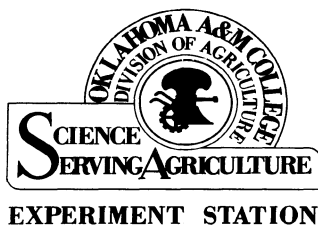


Studies on
Old World Bluestems

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in cooperation with
Field Crops Research Branch
AGRICULTURAL RESEARCH SERVICE
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What You'll Find Inside...

During the past three years the authors have been able to establish the largest experimental garden of Old World bluestems ever assembled in the Western Hemisphere. This was possible principally by the assistance of biologists and agriculturalists from throughout the tropical regions of the world and by the cooperation of the Division of Plant Exploration and Introduction, U. S. Department of Agriculture.

These materials have been studied from the standpoint of agronomic performance, morphological and cytological behavior, and potentialities in a breeding program.

In this preliminary account, certain features of the *Bothriochloa-Dichanthium* complex are discussed. The major emphasis is the morphological variation in the following species complexes: *Bothriochloa decipiens*, *B. intermedia*, *B. pertusa*, *B. ischaemum*, *B. venusta*, *Dichanthium sericeum*, *D. annulatum*, and *D. caricosum*.

The differentiation of the various complexes is outlined in a key, and the readily distinguishable types within each complex are described. Synonymy and the most popular common names are given whenever possible.

A general outline of the geographical distribution of the complexes is discussed as well as the areas that were sampled in this study.

A few general comments on the agronomic performance of the different types are made. Cytologically they all show a basic number of 5 or 10 (the lowest diploid number found was 20), and polyploids seem to exist in all species except *Dichanthium sericeum*.

C O N T E N T S

Principal Taxonomic Characters.....	7
<i>Groove in Pedicel, Relative Length of Racemes, Second Order Branching of Racemes</i>	8
<i>Pits on the Glumes, Hairs on the Pedicel and Rachis, Hairs on Glumes, Hairs on Peduncle, Shape of Glumes</i>	9
<i>Size of Spikelets, Hairs on Nodes, Growth Habit, Essential Oils, Winter Hardiness</i>	10
A Key to Selected Species of the <i>Bothriochloa- Dichanthium</i> Complex.....	11
1. <i>Bothriochloa decipiens</i> C. E. Hubb.....	11
2. <i>Bothriochloa intermedia</i> complex.....	12
3. <i>Bothriochloa pertusa</i> complex.....	22
4. <i>Bothriochloa ischaemum</i> Keng.....	23
5. <i>Bothriochloa venusta</i> A. Camus.....	24
6. <i>Dichanthium sericeum</i> A. Camus.....	25
7. <i>Dichanthium annulatum</i> complex.....	26
8. <i>Dichanthium caricosum</i> complex.....	27
Literature Cited.....	30
Appendix: Taxonomic Summary.....	31

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The genus *Andropogon* has long been recognized as important in the American grassland flora. Little bluestem (*A. scoparius*), big bluestem (*A. gerardi*), and sand bluestem (*A. hallii*), have been highly regarded as important dominants of the North American tall grass prairie formation, and of the mixed grass prairie to the west. Other species assume importance to the south, and the genus is well represented in the savannas of Central America, the campos of Brazil, and the llanos of Uruguay and northern Argentina. Some weedy members of the genus are able to grow on infertile soils of the southeast and are represented by such forms as broomsedge (*A. virginicus*), split-beard bluestem (*A. tenarius*), and others. The group as a whole is characterized by warm season, bunch grasses of tropical and subtropical affinity, some members of which are important range and pasture plants.

From time to time, Old World relatives of the American bluestems have been introduced into the Western Hemisphere. Interest has been aroused in some of these introductions because of their apparent superiority to American forms in quality, production, persistence under grazing, and ability to respond to high fertility levels. The fact that American agrostologists have usually given these introductions the name *Andropogon* has, no doubt, helped to heighten interest and curiosity in the Old World forms. In this, the American taxonomists have largely followed the tradition of Hackel (1889), Hooker (1897), Hitchcock (1935), and Chase (1951). This bulletin is not a taxonomic treatment and the authors have no desire to debate the merits of various classification systems. It is necessary, however, to apply some names to the forms described and discussed in this bulletin. In the absence of any comprehensive American treatment, the only reasonable procedure is to apply the names most commonly used in the regions from which these introductions came. It seems reasonable to assume that such taxonomists as Stapf (1919), Hubbard (1940), Camus (1922), Blake (1944), and others who have studied the group in detail would have a more satisfactory

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system of classification than American taxonomists to whom these materials are occasional, transient, and adventitious.

