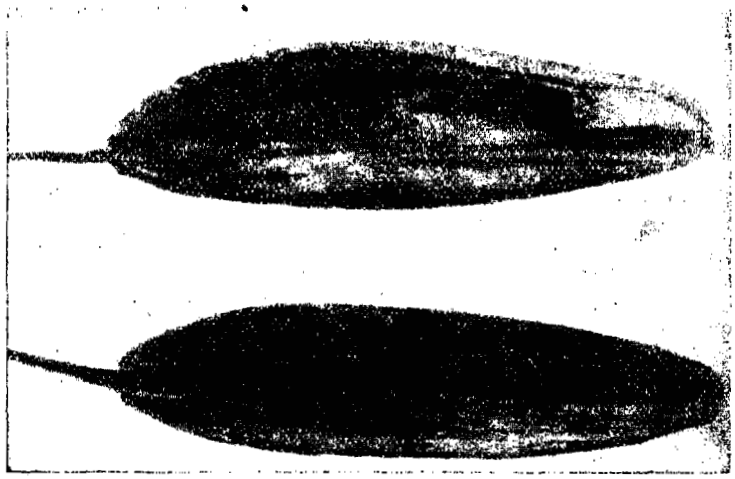
January, 1907 Bulletin 141

Kansas State Agricultural College

Agricultural Experiment Station

Commercial Seeds of Brome-Grass, and of English and Kentucky Blue-grasses: Adulterants and Substitutes and their Detection



Seeds of Cheat, the chief adulterant of Brome-grass and English Blue-grass. Magnified 15 diameters.

H. F. Roberts and Geo. F. Freeman

MANHATTAN

PUBLISHED BY THE COLLEGE PRINTING DEPARTMENT

SUMMARY.

Cheat is the chief adulterant of Brome and English Blue-grass seeds.

Growing plants of the above three species are easily distinguishable from one another. Pp. 74-76.

Seeds of Brome-grass and Cheat also easily distinguishable from each other. P. 84.

Seeds of Cheat somewhat closely resemble those of English Blue-grass, and frequently appear as a substitute for and an adulterant of the latter. For distinguishing characters, see p. 85.

Canadian Blue-grass is used in quantities of nearly 700,000 pounds annually, chiefly for the adulteration of Kentucky Blue-grass.

Plants of Kentucky and Canadian Blue-grass are not difficult to distinguish in the field (pp. 89-90), but the seeds are indistinguishable except to an expert.

The distinguishing characters of the seeds of these two species as hitherto given by the writers are unsatisfactory as aids to identification. Pp. 91-105.

This bulletin presents an absolutely new, hitherto unnoticed and practically infallible test for distinguishing the seeds of Canadian from those of Kentucky Blue-grass. Pp. 103-111.

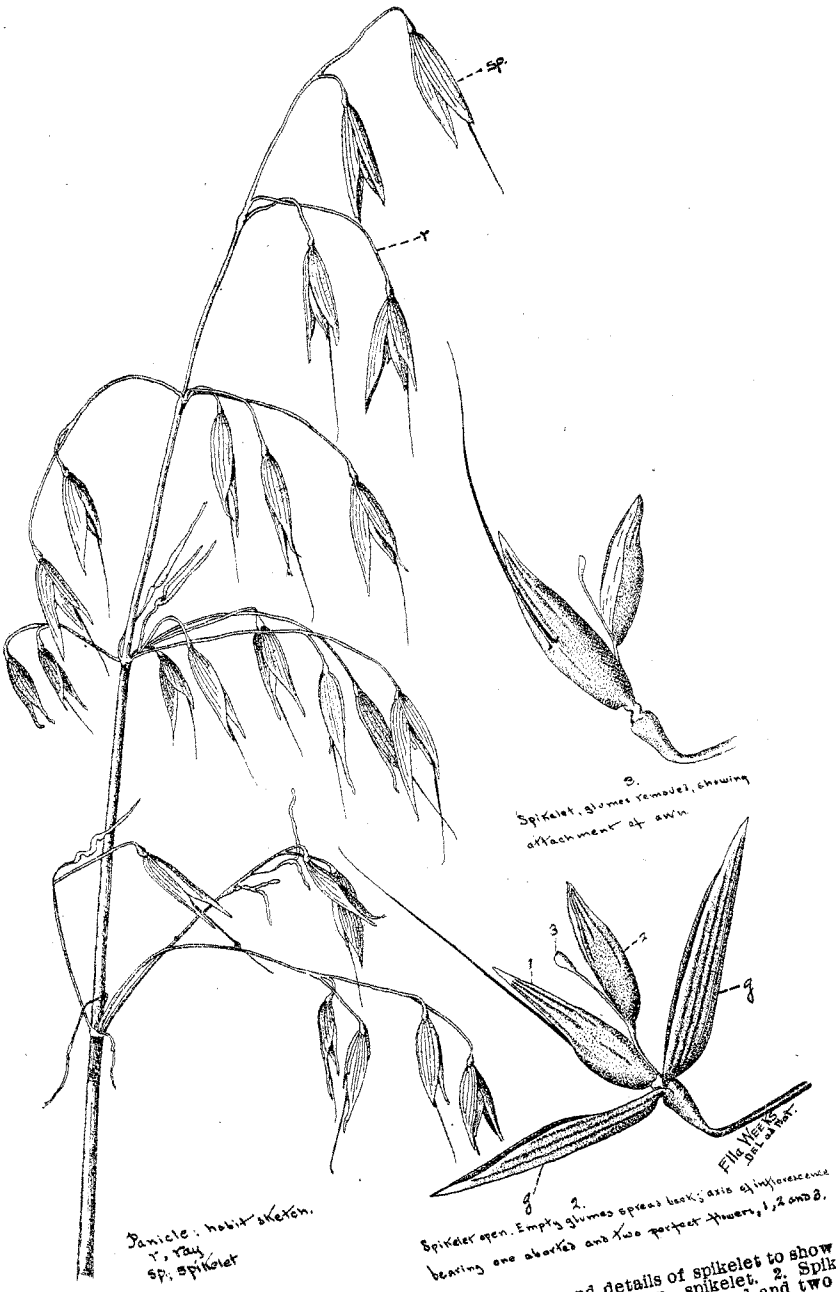


PLATE I.—Typical grass inflorescence (Oats); panicle and details of spikelet to show the structure of flowers of grasses. 1. Panicle, habit sketch; r., ray; sp., spikelet. 2. Spikelet open, empty glume (g.) spread back; axis of inflorescence bearing one aborted and two perfect flowers (1, 2, and 3). 3. Spikelet, glumes removed, showing attachment of awns.

Commercial Seeds of Brome-grass, and of English and Kentucky Blue-grasses: Adulterants and Substitutes and their Detection

By H. F. Roberts and Geo. F. Freeman

INTRODUCTION

The constant appearance in this State of cheat or chess (Bromus secalinus), as an adulterant and substitute in seed of Hungarian Brome-grass (Bromus inermis) and English Blue-grass (Festuca elatior); and the use of Canadian Blue-grass (Poa compressa) as an adulterant of the seed of Kentucky Blue-grass (Poa pratensis), renders it extremely necessary to publish such information as will enable farmers to distinguish the species mentioned clearly and readily.

Of the Brome-grasses, there are about 40 species, all but a few of which are annuals of comparatively slight value; among these are Bromus secalinus, or cheat, just referred to, which occurs as a weed grass amongst the other grasses, and in fields with the cereal grains, all over the north temperate zone. Indeed, its frequent appearance in wheat has given rise to the superstition that wheat changes to cheat under certain circumstances. That this is impossible it is needless to state.

English Blue-grass (Festuca elatior), belonging to the genus Festuca (the fescue grasses) with about 80 species, is more nearly related to the Brome-grasses than to the real blue-grasses. The species known as Meadow Fescue, or English Blue-grass, is the most valuable of all the fescue grasses, and has grown rapidly in favor in recent years through the eastern and central portions of this State.

Kentucky and Canadian Blue-grasses belong to the genus Poa, with about 100 species, distributed through all the temperate and cold regions of the earth. Although nearly related to the fescue grasses, they are quite distinct from them.

It is often the case that a farmer buying the seed of forage grasses is totally unfamiliar with the plants themselves, or if he has seen and examined them he may remain unacquainted with the general appearance of the commercial seed. As with nearly all grasses, so in the case of those species discussed in this bulletin, the true seed is enclosed within the chaff or "glumes,"

which remain as a tight envelope around it. The commercial "seed," therefore, is the true seed plus the enclosing chaff, and with sometimes a bit of the axis of the flower stem adhering. The seeds, or grains proper, within the glumes or chaff, are hardly familiar at all. Nevertheless, in threshing, the grains sometimes escape, and are found mixed in the commercial seed. It is accordingly worth while to learn to know them.

DESCRIPTION OF THE GRASS FLOWER

To understand a close description of the commercial seeds, some knowledge of the nature of the grass flower is presumed as necessary. Grasses usually have their flower heads in close stiff spikes like wheat or foxtail, or in open panicles like blue-grass or oats, although there are all manner of modifications of these two very general types. The spike or panicle, as the case may be, has usually a main or principal axis, upon which more or less numerous secondary branches are borne. In the case of the grasses under consideration in this bulletin, the long, slender, nodding secondary branches are known as "rays." These ray branches bear the spikelets or clusters of flowers, usually, upon yet smaller branchlets. The spikelet in oats, for example, is a very closely set and densely packed group of flowers, growing in alternate order upon a very much shortened axis called the "rachilla." Sometimes the ray will bear several of these spikelets. Coming from the joints or nodes of the rachilla are usually from one to several flowers, of which not all are seed bearing as a rule. Ordinarily in the cereal grains, not more than two or three flowers develop, the remainder aborting. At the base of the spikelet are two scales or chaffs, known as the "empty glumes," because they bear no flowers in their axils. Sometimes, as in oats, the empty glumes are so large as to enclose completely the flowers of the spikelet. In other cases, as in wheat, the flowers, or some of them, appear above the edges of the glumes. The individual flower of grass is devoid of any showy display of colored petals or like appendages. The three stamens, or pollen-bearing organs are situated in a ring around the single carpel, from the top of which appear two plume-like stigmas, upon which the pollen falls. The whole is enclosed within two scales or bracts; the larger and heavier outer scale being called the "flowering glume," and bearing the "awn" or "beard," when it occurs. The inner scale, known as the "palet," is thin, papery, and membranous; and it is often more or less completely enclosed by the infolding edges of the flowering glume. The flowers of grass are opened by means of the swelling of the glandular scales called "lodicules," located

