be paid to geological formations, it is of the greatest importance to observe the physical nature of the soil; whether it is "light" and porous in texture, or stiff, compact, moist or wet. Also whether it is calcareous or peaty. For practical purposes these are the only distinctions of soils which need be made. The general character of the climate also should be noted, whether wet, humid, or dry. It may here be said that "light" dry soils and dry climates are not naturally adapted for the production of good crops of grass and therefore present the greatest difficulties.

(2) *The purpose for which the mixture is required.*

For leys of only one year's duration it is obvious that only annual or biennial plants can be profitably sown.

For leys of from two to four years' duration the following grasses (with clovers) may be employed: Rye-grasses, Timothy, Tall Oat-grass, Cock's-foot, and to a less extent Meadow Fescue.

For leys or temporary pastures of more than four years' duration the proportion of short-lived plants should be gradually reduced, until in the case of permanent grass fully 60 per cent. of the area should be allotted to permanent plants.

If grass land is being formed for mowing only, it is desirable that tall-growing plants should predominate, but both "bottom"

and "top" grasses should always be represented. In practice very little difference can be made between mixtures for meadow and pasture land, as it is of far more importance to consider soil conditions first. Under constant grazing the low-growing species such as Perennial Rye-grass, Crested Dog's-tail, White Clover, etc. are most encouraged; whilst constant mowing favours the taller plants such as Tall Oat-grass, Cock's-foot, Meadow Foxtail, etc.

In all permanent grass mixtures each of the following class of plants should be represented:

(*a*) *Nitrogen accumulators*, i.e. Leguminous plants.
(*b*) *Rapid soil coverers*, e.g. Italian and Perennial Rye-grass.
(*c*) *Short-lived perennials*, e.g. Timothy, Tall Oat, etc.
(*d*) *Permanent species*, e.g. Meadow Foxtail, Cock's-foot, etc.
(*e*) *Bottom growing plants*, e.g. Poas, Dog's-tail, etc.
(*f*) *Early and late maturing species.*

Having selected the species, the next question that arises is *How much seed is it necessary to sow* to secure good results at reasonable outlay?

The determination of the number of seeds required to sow an acre is complicated in many ways as it varies so largely with the soil, climate, etc. On some of the finest old English pastures it has been calculated that there are at least twenty million plant rootings per acre, and on new pastures where the turf is comparatively thin there are frequently ten or twelve million plants per acre. Looking at the matter theoretically it may be presumed that one plant per square inch (6,272,640 per acre, a large proportion of which would form several distinct rootings) would be sufficient to form a thick turf. Owing to adverse conditions, however, the death-rate of seedlings is generally so high that in practice it is often necessary to sow at least three times this number of germinating seeds for permanent grass.

Compounding of Mixtures.

In Table I will be found the minimum, maximum, and average number of seeds per pound of the different species, and in Table II the weight and number of seeds necessary to sow one acre of land under favourable conditions.

TABLE I. *Grass Seed Statistics.*

Species	Number of seeds per lb.			Average number of seeds per gramme	Average weight of 1000 seeds, grammes
	Highest[1]	Lowest[1]	*Average*		
Perennial Rye-grass ...	265,000	200,000	237,000	522	1·916
Italian Rye-grass ...	250,000	200,000	228,000	502	1·992
Timothy	1,200,000	910,000	1,070,000	2,357	0·424
Tall Oat-grass	157,000	110,000	130,000	286	3·491
Golden Oat-grass ...	1,520,000	1,140,000	1,300,000	2,863	0·346
Cock's-foot	562,000	330,000	460,000	1,013	0·986
Tall Fescue	261,000	176,000	220,000	485	2·062
Meadow Fescue ...	298,000	220,000	263,000	579	1·727
Hard Fescue	535,000	467,000	500,000	1,101	0·908
Chewing's Fescue ...	—	—	450,000	990	1·010
Fine-leaved Fescue ...	—	—	1,170,000	2,577	0·388
Crested Dog's-tail ...	810,000	717,000	761,000	1,677	0·596
Meadow Foxtail ...	530,000	300,000	460,000	1,013	0·986
Fiorin	—	—	5,000,000	11,000	0·090
Sweet Vernal-grass ...	—	—	800,000	1,762	0·567
Rough-stalked Meadow-grass	—	—	2,300,000	5,066	0·197
Smooth-stalked Meadow-grass	—	—	2,130,000	4,692	0·213
Wood Meadow-grass ...	—	—	2,300,000	5,066	0·197
Awnless Brome-grass (*Bromus inermis*) ...	—	—	115,000	255	3·960
Schrader's Brome-grass (*Bromus Schraderi*) ...	—	—	34,000	75	13·333

According to Table II it will be seen that from six to eighteen millions of germinating seeds are necessary to sow one statute acre—the number varying with the relative size and vigour of the plants, and with their surface covering capacity. The figures given are based on the results of careful observation made on plots which have been sown down on various kinds of soil, both with mixtures and with the pure seed of each species.