Until recently the bulk of the Old World introductions have reached the Western Hemisphere by accident. Perhaps the first recorded introduction was that of "hay grass" to the West Indies. C. A. Barber reported in the Leeward Islands Gazette of October 4, 1894 that he had found a grass on the island of Antigua locally called hay grass. He adds:

Specimens sent to Jamaica and Kew for identification were differently named, but assuming the Kew determination to be correct, it appears to be *Andropogon caricosus*. I do not at present know it in any other West Indian islands, and some surprise was expressed at Kew at its presence in Antigua, because it is an East Indian species.

—Hynam and Hutson, 1944.

Kew would probably classify the specimen today as *Dichanthium caricosum*, but, at any rate, the grass has spread widely throughout the West Indies including Cuba, and some types are being tried out in southern Texas. Another early introduction to the West Indies is *Bothriochloa pertusa*, which is locally called "hurricane grass" and which also shows some promise along the Gulf Coast of the U. S.

In 1917, a *Bothriochloa ischaemum* was introduced into California from Amoy, China. Records show that it made its way from California to Washington, D.C. (1932), to Stillwater, Oklahoma (1935), to Woodward, Oklahoma (1937), and to College Station, Texas (1937), where it was eventually released as Texas Yellow Beardgrass (1949). In the meantime, it had also gone to the Angleton Experiment Station in Texas (1924). It apparently went from there to the King Ranch in Texas where it was first noticed by Mr. Nico Diaz in 1937, then increased and propagated by the Soil Conservation Service and private growers as King Ranch bluestem. Also in 1937, an adventitious form of the same species was found in Elk County, Kansas, by Mr. Don Cornelius, increased, tested, and eventually released as the Elkan variety of *Bothriochloa (Andropogon) ischaemum*.

Another introduction whose history can be traced is that of Caucasian bluestem, (*B. caucasica*). It was received by the U. S. Department of Agriculture from the director of the Botanic Garden, Tiflis, Caucasus, Russia, on February 4, 1929. It was first grown in the Great Plains at the Texas substation No. 12, Chillicothe, Texas. Increase and distribution was made primarily by the Soil Conservation Nursery at Manhattan, Kansas, under the number K. G. 40.

A form of *Dichanthium caricosum*, first grown at the Angleton Station, Texas in 1915, has been called Angleton bluestem. Other common names applied in south Texas to some of the Old World bluestems are: Medio bluestem for a type of *D. caricosum*, Diaz bluestem or Kleberg bluestem for a form of *D. annulatum*, silky bluestem for several types of *D. sericeum*, and Camagueyana for a type of *B. pertusa*.

In many cases these introductions have been far superior to native species in productivity, persistence under use, aggressiveness, and, in some cases, forage quality. Because of the apparent promise of the group as a whole, the authors began a survey of available material in 1952. By extensive correspondence with workers in Europe, Africa, Asia, Australia, and the East Indies, the largest collection of Old World bluestems ever assembled in the Western Hemisphere was brought together and grown in the nurseries of the Agronomy Department at Stillwater, Oklahoma. The objectives of the preliminary survey reported here were to: (1) grow the material and observe it for agronomic characteristics, (2) examine the material cytologically in order to determine chromosome number, mode of reproduction, if possible, and general affinity between members of the group, (3) survey morphological variability, and develop, if possible, reliable methods for separating the several types, and (4) assess the group from the standpoint of improvement by plant breeding.

Principal Taxonomic Characters

In order to describe the materials studied, it is first necessary to describe the important taxonomic characters which have been used in the group together with the extent to which they have been observed to vary.

The group as a whole is highly dynamic and variable, a fact which has caused considerable confusion in the literature and no little difficulty in classification. Perhaps no single character can be found that will hold absolutely for separating forms within the complex. Nearly every character so far studied in detail has been found to shade from one expression to another with various degrees of expression being shown in different accessions.

Nevertheless, there appear to be distinct natural units characterized by distinctive clusters or groupings of characters which can be readily separated from other units. These units are apparently real and can be usefully separated as species or complexes of species and, in some cases, distinct genera. A complicating feature of the variation pattern, however, is that in several cases taxa are quite distinct and readily recognizable over most of their geographic ranges. However, in one region or

another they tend to blend and converge to the point that their separation becomes dubious. This pattern is not unusual in dynamic groups such as this, but adds to the confusion where species are inadequately sampled. Descriptions in this report will be confined to forms which have been grown and observed in the nurseries, and emphasis will be placed on those for which good samplings have been obtained.