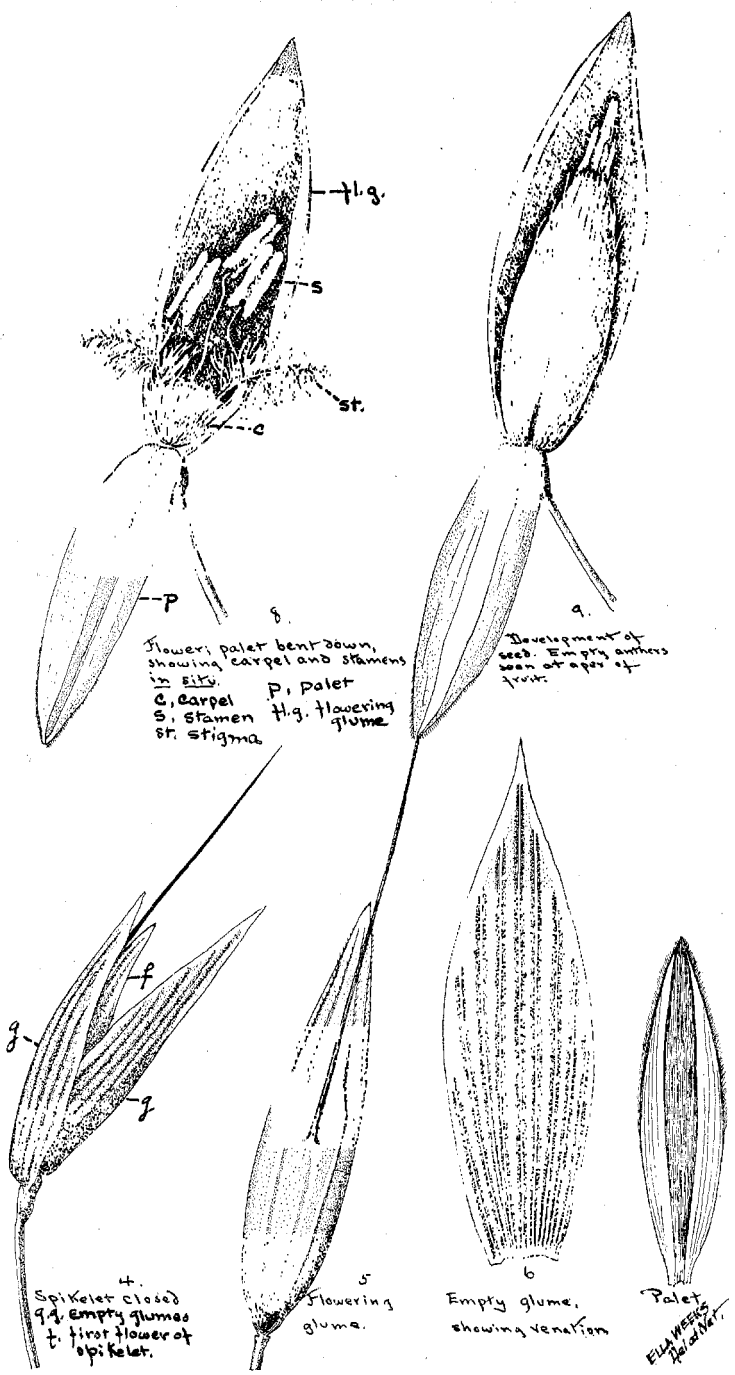


PLATE II.—Details of flower of grass (Oats). (Continuation of figures in Plate I.) 4. Spikelet closed: g. g., empty glumes; f., first flower of spikelet. 5. Flowering glume. 6. Empty glume showing venation. 7. Palet. 8. Flower open, with palet bent down, showing carpel and stamens in position. p., palet; fl. g., flowering glume; c., carpel; s., stamen; st., stigma. 9. Development of seed. Empty anthers visible at apex of fruit.

at the base of the carpel, and lying between it and the base of the flowering glume. See Plate III, Figs. 10 and 11.

The details of the structure can readily be understood by referring to the figures on Plates I, II, and III, in which the oat flower is used for purposes of illustration, because of the simplicity, clearness and distinctness of its flower characters.

The carpel calls for further description. In grasses, the

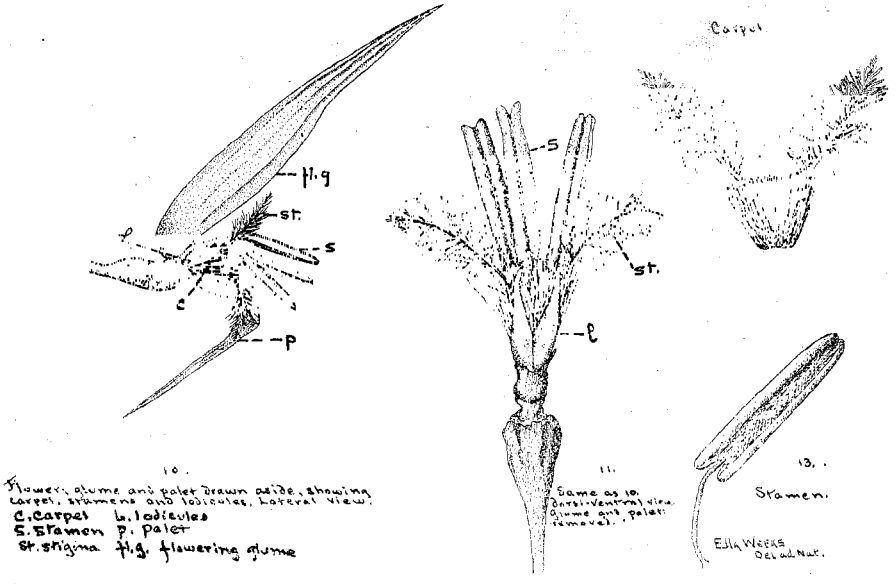


PLATE III.—Details of flower of grass. (Continuation of figures in Plate II.) 10. Flower with flowering glume and palet drawn aside, showing carpel, stamens, and lodicules. Lateral view. p., palet; fl. g., flowering glume; c. carpel; s., stamen; st., stigma; l., lodicules.

carpel, or pistil, contains but a single ovule. This ovule, in the course of its development, grows to and unites with the tissue of the enveloping wall of the carpel, and the entire structure of carpel and ovule grown together ripens as a whole into what is known as the "caryopsis," the so-called "seed" of grasses. See Plate II, Fig. 9.

In the case of most of our cereal grains, as in wheat and rye, and in some of the wild grasses, the "seed" or caryopsis is released from the glumes at maturity and escapes. In most of the common wild and cultivated forage grasses, however, the seed does not escape from the glumes, but either breaks off from the axis of the rachilla or else, as in spelt, emmer, and oats, the whole spikelet, with its several flowers, becomes severed.

In threshing grass seeds, the individual flowers, which contain the ripened seeds, are rubbed off the spikelets, and each such flower, consisting of the now dried and stiff flowering glume and palet, tightly enclosing the seed within, constitutes the "seed" of commerce. The real seed, or caryopsis, not being visible, the characters which are used to distinguish the seeds of grasses are those which appear on the two enclosing glumes.

CHEAT, HUNGARIAN BROME AND ENGLISH BLUE-GRASS

At the present time the comparative unfamiliarity of many of our farmers with the seed of cheat, English Blue-grass and Hungarian Brome-grass has made possible widespread deception in the sale of seed of the two latter species. The unlikeness of the plants of the three species is such that the confusion need not easily occur where they are seen growing in the field.

Bromus inermis is a perennial species, growing in dense clumps, which increase in size through the growth of underground stems or root stocks, as illustrated in Plates IV and V. Bromus secalinus, being an annual, is devoid of the system of underground propagation stems, and has simply a mass of fibrous roots, from the crown of which a number of flower-bearing stems arise. The panicles or heads in Brome-grass and cheat are very unlike in their general appearance as will at once be recognized on comparing Plates VI and VII. Bromus inermis has an erect, open, spreading panicle, with the rays projecting equally in all directions from the main axis when it is in full flower (Plate VI), while the panicle of cheat is looser, and nodding, and frequently more or less one-sided. (Plate VII.) When the cheat panicle is quite young it has somewhat the erect habit of Bromus inermis in the same stage, (See Plate VIII). With the development of the head, however, the latter becomes nodding, and at maturity, when the seeds are ripe, presents the appearance as seen in Plate VII. Bromus inermis, on ripening, may retain the open habit of the flowering period shown in Plate VI. Or, the rays may grow closely appressed against the central stem and upright. This latter is rather the more common type. (See Plate IX.)

English Blue-grass has rather a narrow, slender panicle when young, becoming, on reaching full bloom, open, spreading, and somewhat light and feathery in appearance, (See Plate X for panicle and details of flower); the different ray branches being long, slender and nodding. While young, the lowermost rays of the panicle usually are appressed against the main axis, and stand upright, (Plates XI and XII). Being also a perennial grass, the nature of the underground propagating system will also serve to

PLATE IV.—Bromus inermis, showing method of propagation by underground stems, called "root-stalks" or "rhizomes." These are seen at "r."

PLATE V.—Bromus inermis. System of propagating root-stalks. 1. Panicle. 2. Single ray of panicle. 3 and 4. Flowers.

PLATE VI.—Bromus inermis; panicle in full bloom.