While these figures may be taken as sufficient for leys and temporary pastures, it is advisable to increase these quantities by from 30 to 50 per cent. when sowing down permanent grass. In the latter case we must remember that a large proportion of the

[1] Based upon a count of a minimum of 50 samples.

TABLE II.

Species	Standard of Analyses indicating good seed				Quantities of Seed necessary to sow one statute acre			Approx. relative quantity of produce given under favourable conditions*
	Purity per cent.	Growth per cent.	"Real value" per cent.	Bushel weight	Germinating seeds	Weight of germinating seed	Weight of seed of average "real value" as given in col. 3	
				lbs.	millions	lbs.	lbs.	
Perennial Rye-grass	96–99	90–96	86–95	24–28	8	35	39	70
Italian Rye-grass	96–99	90–96	86–95	18–22	8	35	39	80
Timothy	97–99	90–96	87–95	48–50	12	11	12	80
Tall Oat-grass	90–95	85–90	76–86	14–16	6	46	57	90
Golden Oat-grass	80	70	56	12–14	12	9	16	30
Cock's-foot	90–95	90–95	81–90	19–21	8	17	20	100
Tall Fescue	90	85–90	76–81	20–24	6	27	35	90
Meadow Fescue	96–98	90–96	86–94	27–30	8	30	33	70
Hard Fescue	90	90	81	20–22	12	24	30	40
Chewing's Fescue	90–95	70†–90†	63–85	23–26	12	27	36	40
Fine-leaved Fescue	85–90	80	68–72	23–26	18	15	21	10
Crested Dog's-tail	95–98	85–90	81–88	32–36	12	16	19	30
Meadow Foxtail	90	80	72	10–12	8	17	24	70
Fiorin	90	70–80	63–72	36–37	10	2	3	70
Sweet Vernal-grass	90–95	70	63–67	14–16	12	15	23	30
Rough-stalked Meadow-grass ...	90–95	85–95	76–90	25–28	15	6·5	8	60
Smooth-stalked Meadow-grass ...	90–95	70–85	63–80	23–28	15	7	10	40
Wood Meadow-grass	85–90	70–85	59–76	21–24	18	8	12	30
Awnless Brome-grass	90–95	90	81	17–19	3½	30	37	70
Schrader's Brome-grass ...	95–100	90	85–90	16–18	2	60	68	70

* Taking the produce of Cock's-foot as 100 per cent.

† Very variable.

short-lived plants included in the mixture will have disappeared by the fourth season, and ultimately the whole of the area should be occupied by permanent kinds.

In making up mixtures, after deciding upon the species to be included, it is usual to allot to each an aliquot part of the area according to the amount we wish to have present. If, for example, we wish to allow Meadow Fescue ten per cent. of the area, on looking at Table II we find that 30 pounds of seed are required for

TABLE III. *Types of Mixtures suitable for short Leys, or for Temporary Pasture.*

	For two years' duration		For temporary pasture of 3 to 5 years' duration	
	For mowing or grazing			
Species	Heavy soils per cent. of area	Light soils per cent. of area	Heavy soils per cent. of area	Light Soils per cent. of area
Italian Rye-grass	10	10	5	5
Perennial Rye-grass ...	15	15	15–10	10
Timothy	10	5	15	0–5
Tall Oat-grass...	5	10	5	10
Cock's-foot	10	25	15	25
Meadow Foxtail	—	—	0–5	—
Meadow Fescue	10	—	10	10
Rough-stalked Meadow-grass	—	—	10	0–5
Crested Dog's-tail	—	—	—	5–0
Hard Fescue	—	—	—	5–0
Broad Red Clover	10	10	5	5
Late Flowering Red Clover ...	10	5	5	5
Alsike	10	5	5	5
White Clover	10	10	10	10
Kidney Vetch	—	5	—	5

an acre, therefore 3 pounds will be necessary for one-tenth of this area. These quantities in Table II are for absolutely pure and germinating seed, that is, for seed having a "real value" of 100 per cent. It is necessary to correct these weights according to the "real value" of the seed being used. This is done by multiplying the weight given in the table by 100 and dividing by the figure giving the "real value" of the seed to be sown. If in the above example the Meadow Fescue seed has a "real value" of 90 per cent.,

then the amount to sow will not be 3 pounds, but 3 × 100 divided by 90 = about 3 pounds 5 ounces.