Groove in Pedicel.—Most forms assigned to *Bothriochloa* have a well defined, hyaline groove extending nearly the length of the pedicel of the pedicellate spikelet (Fig. 1). The rachis may also have the groove. No forms of *Dichanthium* have been observed with a groove (Fig. 2), and to date only one species of *Bothriochloa*, (*B. venusta*) appears to be without one. This character is one of the most stable and basic to the group, but is sometimes rather difficult to use in the field even with a hand lens. In some cases, *B. caucasica* for example, the hyaline groove is accentuated by red pigment and is very conspicuous, but in other cases the pedicel is densely bearded and the groove difficult to find. There is also considerable variation in the width and depth of the groove, but presence versus absence is a rather positive character in the materials studied.

Relative Length of Racemes.—This character is especially useful in separating species complexes within *Bothriochloa*. In the *B. intermedia* complex, the lowermost racemes are shorter than the primary axis of the inflorescence (Figs. 8, 9). On the other hand *B. ischaemum*, as well as several other species, have racemes which are usually longer than the primary axis (Figs. 10, 11, 12). This is an especially useful and basic character, and when used with the pedicellar groove serves to distinguish *Bothriochloa* from *Dichanthium* (see key, page 11). Nevertheless the raceme/inflorescence axis ratio varies considerably within species of *Bothriochloa*, and some intermediate types have appeared in the collection.

Second Order Branching of Racemes.—In some forms the branches of the inflorescence are themselves divided into secondary and tertiary branches (Fig. 7, 8, 9), while in others the primary branches bear single racemes (Figs. 10, 11, 12). This character has often been used in the literature to separate some species, but it has been observed to vary so much in expression that it is of dubious value. In general, the types with short racemes and long inflorescences exhibit considerable secondary branching, those with long racemes and short primary axes show much less secondary branching, but intermediates render the character of doubtful value.

CORRECTION NOTE: On this page, third paragraph, starting with the fifth line, copy should read: *nulatum* by this character than by the pedicellate groove which is the more positive "key" character. In *B. ischaemum*, the glumes have short,...

Pits on the Glumes.—A strong tendency for pitting of the glumes is found throughout *Bothriochloa*, but not in *Dichanthium*. Some forms have as many as three deep, sharply defined pits, others have two pits (Fig. 3), and some only one (Fig. 4). Some have pits only on the sessile spikelet, others on both sessile and pedicellate. However no cases were observed with pits on the pedicellate spikelets and no pits on the sessile ones. The number of pits may vary somewhat from glume to glume in the same raceme. The sharply defined pits grade, in certain forms, to a dimpling, to a dishing, and finally to a faint concavity that is hardly perceptible. This may vary considerably in the same raceme, the middle spikelets often showing the highest degree of expression of the character.

Hairs on the Pedicel and Rachis.—This character is helpful, but also one of degree. Most forms have hairs of some type on the pedicels and rachises. In *B. ischaemum* the racemes have a grey or silvery appearance due principally to hairs on the rachises and pedicels. In some other forms the hairy appearance is due mostly to hairs on the glumes (Fig. 2). Thus, the character, where it can be used in the field, becomes one of hairs conspicuous vs. hairs inconspicuous.

Hairs on Glumes.—The hair patterns of the glumes is one of the most useful characters for hand lens field identification of certain forms, but it is also a character of degree, and one especially difficult to describe. It is, for instance, easier to separate *B. ischaemum* from *D. annulatum* by this character. In *B. ischaemum*, the glumes have short, more positive "key" character. In *B. ischaemum*, the glumes have short, woolly hairs on the proximal three-quarters of the glume (Fig. 5), whereas in *D. annulatum* the glumes are sparsely covered with long ciliate hairs which are often recurved (Fig. 2). *D. annulatum* can usually be separated from *D. caricosum* because of the larger number of these hairs arising from tubercles in the former. *D. sericeum* is readily distinguished from several closely related species by the arc of extremely long hairs near the apex of the lower glume of the sessile spikelet (Fig. 6).

Hairs on Peduncle.—A very useful and distinct separation of types in the *D. caricosum* complex can be made by this character. The peduncles of the *mollicomus* and *aristatum* types are densely covered with short, stiff hairs while the typical type has smooth peduncles (Figs. 16, 18, 19).