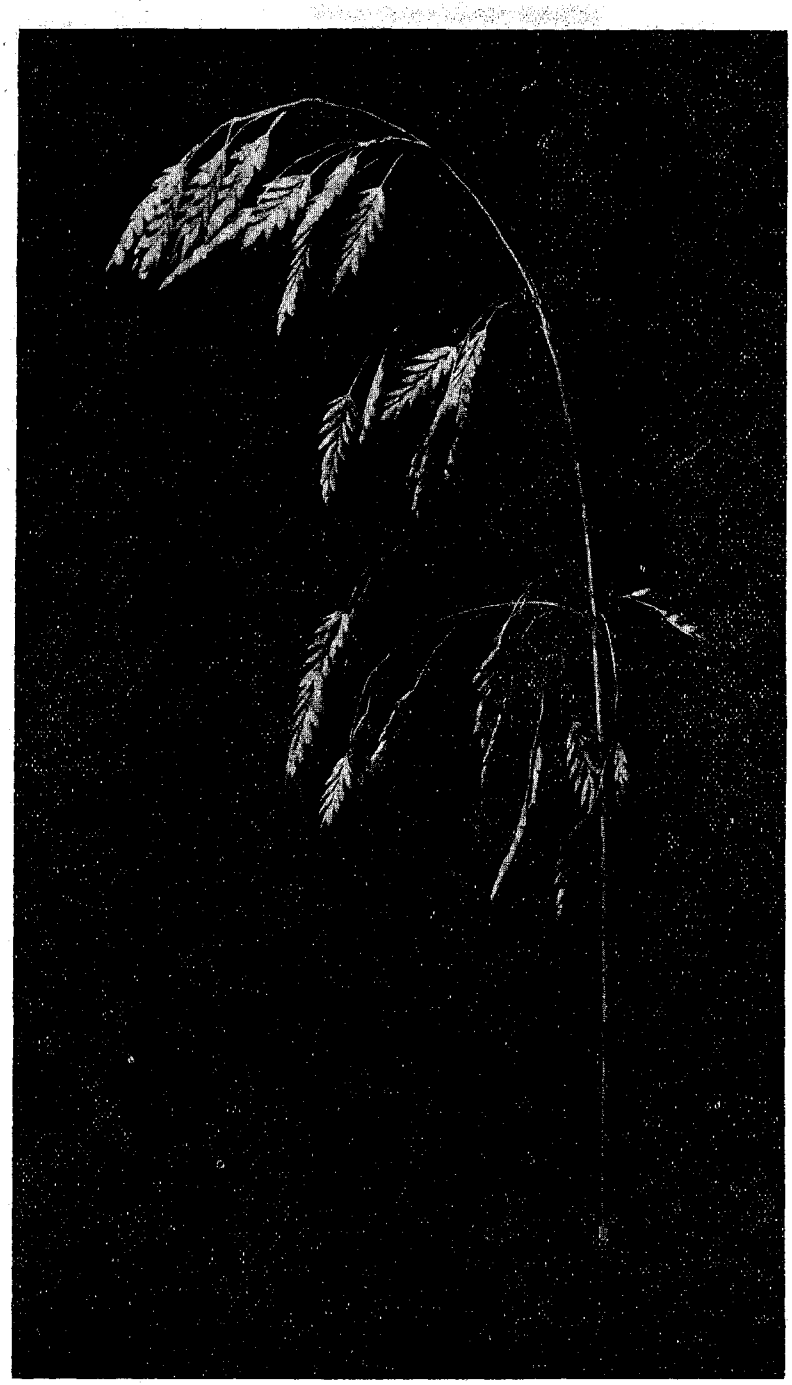


PLATE VII.—Bromus secalinus. Mature panicle bearing ripe seeds. The panicle in full flower presents substantially the same appearance. Note the drooping, nodding habit of the spikelets, as compared with Plate VI.

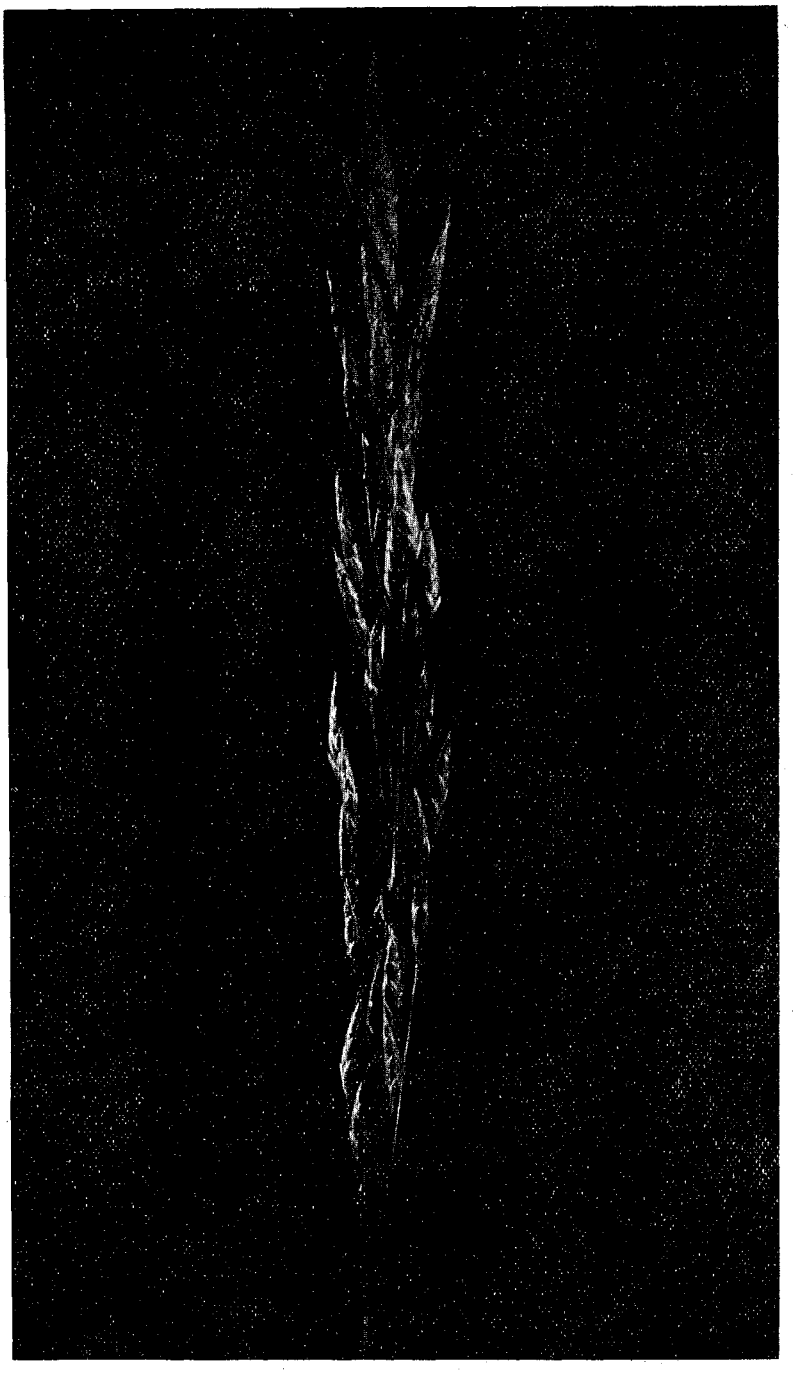


PLATE VIII.—Bromus secalinus. Young panicle with the rays not yet spread.

PLATE IX.—Bromus inermis. Mature panicles bearing ripe seeds. Two common types, an open spreading form (left), similar to Plate VI, and a dense, closely compressed type (right).

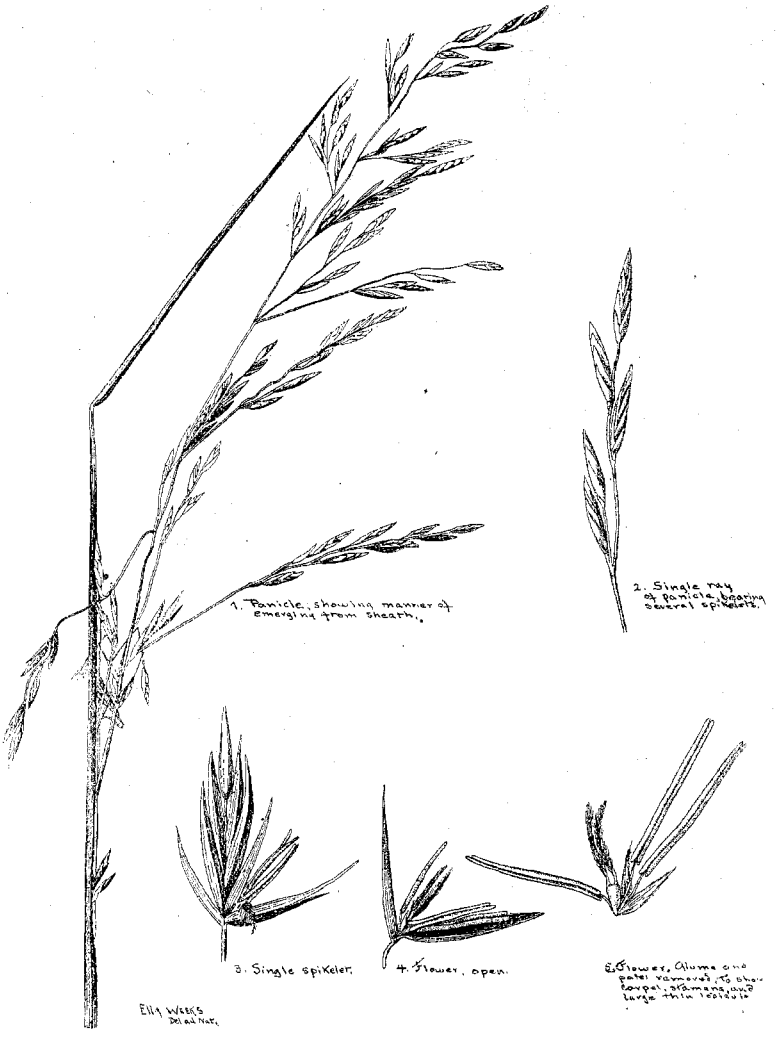


PLATE X.—Festuca elatior (English Blue-grass). 1. Panicle, showing manner of emerging from sheath. 2. Single ray of panicle bearing several spikelets. 3. Single spikelet. 4. Flower, open. 5. Flower: glume and palet removed to show carpel, stamens, and large, thin lodicules.

PLATE XI.—Festuca elatior (English Blue-grass). Panicle at commencement of blooming period.

PLATE XII.—Festuca elatior (English Blue-grass). Panicle in full bloom.

distinguish the plants of English Blue-grass from those of an annual like cheat.

With respect to the commercial seeds of Hungarian Brome-grass and cheat, there need not be the slightest difficulty. The individual spikelets of Hungarian Brome-grass are narrow and linear, with the flowers and finally the seeds lying closely pressed

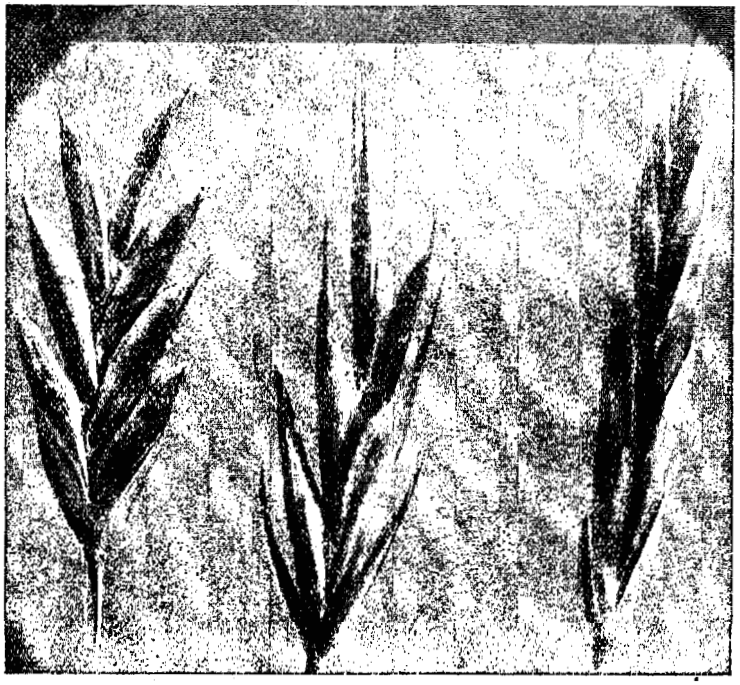


PLATE XIII.—Spikelets of Bromus inermis (right); Bromus secalinus (left); (in center, a spikelet of another species of Bromus not referred to in this bulletin). Magnified 3 times.

against the rachilla, while in cheat the spikelets are broad, with spreading flowers. (See Plate XIII.) The seeds of Bromus inermis are long, very flat, with prominent ribs or veins on the flowering glumes, and the latter are without awns or beards. Cheat seeds are commonly not more than two-thirds as long as those of Bromus inermis, are fuller and plumper, and the glumes are bearded, although in threshing the awns are frequently rubbed off. (Plate XIV.) Comparison of Plates XV and XVI and of the higher magnification in Plates XVIII and XIX, will suffice for the point in question.