In Table II, column 7, will be found the weight of commercial seed of average "real value" which is sufficient to sow one acre.

TABLE IV. *Types of Mixtures suitable for Permanent Pasture or Meadow.*

Species	Heavy wet soils	Good heavy well-drained soils	Light dry soils		For sheep grazing on dry high-lying land
			1st	2nd	
	Percentage of area allotted				
Italian Rye-grass	—	5	5	—	—
Perennial Rye-grass	10	10	—	10	—
Timothy	15	10	—	—	—
Tall Oat-grass	—	3	5	8	—
Golden Oat-grass	—	—	5	5	5
Cock's-foot	10	12	25	20	10
Meadow Foxtail	10–5	10	—	—	—
Tall Fescue	10	—	10	—	—
Meadow Fescue	10	7	—	5	—
Rough-stalked Meadow-grass	10	10	—	—	—
Smooth-stalked Meadow-grass	—	—	10	5	5
Crested Dog's-tail	—	5	5	—	10
Hard Fescue	—	3	5	5	10
Fiorin	10	—	—	—	—
Broad Red Clover	—	—	—	—	—
Perennial Red Clover ...	—	5	5	5	—
Alsike	10	5	—	3	—
Wild White Clover	5–10	10	5	5	10–5
Kidney Vetch	—	—	10	5	10
Lucerne	—	—	5	5	—
Yarrow	—	5	5	4	5–10
Chicory	—	—	—	5	—
Burnet	—	—	—	10	10
Black Medick	—	—	—	—	10
Sainfoin	—	—	—	—	10

In Tables III, IV, and V are given a few examples of mixtures suitable for different purposes. The percentage of the total area allotted to each species is given, and from this the actual weight of seed to be sown can be readily calculated from Table II. It must be clearly understood that these are given only as examples

TABLE V. *Types of Seed-Mixtures for Lawns and Greens.*

Species	Garden lawns: For ordinary conditions per cent.	Garden lawns: For dry and exposed situations per cent.	Garden lawns: When much shade present per cent.	Suitable for: Cricket or Tennis per cent.	Suitable for: Tennis or Bowls per cent.	Suitable for: Putting or Bowling greens: Fine per cent.	Suitable for: Putting or Bowling greens: Finest per cent.
Festuca ovina var. *tenuifolia* ...	—	10	—	10	20	30	50
F. ovina var. *vulgaris*	—	10	—	10	10	10	10
F. rubra var. *genuina*	15	20	10	15	20	20	20
F. duriuscula	10	10	10	15	10	10	—
Poa trivialis	15	—	20	10	20	20	20
P. pratensis	10	10	10	10	10	10	—
P. nemoralis	—	—	20	—	—	—	—
Cynosurus cristatus	15	20	—	20	10	—	—
Lolium perenne	15	—	—	10	—	—	—
Aira flexuosa	—	10	—	—	—	—	—
Anthoxanthum odoratum	—	—	20	—	—	—	—
Achillea millefolium	—	10	—	—	—	—	—
Agrostis stolonifera	10	—	10	—	—	—	—
Trifolium repens (wild variety) ...	10	—	—	—	—	—	—

N.B. The figures indicate the percentage of the total area allotted to each species.

of the kind of mixture most generally suitable for the purpose mentioned. To prescribe the most useful mixture for any particular place or purpose it is necessary that all the special conditions and requirements should be understood.

Table V gives mixtures which will generally be found serviceable for various types of lawns, etc. For ordinary garden lawns some wild white clover may also be included if desired, but for tennis, and other playing lawns the presence of clover is not desirable. When forming lawns the soil should be thoroughly cleaned, and the finest possible tilth secured. The seed-bed should be perfectly level and very firm. The seed-rate should be from twice to four times as heavy as that indicated for agricultural purposes in Table II. The object is not to grow fully developed plants, but *to secure a dense pile of short hard-wearing foliage*, and this is obtained by thick sowing followed by constant close cutting and rolling. Due attention must also be given to the nourishment of the turf.