Shape of Glume.—The *Bothriochloas* in general tend toward rather narrow, pointed glumes (Figs. 3, 4, 5). This is especially marked in the *B. intermedia* complex, and somewhat less so in *B. ischaemum*. The

Dichanthiums tend toward wider, more inflated glumes (Fig. 2), becoming roughly obovate with truncated tips in the *D. caricosum* complex. This is a useful naked-eye character, but again is not definite because of intermediates.

Size of Spikelets.—In some forms the pedicellate spikelet is reduced (Fig. 1) (e.g. *B. decipiens*), and smaller than the sessile one. In other forms the two types of spikelets are subequal, while in the *mollicomus* and *aristatum* forms of *D. caricosum* the pedicellate spikelets are definitely larger than the sessile ones.

The ratio of the awn length to glume length is another spikelet character which is sometimes useful.

Hairs on Nodes.—This is another useful naked eye character although there is a considerable gradation between types and some variation between nodes on the same plant. In general there are four degrees of hairiness at the nodes: (1) glabrous, (2) very short woolly hairs on most nodes of the plant, (3) a distinct ring of short hairs at each node, and (4) a large, conspicuous ring of long hairs at each node. In some forms, there is a gradation between types one and two, but types one, three, and four are usually quite distinct (Fig. 20).

Growth Habit.—This character ranges from low growing stoloniferous creepers to erect bunch types with little regard for species or genus. As a whole, perhaps, the *Bothriochloas* have fewer spreading types than the *Dichanthiums*, but all growth forms appear in both genera and some species of both groups have both spreading and bunch forms. Among the bunch types, some forms can be readily distinguished from others by their dishlike crowns and decumbent growth.

Essential Oils.—The forage of many of the *Bothriochloas* tend to be pungent. The aromatic oils are especially strong in the *B. intermedia* complex, and often noticeable in most forms of *B. ischaemum*. Oil production is not pronounced in the *Dichanthiums* observed.

Winter Hardiness.—This character ranges from completely winter hardy to completely non-hardy in *Bothriochloa* under Oklahoma conditions. Hardy forms have been found in *B. caucasica*, *B. intermedia*, and *B. ischaemum*. To date, only a few entries of *Dichanthium* have overwintered and most of these were severely injured by cold.

This general survey of the major characters in the group should make the following key more readily usable.

**A Key to Selected Species
Of the *Bothriochloa*-*Dichanthium* Complex**

A. Pedicels of pedicellate spikelets with translucent groove
(*Bothriochloa* except *B. venusta*)

- 1. Anthers of sessile spikelet one.....1. *B. decipiens*
- 1. Anthers of sessile spikelet three
 - 2. Lower racemes shorter than primary axis...2. *B. intermedia*
complex
 - 2. Lower racemes longer than primary axis
 - 3. Sessile spikelets with distinct pits...3. *B. pertusa* complex
 - 3. Sessile spikelets without pits.....4. *B. ischaemum*

A. Pedicels of pedicellate spikelets without groove
(*Dichanthium* except *B. venusta*)

- 1. Lower racemes shorter than primary axis.....5. *B. venusta*
- 1. Lower racemes longer than primary axis
 - 2. Rachis and pedicels with long white hairs, lower glume densely covered, and with an arc of extremely long hairs at the tip.....6. *D. sericeum*
 - 2. Rachis hairs short, glume without arc of long hairs
 - 3. Stem nodes with conspicuous collar of long hairs, ligule well developed.....7. *D. annulatum* complex
 - 3. Nodes glabrous or with a band of short velvety hairs, ligule wanting or very small.....8. *D. caricosum* complex

1. *Bothriochloa decipiens* C. E. Hubb.

Common Names.—Pitted Blue Grass, Pitted Beard Grass.

Scientific Names.—*Bothriochloa decipiens* C. E. Hubb. 1934.
Andropogon pertusus var. *decipiens* Hack. (1889); *Andropogon decipiens* Domin. (1915).

Geographic Distribution.—The species is restricted to Australia where it is very widespread along the eastern coast, especially in Queensland.

Readily Distinguished Types.—Two types have been recognized by Hubbard (1934) but the two accessions grown in this study are both of the typical types.

TYPICAL.—Groove in the pedicel is extremely well developed, joints and pedicels densely covered with silvery hairs, sessile spikelets with solitary anther, quite glossy, deeply pitted, naked or sparsely covered with hairs both at the apex and the lower two-thirds. Pedicellate spikelet much smaller than the sessile one and reduced to one glume. Plants erect from small tufts, lowermost internodes with numerous stiff silvery hairs arising from a distinct gland or tubercle. Nodes glabrous, leaves small and thin, glabrous or with short hairs. The entries studied were often cleistogamous.