The real difficulty lies in distinguishing the commercial seeds of cheat fromthose of English Blue-grass, which they certainly at

first sight, and superficially, greatly resemble. It is on this account that cheat has been so often and so successfully sold for the seed of this species. As a matter of fact, the seeds of cheat are somewhat larger and very much plumper than those of English Blue-grass, and have bearded glumes, while the latter have not. Under a lens magnifying about fifteen diameters, it will be seen

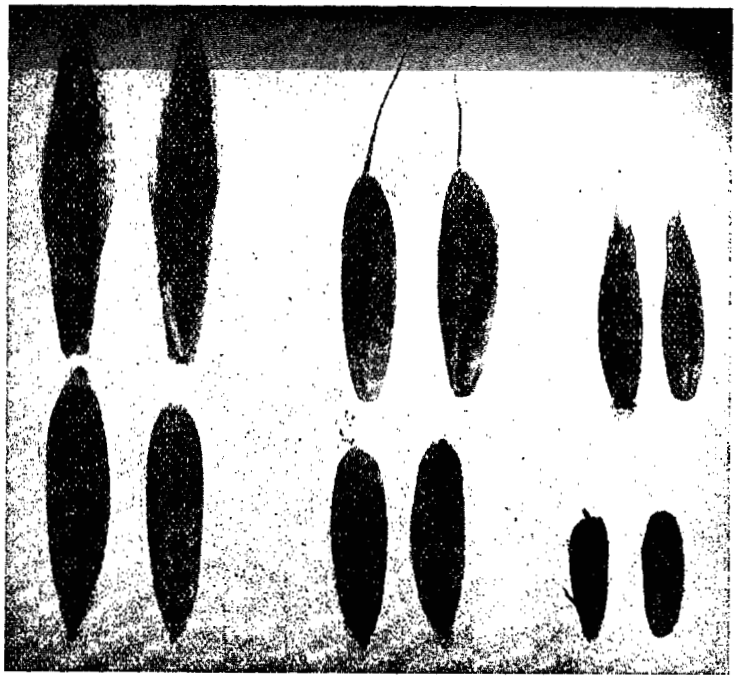


PLATE XIV.—Seeds of Bromus inermis (left); Bromus secalinus (Cheat), (center); Festuca elatior (English Blue-grass) (right). Upper row of seeds enclosed in glumes (the commercial "seed"); lower row, the seeds proper removed from the glumes. Magnified 4 times.

that the cheat seed is greatly swollen about the middle, due to the flaring out of the flowering glume, which is strongly curved to form a very deep furrow on the inner face of the seed, and is provided with a row of curved teeth running upward along the edge of the flowering glume. Compare Plates XVI and XVII, and the higher magnification in Plates XIX and XX; and see also Plate XIV. It seems unlikely that any difficulty need arise in distinguishing cheat from Hungarian Brome-grass and English Blue-grass that may not be solved by referring to the illustrations of the species herein as explained by the text.

KENTUCKY AND CANADIAN BLUE-GRASS

In Bulletin 84, Bureau of Plant Industry, United States Department of Agriculture, appears the statement (p. 10: "The seed of Canada Blue-grass is the only kind used as an adulterant of Ken-

PLATE XV.— Bromus inermis, commercial seeds. Magnified 4 times.

tucky Blue-grass in this country. During the year 1904, 649,451 pounds of Canada Bluegrass seed were imported from Canada, practically none of which is being sold under the true name. Among the samples of seed sold for Kentucky Blue-grass, and sent to the Seed Laboratory for examination, a large number have

contained from thirty to fifty per cent of Canada Bluegrass seed, and several have been entirely composed of the Canada seed."

Poa compressa is cheaper than Poa pratensis, the price of seed of the former in the New York market being $10.00 per 100

PLATE XV1.—Bromus secalinus (Cheat) **seeds.** Magnified **4 times.**

pounds as against $14.00 per 100 pounds for that of the latter. In view of these facts, and of the general inferiority of Canadian Blue-grass to the other species, it is advisable for Kansas farmers to be placed on their guard with respect to the seed sold for Kentucky Blue-grass.

From the 14th Biennial Report of the Kansas State Board of Agriculture, Vol. XIX, 1903-'04, pp. 992-3, is derived the information that the acreage in blue-grass in 1903 was 311,418, and had risen in 1904 to 388,961, an increase of 77,543 acres, or 26 per

PLATE XVII.—Festuca elatior (English Blue-grass), commercial seeds. Magnified 4 times.

cent. Such a rapid increase in the blue-grass acreage in this State necessitates vigilance on the part of the Experiment Station with respect to the genuineness and quality of the seed sown.

The two species of blue-grass are not difficult to distinguish in the field. Both are perennial from horizontal creeping rootstocks

or underground stems. Kentucky Blue-grass has cylindrical, smooth, rather stout stems, from 12 to 24 inches, rarely 4 to 48 inches in height, its panicle being from 2/5 to 8 inches, usually about 4 inches long, pyramidal in shape, usually loose and open,

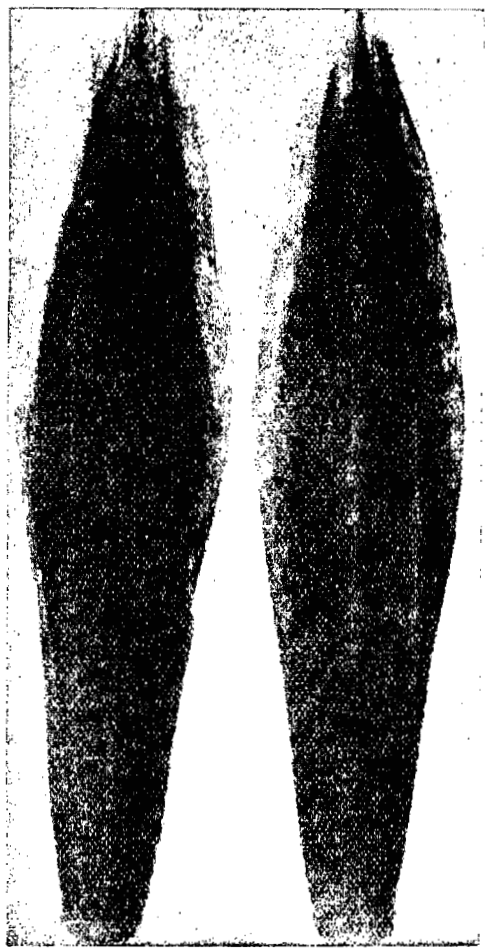


PLATE XVIII.—Bromus inermis, seeds in glumes. Magnified 15 times.

with spreading ray branches which grow from the main axis in half-whorls of from three to six in a place, and which are densely flower-bearing in the upper half of the panicle.

Canadian Blue-grass is generally of pronouncedly shorter habit than other species. The flowering stems may be from 12 to 24 inches tall which is indeed the average range of height for Kentucky

Blue-grass. In most cases, however, Canadian Blue-grass is noticeably shorter, usually about 6 inches tall, perhaps because it is more often found growing on poor, dry soils, on which Kentucky Blue-grass would not grow. The habit of growth of the flowering stems is different, since they have quite a marked tendency to prostrateness, at first, and are very much flattened instead of cylindrical. The color of the plants is distinctly of a dark blue-green,

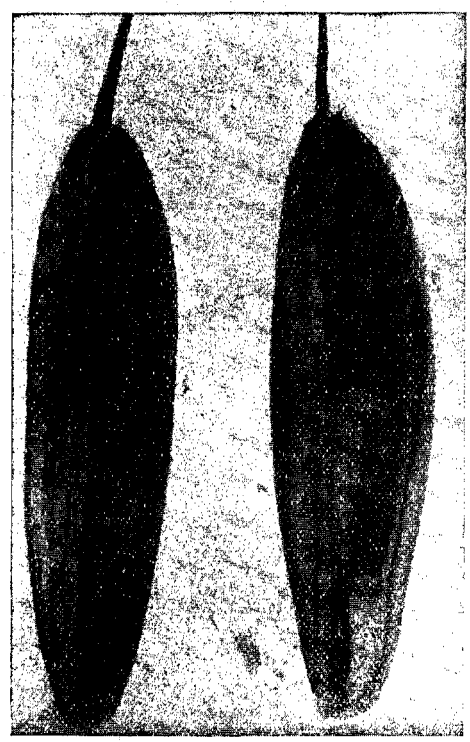


PLATE XIX.—Bromus secalinus, seeds in glumes. Magnified 15 times.

and contrasts quite sharply with the brighter "grass-green" Kentucky Blue-grass. The flowering heads or panicles are usually somewhat compressed or contracted, somewhat narrowly oval in outline, 2 to 4 inches long, and bearing the lower rays in pairs or singly, the middle ones being in 2's or 3's. The rays are moreover spikelet-bearing nearly to their bases.

Plates XXI, XXII and XXIII show successive stages in the development of the panicle of Poa pratensis, while Plate XXIV shows an early stage in Poa compressa; the later flowering stages differing but little in their general aspect.