A suitable mixture for one year's duration, for mowing or grazing, is as follows:

	Per cent.	Area allowed	lbs.	Millions of germinating seeds per acre
Italian Rye-grass ...	20	(10–30)	6	1¼
Broad Red Clover ...	80	(90–70)	16	4
Total	100	(100)	22	5¼

Such a mixture is generally suitable for soils of good or medium quality. Both species are practically biennial and therefore give their full yield the first season, i.e. if sown in the spring cereal crop they give a full yield in the summer of the following year. The proportions can be varied considerably as indicated by the figures in brackets. On land which is liable to clover sickness the Red Clover can be partly or wholly replaced by Alsike, or more Italian Rye-grass can be sown. On poor, dry soils, Black Medick can replace some of the Red Clover, and Perennial Rye-grass and possibly Tall Oat-grass take the place of the Italian Rye-grass.

CHAPTER XI

THE GENERAL TREATMENT OF GRASS LAND, AND THE EFFECTS OF VARIOUS FERTILISERS UPON THE DIFFERENT SPECIES

It seems desirable, in such a work as this, to make a few brief observations on the general treatment of grass land.

Drainage. Before laying down land to permanent grass drainage must be attended to if necessary. So long as the ground is effectively drained, either by natural or artificial means, it is rather an advantage for grass production that the soil should be inclined to be moist. But for good grass there must be no possibility of stagnant water remaining on or near the surface.

Seed-bed and Sowing of Seed. Land is best prepared for sowing down with grass seeds either by (1) a bare fallow, or (2) a root crop or potatoes. *A clean seed-bed with fine tilth and a firm surface* are the important conditions to secure.

The equal distribution of the seed is another important matter. This is best secured by using a low delivery seed barrow, or other low delivery broadcast sowing-machine. Messrs James Hunter, Ltd., seed merchants, of Chester, recommend Turnbull's Broadcast Sowing Machine as being very suitable. With this machine one sowing operation is said to be sufficient. Two sowing operations are however preferable to one, and when this is practised the light seeds can be sown in one direction and the heavy seeds (Timothy, Clovers, etc.) at right angles to the first direction. Very light harrows should be used to cover the seed, and the operations should then be completed by rolling—twice by preference—with a roller of moderate weight.

In dry districts, when the larger and stronger growing seeds such as Clovers and Rye-grasses are sown they may be drilled at a shallow depth with the coulters set very close.

Time of Sowing. Sufficient soil moisture and a suitable temperature are required to give the seedlings a good start. These conditions are obtained in England most frequently in April and

August, but sowing may be done at any time between March and September when weather conditions are favourable. Sowings made in May or June are very risky as a dry summer is almost sure to be fatal to the seedlings either on a light or heavy soil. Late summer or early autumn is generally the best time upon heavy soil because such land can be got into a good condition as regards tilth, etc. by previous summer cultivation. On lighter soils a good tilth can be secured early enough in the spring.

Although young grass plants grow more rapidly when sown alone, it is usually safer to sow a thin seeding of some annual crop, generally a cereal, to protect the young grass and the soil from the effects of drought. This "cover" or "nurse" crop must be a thin one and the land should receive liberal manurial treatment. A sowing of two bushels of oats per acre, the crop to be cut green just after flowering, affords all the advantages of a cover crop and also provides a return of useful fodder the same year. Vetches or rape also serve as good "nurse" crops.

Immediate after-management. After harvesting the cover crop the young grass may be thoroughly rolled with advantage. If a cover crop has not been sown and the grass is well forward a little light grazing may be done by cattle towards the end of the first season. It is however better practice generally to cut the first year's crop. None of the plants should be allowed to form seed, and at this stage every effort should be made to enrich the soil and to cause the plants to spread. The importance of liberal manurial treatment during the early years in the life of a pasture cannot be over-emphasized. This early attention will be amply repaid by the more rapid formation of a thick turf.

General after-management.

In this connection it is advisable to distinguish more clearly between *pasture* and *meadow land*. By meadow land should be understood land from which hay crops are taken each year, and grazing only practised on the aftermath. The term is however very loosely used for grass land whether reserved for hay every season or only occasionally. By the best practical farmers it is generally considered best to reserve some fields for mowing annually, while others are continuously grazed. The practice of grazing and mowing in alternate seasons is not a sound one and

is usually carried out only on land of moderate quality. The richest grazings soon fall in value under this treatment.

Meadows. The exhaustive effect on the soil caused by the annual removal of hay crops is very great. An average hay crop of 30 cwt. per acre removes as much nitrogen, almost as much phosphoric acid, and nearly twice as much potash as an average crop of wheat or barley. Moreover, in the case of a permanent meadow the soil does not get the advantages of exposure to the weather as does ploughed land. Further, constant mowing generally greatly diminishes the proportion of white clover present, and thus the main source of the natural nitrogen supply to grass land is cut off. The annual loss to the soil by the removal of hay must therefore as far as possible be made good by the direct application of manures, and the use of feeding-stuffs to animals grazing the aftermath.