A very small, slender leaved, non-productive grass under Oklahoma conditions, and of questionable winter hardiness. One entry was studied cytologically and found to be tetraploid with regular meiotic divisions.

Accessions Studied.—Bellata, New South Wales, (1) and Lawes, Queensland (1).

2. *Bothriochloa intermedia* complex

Common Names.—Sundhaur; Burnett River blue grass; Poverty grass, Sour grass, Purple tassel grass, Co-co, intermediate bluestem.

Scientific Names.—*B. intermedia* A. Camus, 1930; *Andropogon intermedius* R. Br. (1810); *Amphilophis intermedia* Stapf (1916); *Bothriochloa glabra* A. Camus (1930); *Andropogon intermedius* var. *punctatus* subvar. *glaber* Hack. (1889); *Amphilophis glabra* Stapf (1917); *Bothriochloa caucasica* C. E. Hubb (1939); *Andropogon intermedius* var. *caucasica* Hack. (1889); *Andropogon caucasica* Trin. (1832).

Geographic Distribution.—This complex is one of very extensive distribution in the Old World tropics. It is rather uncommon but widely distributed throughout Africa, is found in almost all of India, Pakistan, and Ceylon but is more common in middle and north India. It is present in Assam, Burma, Malaya, Indo-China, China, and Australia. It is also found in abundance in most of the Pacific Islands.

Readily Distinguished Types.—Although there are a large number of types that have been named either as varieties or species, for the most