It is, however, with the commercial seeds of the two species that the difficulty arises. A comparison of Plates XXV and XXVI and of the higher magnification in Plates XXVII and XXVIII will make evident some of the difficulties attendant upon distinguishing the seeds of the two species. The writers of this bulletin, after a most careful and exhaustive study of authentic seeds of the two species, are convinced that while the botanical characters which are stated

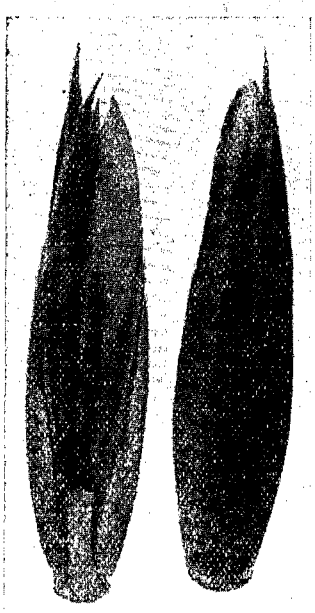


PLATE XX.—Festuca elatior (English Blue-grass). Magnified 15 times.

to occur as differentiating marks do present themselves to a greater or less extent, and to a greater or less degree; none of them can be relied upon absolutely and constantly in all cases.

In Bulletin 84, Bureau of Plant Industry, previously referred to, entitled, "The Seeds of the Blue-grasses (1905), there is the most thoroughgoing and elaborate treatment of the botanical characters of the seeds of the commercial species of Poa to be found anywhere. From the results of the careful diagnoses made by the authors of the bulletin in question, they present (p. 20) a comparative table of the characters of nine species of blue-grasses, which will be discussed later in detail.

In Bulletin 124, from the Kentucky Experiment Station (March 1906), it is stated (pp. 4-5): "Seeds of Kentucky Blue-

grass seed when in a mass are of a deeper brown color than Canada Blue-grass, and average larger. Examples measure from .10 to .15 inches in length, are sharply keeled along the back, the

PLATE XXI.—Poa pratensis (Kentucky Blue-grass). Panicle in early bloom; rays still upright. Slightly reduced.

sides with two evident longitudinal veins. The greatest width of a seed is toward the base, and from this point it tapers gradually to the pointed tip. Canada Blue-grass seeds measure only .08 to .09 inches in length, and widen toward the tip, being widest

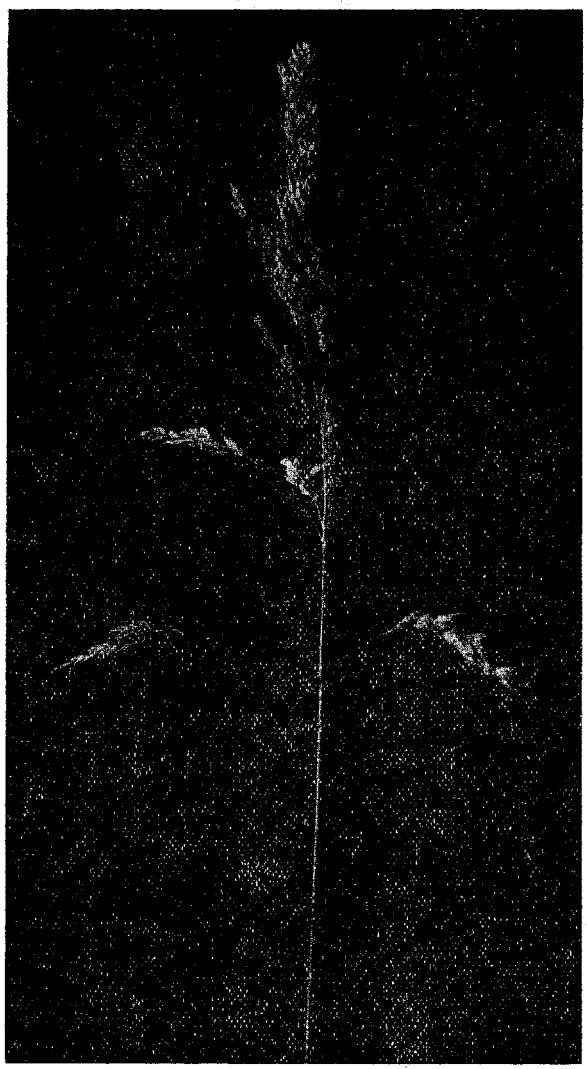


PLATE XXII.—Poa pratensis (Kentucky Blue-grass). Lower rays of panicle spreading, panicle approaching full bloom. Slightly reduced.

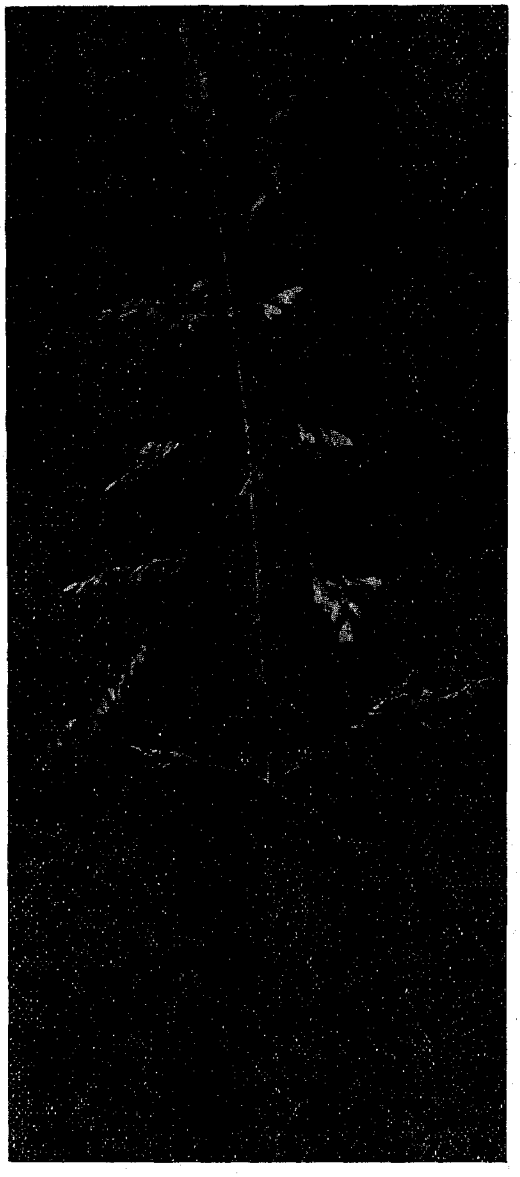


PLATE XXIII.—Poa pratensis (Kentucky Blue-grass). All the rays of the panicle spread and in full bloom. Slightly reduced.

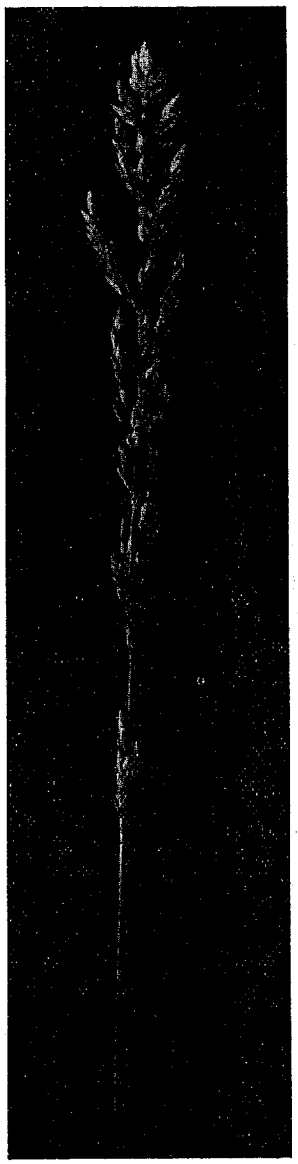


PLATE XXIV.—Poa compressa (Canadian Blue-grass); panicle about half in bloom. Note the shorter rays and the close, narrow, compressed habit of the head, as compared with the loose, open spreading panicle of Kentucky Blue-grass.

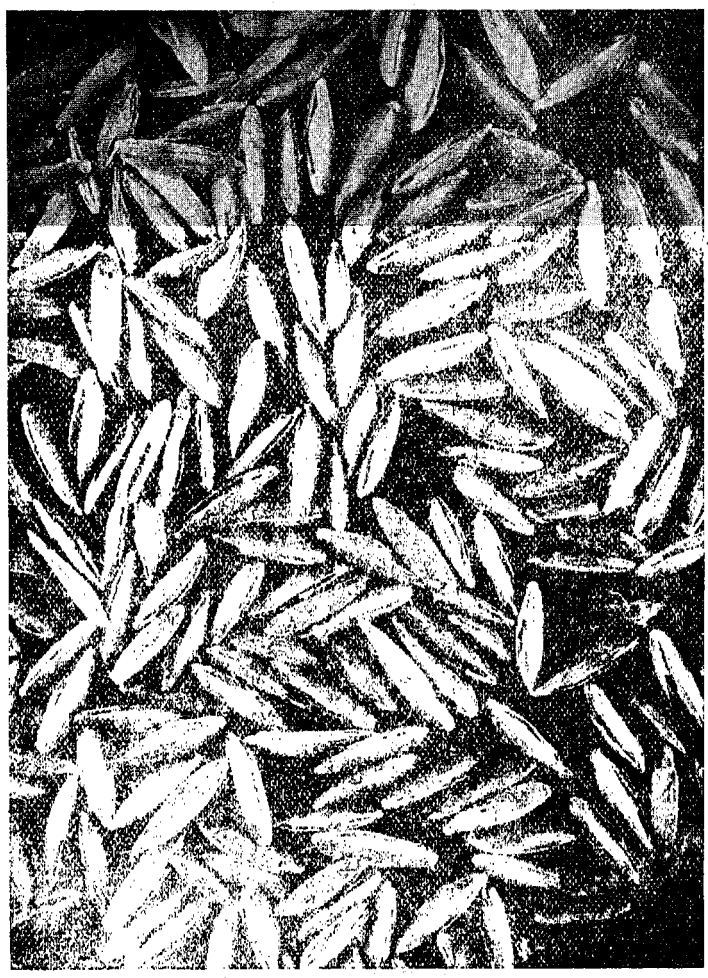


PLATE XXV.—Poa pratensis (Kentucky Blue-grass); commercial seeds magnified 5½ times.