The common practice of allowing the hay crop to become quite ripe, or even over-ripe, before cutting is a very harmful one. A large proportion of the plants produce seed with the result that they are greatly weakened, and the growth of the valuable aftermath very materially reduced. It is erroneously supposed that the crop continues to increase in weight until the plants are quite mature, and that cutting in the second or third week in July will give a more valuable return than is attained by taking the crop in June. Even if the crop is slightly heavier, it is at the expense of the aftermath, and the produce is certainly less digestible than the less mature crop would be. As Wolff points out in his work on *Farm Foods*, page 149: "Hay rich in nitrogen and lacking in fibre is clearly the best and most digestible, while that poor in nitrogen and rich in fibre has the least feeding value." From the time of flowering onwards a marked increase in the proportion of crude fibre takes place, while at the same time the percentage of protein and amides (nitrogenous substances) decreases very considerably. It follows therefore that the right time for cutting is just when the bulk of the plants are flowering or immediately afterwards[1].

The practice of chain-harrowing to pull out moss and spread loose soil, etc., and also that of thoroughly rolling in the spring

[1] See Bibliography, No. 5.

are to be recommended. The operations of cultivation are so much limited in the case of permanent grass land that the foregoing should never be neglected.

Pastures. The art of the grazier is one which is only mastered by much experience. It is generally found that mixed grazing, i.e. putting two or more kinds of stock on the same ground together serves to keep the turf more evenly eaten off than when bullocks or sheep are used alone. This remark however only applies to good grazing land; upon poorer land the grass may only be able to carry sheep. If strong and coarse growing plants tend to predominate, e.g. Cock's-foot, it is advisable to stock rather heavily during the early part of the season. It is a point with good graziers to keep the grasses well eaten down until the end of June, after which little fear of seeding need be entertained. It is also a good plan, based upon long practical experience, to keep store cattle on the inferior or only moderately good pastures, and as the animals become ready to fatten off to move them on to better grazing land. When animals become heavy and less active an abundance of food ready at hand is necessary to finish them off rapidly and economically. Oilcake and other feeding stuffs are generally more freely given at this stage than at any other. Although the above is undoubtedly sound practice *it is much more exhaustive to the poorer grazings than to the better ones.* It should always be remembered that young growing animals and breeding stock make far larger demands upon the soil for nitrogen, phosphoric acid, lime, etc. than do more mature and fattening animals. The latter make comparatively small demands upon the soil since their increase in weight consists largely of fat. Good grazing land on which animals are fattened with the assistance of cake, etc. will easily maintain its quality under judicious grazing alone.

It is the poorer land and that which carries young stock continuously which stands most in need of the direct application of manures. Generally the use of phosphatic manures proves the most effective and economical since clovers are favoured and the spread of these leads to a large addition of nitrogen to the soil. Soils which are heavy and damp generally respond well to basic slag only. Lighter and drier land, if containing sufficient free lime, is better dressed with superphosphate and potash, and

afterwards the improvement effected can be most economically maintained by the moderate use of feeding cakes, etc.

No further general rules for manuring can be usefully given here. The local and special conditions to be met must be duly considered in each case.

The Effects of Manures[1] upon the different grasses. While a considerable amount of information has been obtained with regard to the general effects of the various common fertilisers upon the composition of the turf of pastures and meadows, our knowledge of the precise action of each upon the different species is very small. Only in a few experiments—notably those at Rothamsted—has any serious attempt been made to discover which grasses tend to increase or decrease under any definite kind of manurial treatment. Although these few experiments are of great value, we must be careful not to generalise from them too much since the composition of the original turf will greatly modify the ultimate effect of manures. For in speaking of the effect of any special fertiliser we must bear in mind that *this is to a large extent dependent upon the particular association of plants composing the turf.*

With different associations of plants (and on different soils) rather different results or effects will be produced by the same kind of manuring. It is the finely adjusted "balance of equilibrium" in the natural struggle for existence which is upset by any particular manurial treatment.

Bearing these precautions in mind we may briefly consider what is known about the effects of fertilisers on (1) *the vegetation as a whole*, and on (2) *the more common grasses individually.*

Numerous experiments have shown that one of the general effects of manuring (or otherwise improving the soil) *is to reduce the number of species present*, or at least to cause a few kinds to become predominant. This is especially noticeable on the more inferior kinds of soil where a relatively large number of species make an almost equal contribution to the annual crop. At Rothamsted on the permanently unmanured hay plots the number of species present was about fifty, while on some of the manured plots this number fell to twenty or even less. The same fact

[1] See also Bibliography, Nos. 6, 11, 12, 16 and 27.

is almost constantly borne out by a comparison of the turf of inferior pastures with that from better class pastures in a given district.

While this reduction of species is chiefly due to the disappearance of weeds belonging to a number of widely separated Natural Orders, it is also found that the number of grasses frequently becomes reduced. Crested Dog's-tail, Golden Oat-grass, Sweet Vernal-grass, and perhaps to a less extent Hard Fescue and Fiorin are often materially reduced as regards number of individuals, or even die out altogether when land is highly manured. This is not because manures are of no benefit to these plants, for if grown separately they respond readily to them. It is usually because more vigorous species present respond to such an extent that the above named plants are largely elbowed out of existence. It is however necessary to speak more precisely as to the effects of the various kinds of fertilisers.

The general effect of **Nitrogenous manures** upon grasses is to favour luxuriant and continuous growth. If applied in excess the vegetative organs are especially developed and the ordinary processes of maturation are delayed until late in the season. The very dark green colour of the foliage is characteristic of plants receiving excess of nitrogen in proportion to other plant food materials. Leguminous plants are much less favoured than grasses and thus tend to die out.

The use of *Sulphate of Ammonia* or of *Ammonium Chloride* alone usually tends to reduce the number of species composing a turf very considerably, and this reduction appears to be shared by plants belonging to all the Natural Orders commonly represented. Usually two or three kinds of grasses are greatly stimulated and caused to predominate. The following grasses appear to be specially favoured by salts of ammonia: Cock's-foot, Timothy, Meadow Foxtail, Tall Oat-grass, Sweet Vernal-grass, Sheep's Fescue and its varieties, Fiorin and Yorkshire Fog.

Nitrogen in the form of nitrate (*Nitrate of Soda*, etc.) generally favours a larger number of species than salts of ammonia, and the herbage therefore remains more mixed in character, even when the nitrate is continuously applied. This appears to be at least partly due to its being more readily available to plants whether

deep or shallow rooted. In other respects its action is similar to that of ammonium salts.

The grasses especially favoured by nitrate of soda are: Rough-stalked Meadow-grass, Meadow Foxtail, Fiorin, Cock's-foot, Timothy, Tall Fescue, Meadow Fescue, Rye-grasses and Tall Oat-grass.

Phosphates alone. As is well known, the application of phosphates alone usually leads to a great stimulation of the leguminous plants present, and brings about a corresponding reduction in the proportion of the gramineous herbage at least for a time.

This is the usual result of using *superphosphate alone*, and even to a greater degree when *basic slag*—which contains free lime—is employed. As the result however of the increased nitrogen supply to the soil, the better grasses are gradually enabled to take the place of inferior sorts, and thus a general improvement of the herbage follows.

The general effect upon grasses of the use of phosphates alone is to produce a more dwarf and stemmy growth, favouring early maturation and promoting seed production.

The general action of *Potash manures alone* is also similar, i.e. early maturation is favoured.

The effect of *lime* is generally most marked upon the leguminous herbage, which it stimulates. It possibly also tends to reduce such plants as Fiorin, Tussock-grass, etc.

The general effect of *mixed mineral manures alone* (*phosphates and potash*) is to greatly favour stem and seed production, and to lead to premature ripening. Leguminous plants are much more favoured than are the grasses.

The use of *ammonium salts in addition to phosphates and potash* if well proportioned leads to a greatly increased yield with normal maturation. The following appear to be favoured by such manuring: Timothy, Cock's-foot, Foxtail, Tall Oat-grass, Smooth-stalked Meadow-grass, Fiorin, and Sheep's Fescue.

If the ammonium salts are in excess the stronger grasses are particularly favoured and become very coarse.

The following are especially promoted by the use of *Nitrate of Soda with phosphates and potash:* Rough-stalked Meadow-grass,

Foxtail, Cock's-foot, Rye-grasses, Meadow Fescue, and Timothy. At Rothamsted Soft Brome and Yorkshire Fog were also greatly encouraged, but this was on land mown every year.

Farmyard manure generally encourages the growth of the more vigorous grasses such as Cock's-foot, Rough-stalked Meadow-grass, Foxtail, Tall Oat-grass, Meadow Fescue and Rye-grasses. Leguminous plants are usually reduced.

It is unfortunately impossible to give any fuller reliable information regarding the precise effects of fertilisers upon the different species, and our knowledge must remain incomplete on these points until definite researches have been carried out.