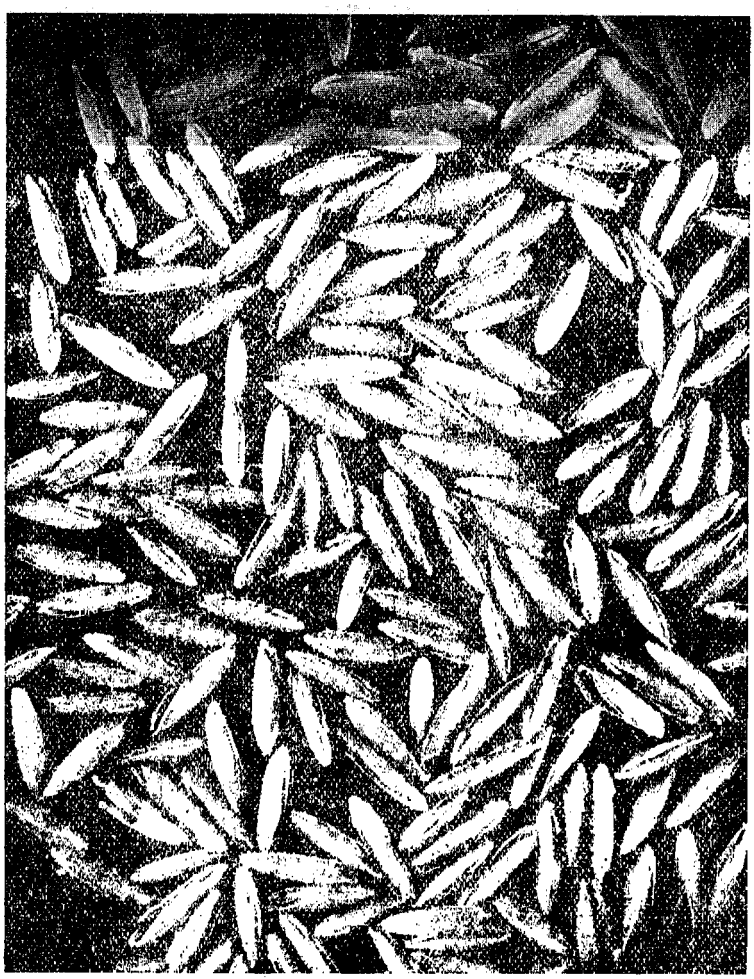


PLATE XXVI.—Poa compressa (Canadian Blue-grass); commercial seeds magnified 5½ times.

PLATE XXVII.—Poa pratensis (Kentucky Blue-grass); commercial seeds magnified 12¼ times.

PLATE XXVIII.—Poa compressa (Canadian Blue-grass); commercial seeds magnified 12¼ times.

toward the beginning of the terminal fourth. The nerves on the sides are faint or almost wanting, the keel less acute, the sides being more sloping, while the membranous margins at the tip are commonly more flaring," To state that the seeds of Poa pratensis average larger than those of Poa compressa is correct. It is incorrect, however, if it assumed that the differences in this case can be successfully utilized for purposes of identification.

From measurements made in this laboratory, of 100 seeds of each species, we find an average length and width of commercial seeds as follows:

	Length		Width	
	Millimeters	Inches	Millimeters	Inches
Kentucky Blue-grass.....	2.318	0.0913	.60	0.2364
Canadian Blue-grass.....	2.296	0.0905	.56	0.2206

This indicates the very slightly larger size of the seed of Kentucky Blue-grass; the range and the mean lengths and widths will be readily seen from the following table, compiled from the measurements:

Measurements of 100 florets (commercial seeds), of Poa pratensis and Poa compressa

Lengths in millimeters	No. of individuals		Widths in millimeters	No. of individuals	
	Poa pratensis	Poa compressa		Poa pratensis	Poa compressa
1.70–1.80	1	1	.46	2	0
1.80–1.90	1	1	.47	0	1
1.90–2.00	8	2	.48	0	0
2.00–2.10	8	11	.49	1	2
2.10–2.20	14	12	.50	3	7
2.20–2.30	19	31	.51	3	4
2.30–2.40	12	14	.52	7	10
2.40–2.50	18	12	.53	3	9
2.50–2.60	8	10	.54	9	9
2.60–2.70	5	3	.55	2	9
2.70–2.80	3	1	.56	3	9
2.80–2.90	3	2	.57	4	3
2.90–3.00	0	0	.58	5	11
			.59	7	8
			.60	2	4
			.61	6	2
			.62	9	3
			.63	1	1
			.64	5	2
			.65	4	3
			.66	3	0
			.67	6	0
			.68	5	1
			.69	2	1
			.70	2	0
			.71	5	0
			.72	1	1
			.73	0	0

Let us return to consider the sets of contrasting characters given for Kentucky and Canadian Blue-grass in U. S. Bulletin 84, p. 20, which is given below.

Comparison of the principal distinguishing characters of Blue-grass seeds

Species	Florets				Glume				Palea	Rachilla segment	Aborted floret
	Number in spikelet	Length in millimeters	General form	Apex	Intermediate veins	Silky pubescence	Basal web	Color			
P. pratensis.	3–5	2–2¾	Lanceolate or ovate-lanceolate.	Acute, mostly torn in commercial seed.	Distinct; not sharply defined, slender ridges; smooth.	On keel and marginal veins; absent in commercial seed.	Well developed; absent in commercial seed.	From light brown to dark brown, often purplish.	Equal to or somewhat shorter than the glume; keels hispid-ciliate and more or less exposed.	$\frac{1}{6}$ to $\frac{1}{3}$ the length of glume; smooth.	Minute.
P. compressa.....	3–9	2–2½	Oblong-obovate or lanceolate.	Usually obtuse; torn or flaring in commercial seed.	Indistinct or apparently wanting; smooth.	Same as in P. pratensis.	Slight; absent in commercial seed.	Straw colored or light brown, sometimes purplish.	Same as in P. pratensis.	$\frac{1}{5}$ to $\frac{1}{2}$ the length of glume.	Minute.

With respect to the number of florets in a spikelet and their length, it will be seen at once that the differences are not such as to be decisive in any individual case. With respect to the matter of the length of the florets (the commercial seeds), it may be said that there is a racial tendency to greater size in the case of Kentucky Blue-grass; but for purposes of determination in any specific instance the difference in this particular is not a distinguishing character, as we have stated before.

The length of the rachilla segment falls into the same category of differences which are not distinctive.

The web of hairs at the base of the floret, well developed in Kentucky and slight in Canadian Blue-grass, is absent in both cases in commercial seed, having been rubbed off in the threshing.

Omitting the characters of silky pubescence and aborted floret, which are identical with the two species, we come to the matter of general form, apex, intermediate veins, and color, in which more or less contrasting characters are given.

First, with respect to the general form of the seed, the terminology used expresses the general fact stated both in Kentucky Bulletin No. 124 and in the bulletin under consideration (p. 19). in which for Kentucky Blue-grass it is stated that the seeds are "contracted at the apex and not wider above than below the middle," and for Canada Blue-grass that the seeds are "broader above than below the middle." (See Plates XXVII and XXVIII.) This distinction may again be used in describing racial tendencies in point of structure, which holds good in the long run, and with the examination of a sufficient number of seeds, but which fails repeatedly according to the studies of the writers hereof when sought, to be applied to individual cases.

With respect to the apices of the seeds of the two species, this much may be said: the flowering glume in Kentucky Blue-grass usually narrows down to a more acute tip than in Canadian Blue-grass, and the thin, papery margin of the glume is usually wider and more flaring in the latter than in the former species. While this is a distinction that does exist in the long run and for adequate numbers, it also fails in specific instances, especially in threshed seed, in which the flaring edges of the glume are apt to be rubbed off. Furthermore, the writers repeatedly find Poa pratensis seeds with the glume margins as widely flaring as in the Canadian species.

A further distinguishing character relied upon for systematic purposes in Bulletin 85 and elsewhere is the degree of distinctness of the intermediate veins on the flowering glumes. In all the spe-

cies of Poa there are five veins, which run lengthwise of the flowering glume. The middle one along the keel and the two marginal ones at the edges of the glume where the latter folds under to enclose the palet are usually sufficiently evident. But between the central and marginal veins are two intermediate veins which vary in distinctness in different species. In Bulletin 84 referred to, these intermediate veins for Kentucky Blue-grass are stated to be "distinct; not sharply defined," while for Canadian Blue-grass the same veins are stated to be "indistinct or apparently wanting." To tell whether in a given case certain structures which are "not sharply defined" are really "distinct" or "indistinct" is a refined process that obviously has practical difficulties in the way of its successful use for the purpose of distinguishing species. The writers of this bulletin, after careful comparison, find that the differences in the venation of the flowering glumes are really just about as described above, and for that reasoncannot be successfully employed for practical purposes. Reference to Plates XXIX and XXX will suffice to indicate the facts. In Poa pratensis, the intermediate veins, as a matter of fact, are sometimes distinct and sometimes indistinct; but in the long run again, and for a sufficient number of cases, they are less indistinct or even more distinct than in Poa compressa.

With respect to the matter of color of the commercial seed as a basis of distinction between Kentucky and Canadian Blue-grass it may be stated, as in Bulletin 84 of the Bureau of Plant Industry, and in Kentucky Bulletin 124, that given the proper conditions for ripening, maturing and storing the seed, Canadian Blue-grass seed is in the mass lighter'brown in color than that of Kentucky Blue-grass. But to quote again the distinctions in Bulletin 84, where, for Kentucky Blue-grass, the color of the seed is stated as "from light brown to dark brown, often purplish," and for Canadian Blue-grass as "straw color or light brown, sometimes purplish," it is again evident that we are dealing with a character that is indistinctly distinct in the one case and distinctly indistinct in the other.

The simple fact is that usually the commercial seed of Kentucky Blue-grass will be darker brown than the seed of Canadian Blue-grass. This assumes, however, proper conditions during the maturing, harvesting and storage of the seed. In our specimens we have not found the color differences in the commercial seed as they come on the market reliable for diagnosis in most instances, although the differences are existent as botanical facts

under proper conditions, and for the most of the seeds in the long run.