APPENDIX

CONTAINING A LIST OF LOCAL, RARE, OR INTRODUCED FOREIGN GRASSES NOT OTHERWISE DESCRIBED IN THIS VOLUME

Aira alpina, L. An alpine dwarf variety of *A. cæspitosa* common on the higher mountains of Scotland. The panicles usually pass more or less into the viviparous state.

Alopecurus alpinus, Sm. Occurs in the Highlands of Scotland. Perennial. The spike-like panicle is seldom more than an inch long, ovoid in form, and silky. The awn is shorter than that of *Alopecurus pratensis*.

A. bulbosus, Sm. A variety of *A. geniculatus* in which the lowermost nodes of the culms are enlarged and bulb-like. It is mostly found on wet salt marshes around the coasts.

A. fulvus, Sm. Another slight variety of *A. geniculatus* with a shorter awn which does not project beyond the tips of the empty glumes. Rare.

Bromus madritensis, L. A rare annual; 6—12 inches high; waste places. Panicle erect. Upper empty glume three-ribbed. Awn equal in length to the paleæ.

B. maximus, Desf. Occurs in Jersey. An annual, closely allied to *B. sterilis* but with a more erect and compact panicle. Rachis pubescent. Spikelets about 8-flowered, and from $2\frac{1}{2}$ to $3\frac{1}{2}$ inches in length including the awns. Awns longer than the paleæ.

Echinochloa Crus-galli, Beauv. Cockspur Panic-grass.

A course annual, growing from one to two feet high, with broad leaves. *Ligule wanting.* Panicle about five inches long, irregular, and one-sided. Spikelets clustered, two-flowered. Empty glumes very unequal. Lower flower rudimentary or barren.

Occasionally a weed of cultivation in England.

Festuca uniglumis, Soland. A tufted annual with inrolled leaves, growing from six to twelve inches high. Inflorescence racemed, about two inches long. Spikelets on short simple branches, 5—6-flowered. *Lower empty glume obsolete*, the upper glume long, narrow, and pointed. The outer palea terminates in an awn which is longer than the palea itself. Scattered around the coasts of England and Ireland.

Gastridium lendigerum, Beauv. Nit-grass. An annual, 6—12 inches high. Panicle close, spike-like, pale green. Spikelets crowded, one-flowered. Awn sub-terminal (sometimes absent) and longer than

the paleæ. Abundant in the Mediterranean region. Occasionally found in moist waste places in the south of Britain.

Hierochloë borealis, Sm. Holy-grass.

A creeping perennial grass with flat leaves. In Britain has only been met with in Caithness and Forfarshire, and is a very doubtful native species.

Lagurus ovatus, L. Hare's-tail. An erect annual, 6 inches to a foot high. Sheaths inflated. Sheaths and blades softly downy. Panicle dense, ovoid, about an inch long. Spikelets crowded, one-flowered. Empty glumes equal, taper-pointed, hairy. Outer palea terminating in two long bristle-like points and bearing a very long, fine, dorsal awn. Occasionally found on our coasts (Suffolk).

Leersia oryzoides, Sw.

Flowering culms about two feet high; panicle loose; spikelets one-flowered and compressed. Occurs in wet places in Hampshire, Sussex, and Surrey.

Lepturus incurvatus, Trin.

A decumbent annual, about six inches high and bent at the nodes. Inflorescence a curved spike, from two to four inches long. Spikelets one-flowered, in two alternate rows, and very closely inserted in a kind of notch against the rachis. When ripe the latter breaks up at each joint. Generally scattered around the sea-coasts of Britain.

Mibora verna, Adans.

A tufted annual, seldom more than three inches high. Inflorescence a raceme, unilateral, and about half an inch long. Spikelets sub-sessile, one-flowered. Outer palea very hairy and shorter than the empty glumes. Found in Anglesea and the Channel Islands.

Panicum, L. General characters of the genus:

Spikelets in either loose or spike-like panicles, one to two-flowered. Three empty glumes present, the first (or lowermost) usually smaller than the others. The third or uppermost glume often encloses a male flower. The paleæ are indurated, awnless or very shortly awned.

Panicum Crus-galli, L., see *Echinochloa*, p. 188.

Panicum glabrum, Gaud. Glabrous Finger-grass.

An annual, from six inches to a foot high. Sheaths glabrous. Spike-like branches of the panicle from two to four in number. The two uppermost empty glumes equal in size. An introduced weed in the south of England.

Panicum sanguinale, L. Hairy Finger-grass. An annual, from one to two feet high, with more or less hairy sheaths. The inflorescence

consists of from two to six (or more) simple, one-sided, digitate branches. Glumes very unequal.

Very common in all tropical and warm countries. It occurs as an introduced weed of cultivation in the southern counties of England.

Phleum asperum, Sm. Rough Cat's-tail Grass.

An annual growing from 6—18 inches high. Rare in Britain. It is distinguished from the other British species by its wedge-shaped empty glumes which are rough along the keels—but not hairy.

Phleum Bœhmeri, Schrad.

A perennial, very similar to *P. pratense*, but smaller. The glumes are not awned but simply pointed, and the hairs are confined to the upper half of the keels. The inner margins of the glumes are not fringed with hairs.

Sometimes met with in the eastern counties of England. Rare.

Poa laxa, Hænke. Wavy Poa.

A slightly creeping perennial, 6—12 inches high, closely allied to *Poa alpina*. Panicle loose. Spikelets few, on spreading branches, oblong-ovate, 3—4-flowered. A native of high elevations in northern latitudes.

In Britain it is only known to occur on Ben Nevis, where it is generally in a viviparous state.

Poa loliacea, Huds. A small annual about four to six inches high. Panicle reduced almost to a simple spike of spikelets. Spikelets 6—10-flowered, the flowers without a "web."

Empty glumes acute and without lateral ribs. The outer palea five-ribbed, the marginal ribs broad. Scattered around the coasts of Britain on rocks and sands.

Poa procumbens, Curt.

A tufted annual, with decumbent stems six to twelve inches long. Panicle secund. Spikelets 3—5-flowered. Empty glumes each with three prominent nerves. The outer palea five-nerved. Flowers without a "web." The whole plant glaucous.

Waste places on our sea-coasts. Rare.

Polypogon, Desf. Beard-grass. General characters of the genus: Spikelets one-flowered, crowded in a contracted and often interrupted panicle. Empty glumes each ending in a fine straight awn. Outer palea awned.

Polypogon littoralis, Sm. Perennial Beard-grass.

A procumbent perennial growing from six to twelve inches high. Panicle moderately close. Empty glumes equal, hairy, strongly toothed on their keels, and each bearing an awn about as long as the

glume itself. Awn of the outer palea sub-terminal and variable in length.

It occurs in salt marshes on the south and east coasts of England.

Polypogon monspeliensis, Desf. Annual Beard-grass.

An annual growing from twelve to eighteen inches high. Panicle erect, dense, interrupted and silky; about two inches long. Empty glumes hairy, strongly toothed on the lower half of their keels, and each bearing an awn more than twice as long as the glumes. Outer palea bearing a short awn.

Common in the Mediterranean region. Rare in Britain. Occasionally found as an introduced plant in the south of England.

Setaria, Beauv. Bristle-grass.

General characters of the genus:

Spikelets 1—2-flowered, ovate, in a close, cylindrical or bushy panicle. Empty glumes awnless, the lowermost one short. Paleæ blunt, becoming hard and shining or transversely wrinkled when the grain ripens. Involucral bristles rough, and generally projecting beyond the spikelets.

Setaria glauca, Beauv. Glaucous Bristle-grass.

An erect annual, with a panicle from 1 to 1½ inches long, and numerous bristles under each spikelet. Bristles rough with minute erect teeth. The outer palea marked with numerous strong transverse wrinkles when ripe.

Abundant as a weed of cultivation in most warm countries, and occasionally introduced into Britain.

Setaria verticillata, Beauv. Reflex Bristle-grass.

An erect annual, one to two feet high. It is readily distinguished from *S. glauca* and *S. viridis* by the *reflexed teeth* on the bristles. Sometimes met with as a weed of cultivation in England.

Setaria viridis, Beauv. Green Bristle-grass.

Very similar to *S. glauca* but with only 2—3 bristles under each spikelet. The transverse wrinkles on the outer palea are also much less distinct. Introduced into Britain and appears to be established in some parts.

Spartina stricta, Sm. Cord-grass.

A stiff erect perennial with creeping rhizomes. Leaves erect, mostly inrolled. Culms from one to two feet high. The inflorescence consists of from two to four spike-like branches each three or four inches long. Spikelets one-flowered, compressed, erect, awnless, and sessile; situated on one side of the spike-like branches. Empty glumes very unequal, hairy. The inner palea is longer than the outer one.

Found on some of the salt marshes on the south and east coasts of England.

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LIST OF SYNONYMS AND GLOSSARY OF TERMS

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