It must be stated, however, in deference to the accurate and careful work on seeds of Blue-grasses in U. S. Bulletin 84, that

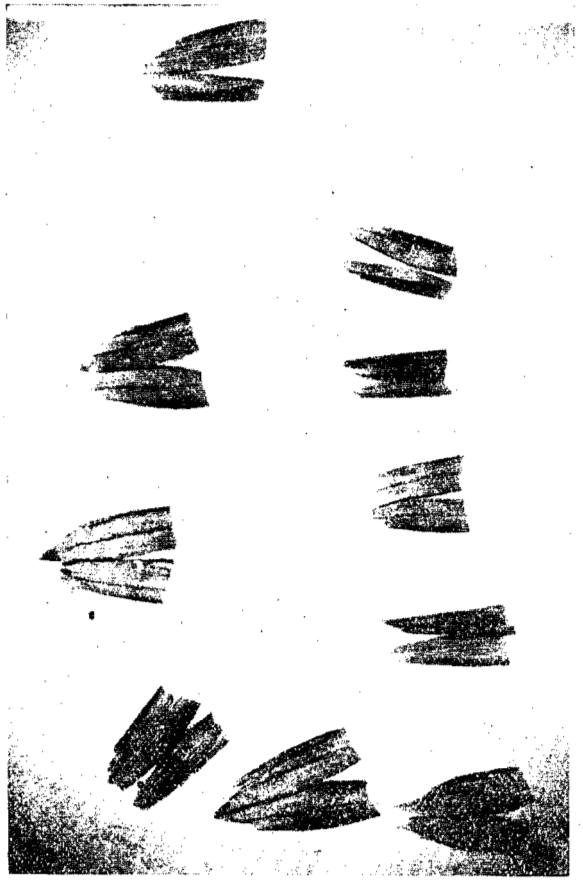


PLATE XXIX.—Poa pratensis (Kentucky Blue-grass); flowering glumes from various seeds, detached. Each of the apparent pairs represents a single glume flattened out, splitting in the process along the middle line or "keel" of the glume. The two rather prominent lines, one on either half, are the "lateral veins" of the glume. Magnified 10 times.

all of the characters given by the authors do actually exist as what may be called race tendencies in the two species under consideration, and they do serve as aids for identification, but no one of them is a constant character that can be relied upon for any given case. Many delicate shades of difference exist between species, that can be instinctively grasped and appreciated by the

experienced observer, which, however, are difficult if not impossible to put into definite language, or to offer in the form of hard and fast distinctions. Of such a nature are all, or nearly all, of

PLATE XXX.—Poa compressa (Canadian Blue-grass); flowering glumes from various seeds, detached. Each of the apparent pairs represents a single glume flattened out, splitting in the process along the middle line or "keel" of the glume. The two rather prominent lines, one on either half, are the "lateral veins" of the glume. Note that the "lateral veins" are somewhat less prominent than in Plate XXIX. Magnified 10 times.

the characters used thus far by seed experts for distinguishing the commercial seeds of Kentucky and Canadian Blue-grass,

The writers of this bulletin, after careful investigation, believe, however, that they are able to offer a distinct mark in this case that is practically infallible.

It will be observed that the tabular comparison of characters from U.S. Bulletin 84 says of the palet, that the characters are

PLATE XXXII.—Poa compressa (Canadian Blue-grass). Three palets from ripe com-

the same in both species. It is precisely here that we believe a distinction to exist that has hitherto been wholly overlooked. A careful examination of the palet in the two species shows a marked difference in the form and arrangement of the teeth on the lateral veins that we find to be constant for all cases where examined. In Poa pratensis the palet is armed with teeth set well apart, long-

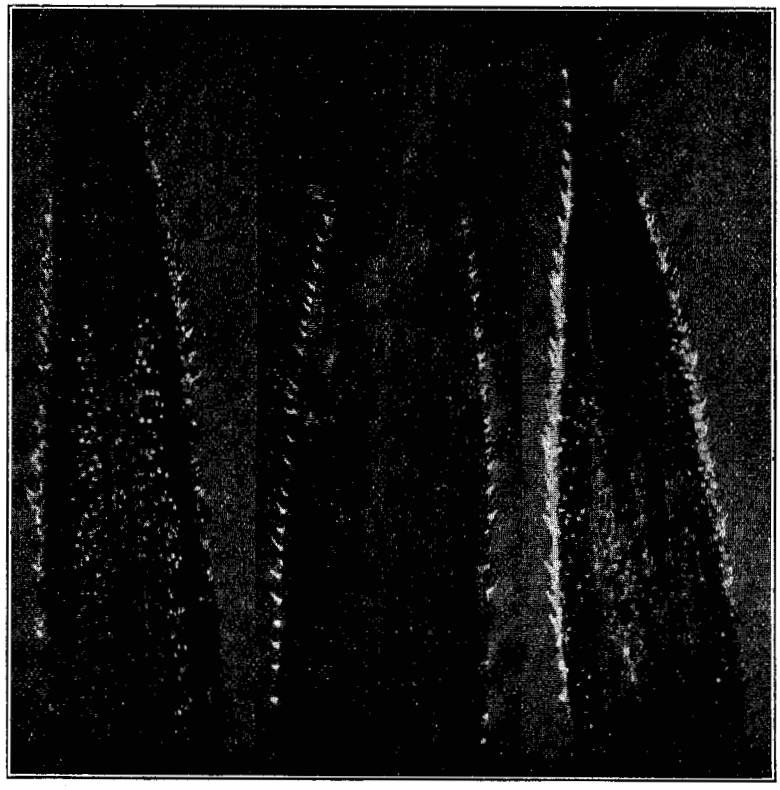


PLATE XXXI.—Poa pratensis (Kentucky Blue-grass). Three palets from ripe commercial seeds showing the form and arrangement of the teeth on the two lateral veins, here appe aring marginal. Magnified 50 times.

acuminate, standing at progressively greater distances apart as the apex of the palet is approached, and finally disappearing short of the apex (Plate XXXI); or in rare cases the teeth are wholly lacking. In Poa compressa the marginal teeth are shorter, blunter, not long-acuminate, continuous, not widely separated, becoming gradually smaller and of an equilaterally triangular form as the apex is approached; densely crowded together like the teeth of a saw, without intervening spaces, and continuing up to the very apex

of the palet, (Plate XXXII.) This difference in the form and arrangement of the marginal teeth of the palet noticed by the writers of this bulletin, and thoroughly reviewed and tested with ample and authentic material, seems to afford a distinguishing character that is valid and constant, and that appears to us to be of a more sharply contrasted and definite nature than the characters hitherto cited and generally relied upon. Details of the palets of the two

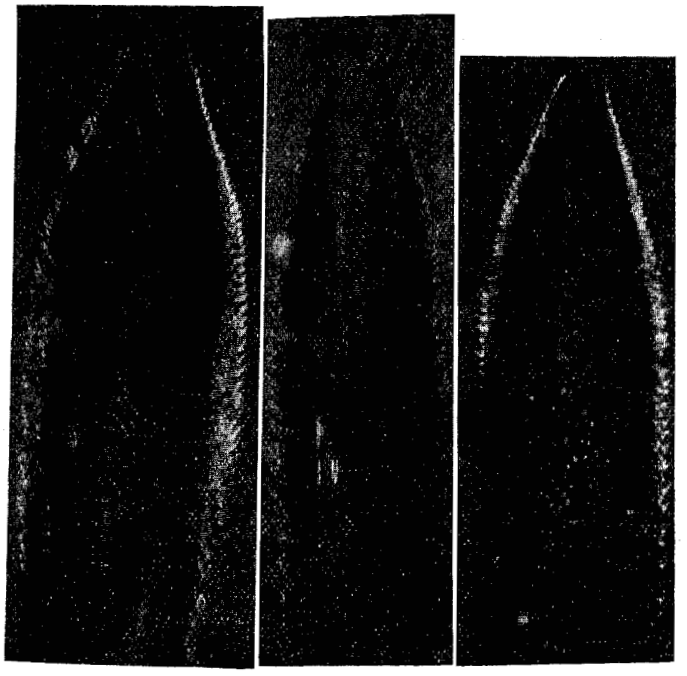


PLATE XXXII.—Poa compressa (Canadian Blue-grass). Three palets from ripe commercial seeds, showing the form and arrangement of the teeth on the two lateral veins, here appearing marginal. Magnified 50 times.

species involving the points in question are well seen in Plates XXXIII, XXXIV, and XXXV for Poa pratensis, and in Plates XXXVI, XXXVII and XXXVIII for Poa compressa.

It should be said that in all initial studies, measurements and diagnoses of seeds of the blue-grasses the specimens relied upon in the first instance, and from which all photographs and drawings in this bulletin have been made, are taken from Nos. 112 and 115 of the series of economic seeds issued from the seed laboratory of the Division of Botany, U. S. Department of Agriculture, November 15, 1898.

Comparisons have been made from herbarium material in the

Department of Botany of the Kansas State Agricultural College, and from authentic living specimens taken from plots in the botanic garden of the same department. It is therefore believed that the observations thus far made will be confirmed, and that if so, a distinguishing character has been found that will enable the Experiment Station investigators and seed experts generally, to distinguish instantly and without delay the seeds of the two species of Poa, in question.

With reference to the best manner of manipulating the seeds for observation we find that with increasing familiarity with the seeds, a magnification of 25 diameters is adequate in most cases, and for this purpose we prefer the Zeiss binocular microscope. For accurate work and careful observation, especially at first, we would recommend the use of a compound microscope, employing a magnification of about 80 diameters. At this magnification, with transmitted light, the seeds may be examined whole, preferably after dehydration with absolute alcohol, and after being mounted temporarily in clove oil, or permanently in 10 per cent Venetian turpentine. If in the latter, they should be left in a desiccator 24 hours or more to thicken the turpentine, and then be mounted in pure Venetian turpentine under a cover glass. The marginal teeth of the palet can clearly be seen in most cases by either of these two methods, using the entire seed without dissecting off the palet. If it is desired to examine the palets separately, which, of course, is necessary for more accurate work, the seeds should be boiled in distilled water in a test-tube and then cut in two, when the glumes can easily be slipped off and mounted, then dehydrated with absolute alcohol, and mounted as recommended for the seeds as entire. From the clove oil, if it is used, the palets, of course, may be mounted permanently in Canada balsam.

In conclusion, it must be said that while the ordinary observer can readily be taught to distinguish Canadian Blue-grass from Kentucky Blue-grass in the field, the writers know of no really effective and satisfactory way of distinguishing the commercial seed of the two species that can be used by an ordinary purchaser. It remains, in our judgment, absolutely a question for the expert. It is therefore earnestly recommended by the writers that, in case of doubt, samples of the seed in question be sent to the Experiment Station for examination.

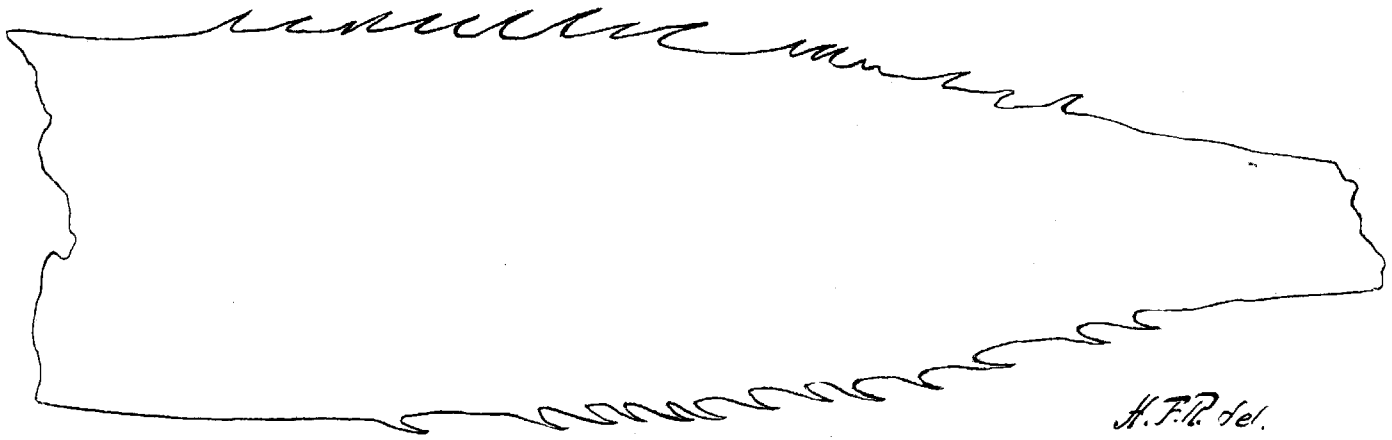


PLATE XXXIII.—Poa pratensis (Kentucky Blue-grass); palet. Drawing from Abbé camera lucida with Zeiss AA objective and compensating ocular No. 6. Magnified 110 times.

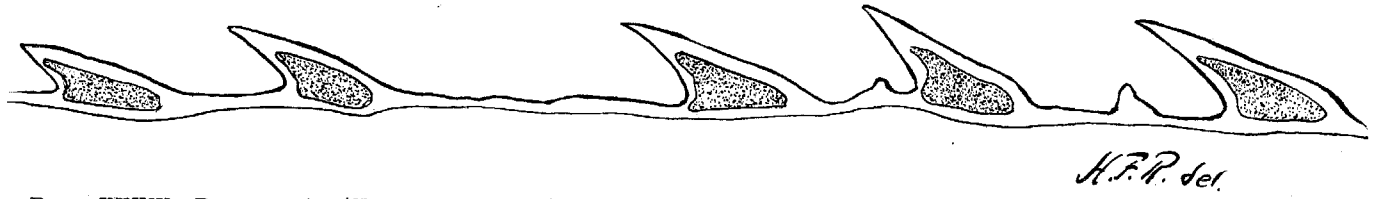


PLATE XXXIV.—Poa pratensis, (Kentucky Blue-grass). Marginal teeth of palet. Drawing from Abbé camera lucida with Zeiss 4 mm. objective and compensating ocular No. 6. Magnified 400 times.

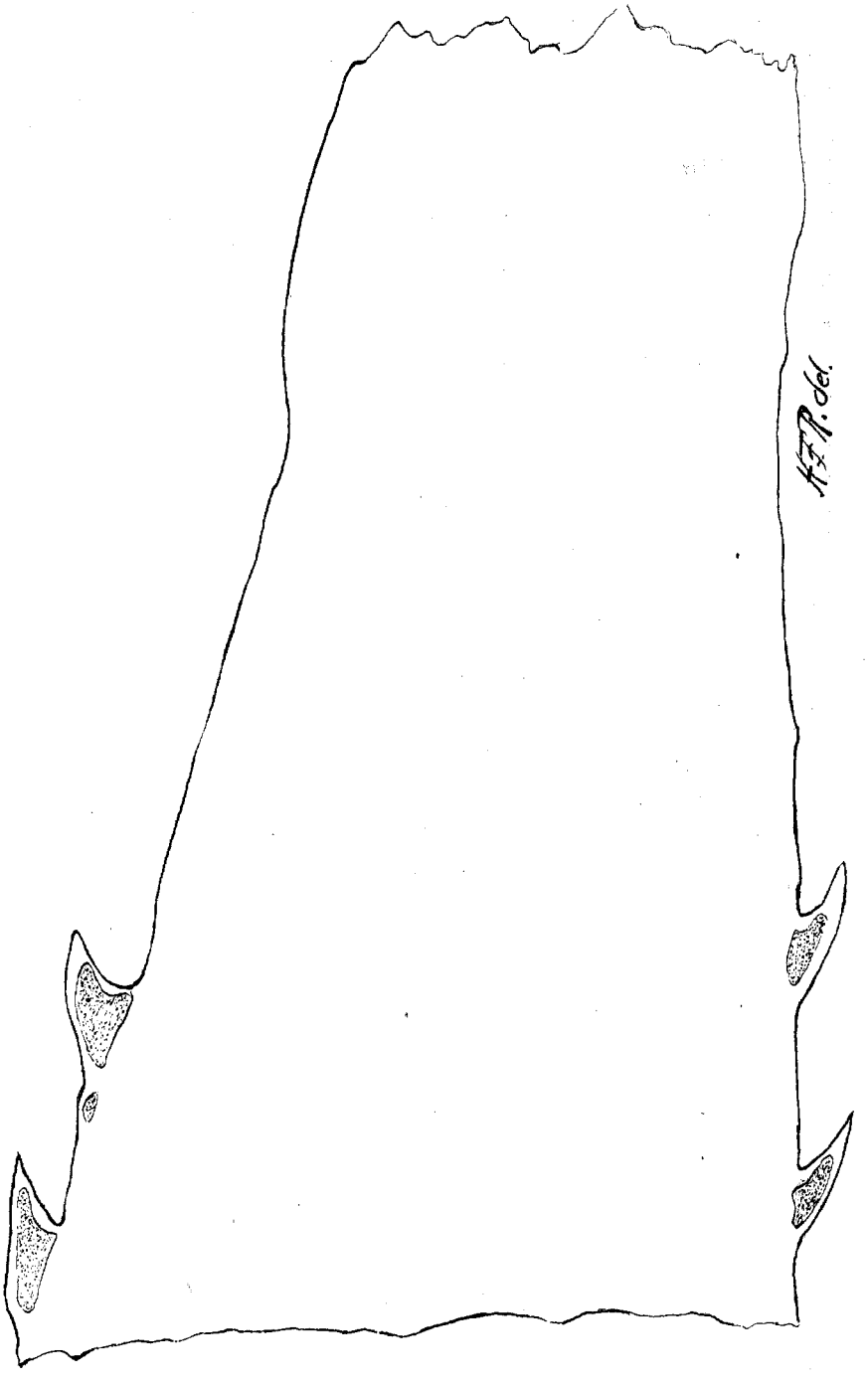


PLATE XXXV.—Poa pratensis, (Kentucky Blue-grass). Tip of palet showing the manner in which the marginal teeth disappear short of the apex. Drawing from Abbé camera lucida, with Zeiss 4 mm. objective and compensating ocular No. 6. Magnified 400 times.

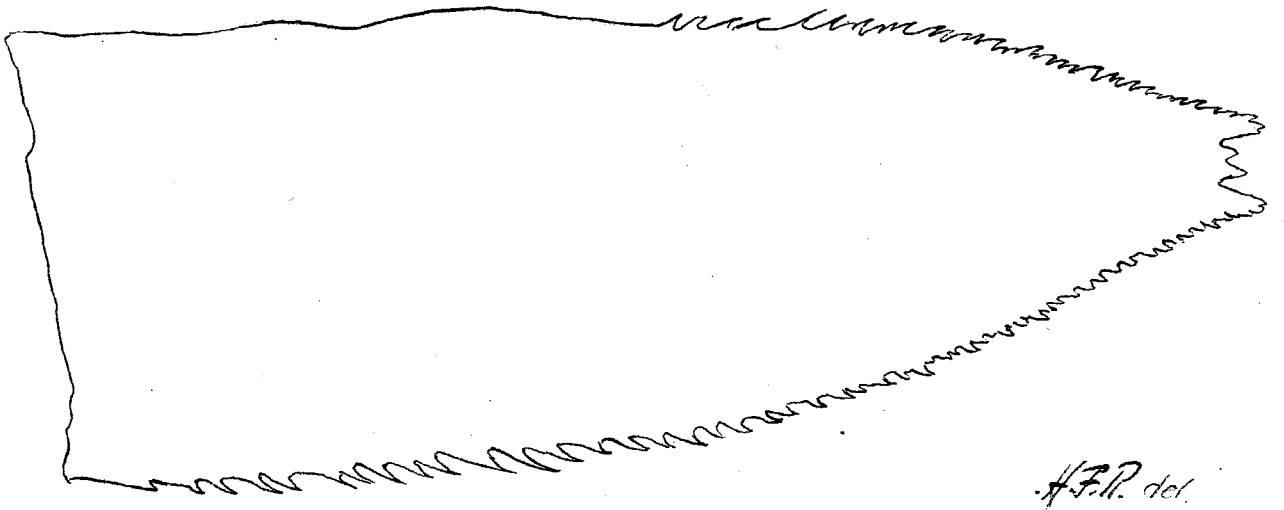


PLATE XXXVI.—Poa compressa, (Canadian Blue-grass). Palet. Drawing from Abbé camera lucida with Zeiss AA objective and compensating ocular No. 6. Magnified 110 times.

PLATE XXXVII.—Poa compressa, (Canadian Blue-grass). Marginal teeth of palet. Note their closely compacted condition, and short, tri-angular apices, as compared with the well-distanced teeth with long-acuminate apices in Poa pratensis. Drawing from Abbé camera lucida, with Zeiss 4mm. objective and compensating ocular No. 6. Magnified 400 times.

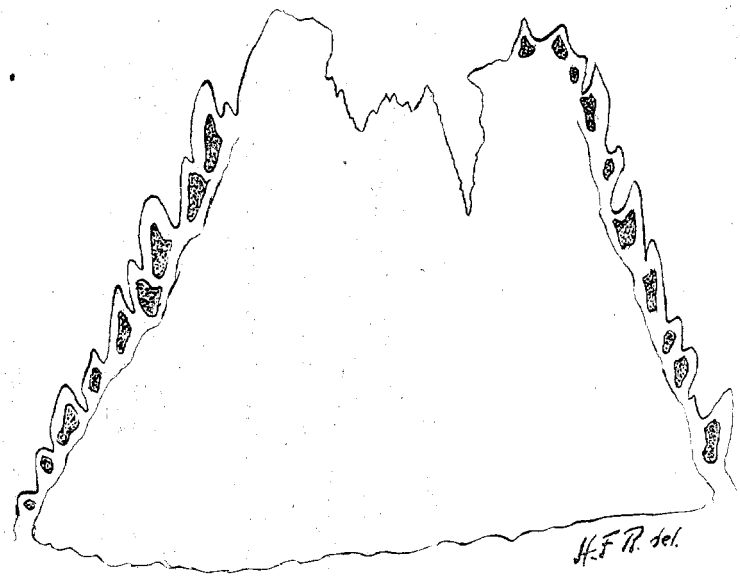


PLATE XXXVIII.—Poa compressa. (Canadian Blue-grass). Tip of palet showing the manner in which the marginal teeth continue to the extreme apex. Drawing from Abbé camera lucida, with Zeiss 4 mm. objective and compensating ocular No. 6. Magnified 400 times.