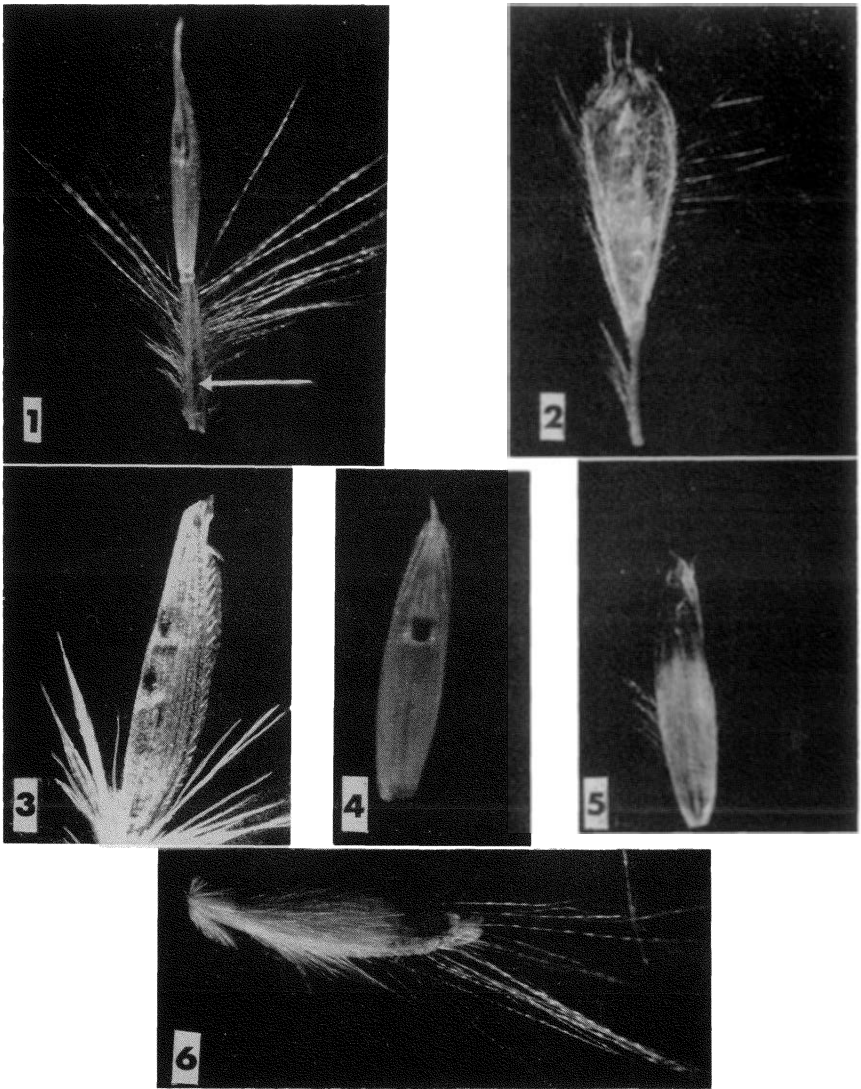


Fig. 1-6.—Spikelets of *Bothriochloa* and *Dichanthium*

Fig. 1.—Strap-like pedicellate spikelet of *B. decipiens*, A-3727 from Bellata, N.S.W., Australia, showing a deep groove in the pedicel. Fig. 2.—Obovate pedicellate spikelet of *D. annulatum*, A-4080 from Pretoria, South Africa, showing the absence of a groove in the pedicel. Fig. 3.—Pedicellate spikelet in *B. pertusa*, A-4090 from South Africa, with two distinct pits. Fig. 4.—Sessile spikelet of *B. decipiens*, A-3727, with a single deep pit. Fig. 5.—Sessile spikelet of *B. ischaemum*, A-3465 from Kayseri, Turkey, showing the absence of a pit and hairs restricted to the lower portion. Fig. 6.—Sessile spikelet of *D. sericeum*, A-3723 from N.S.W., Australia, densely covered with long hairs and with an arc of extremely long hairs at the apex.

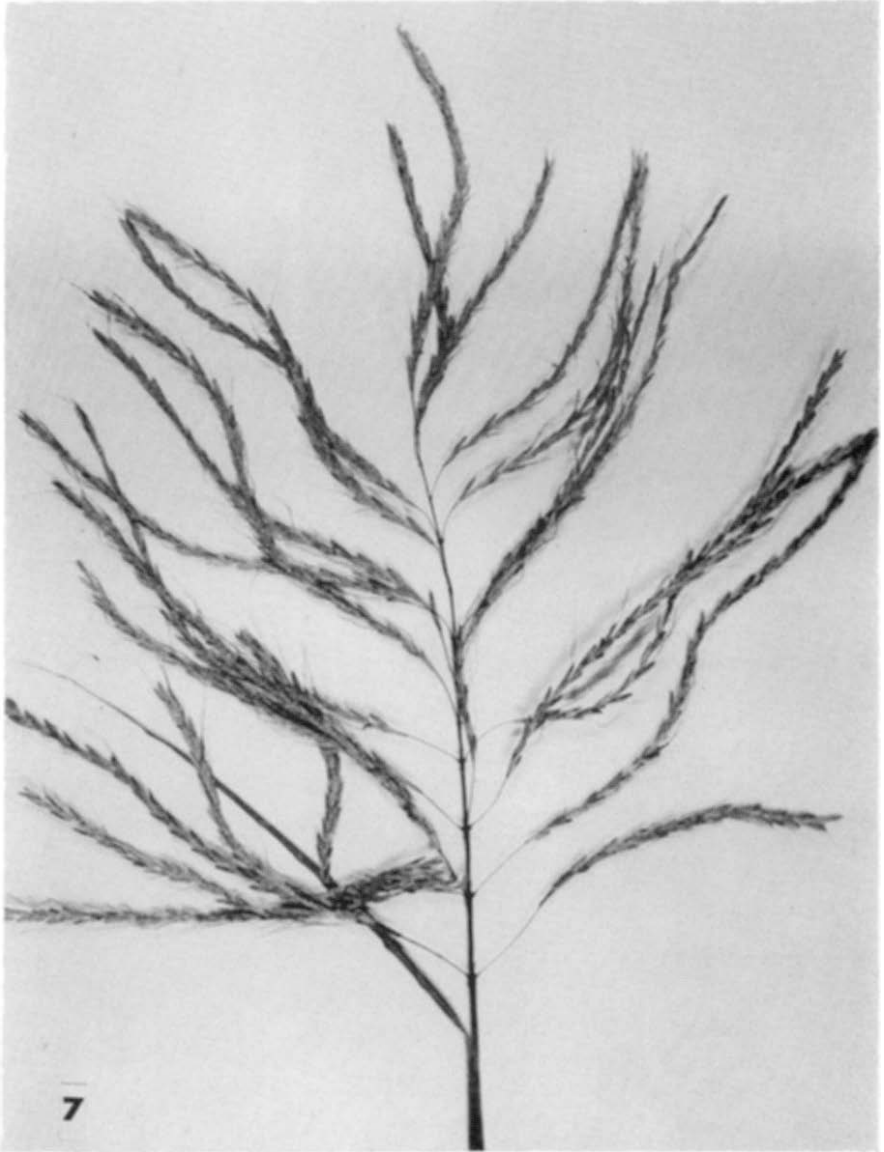
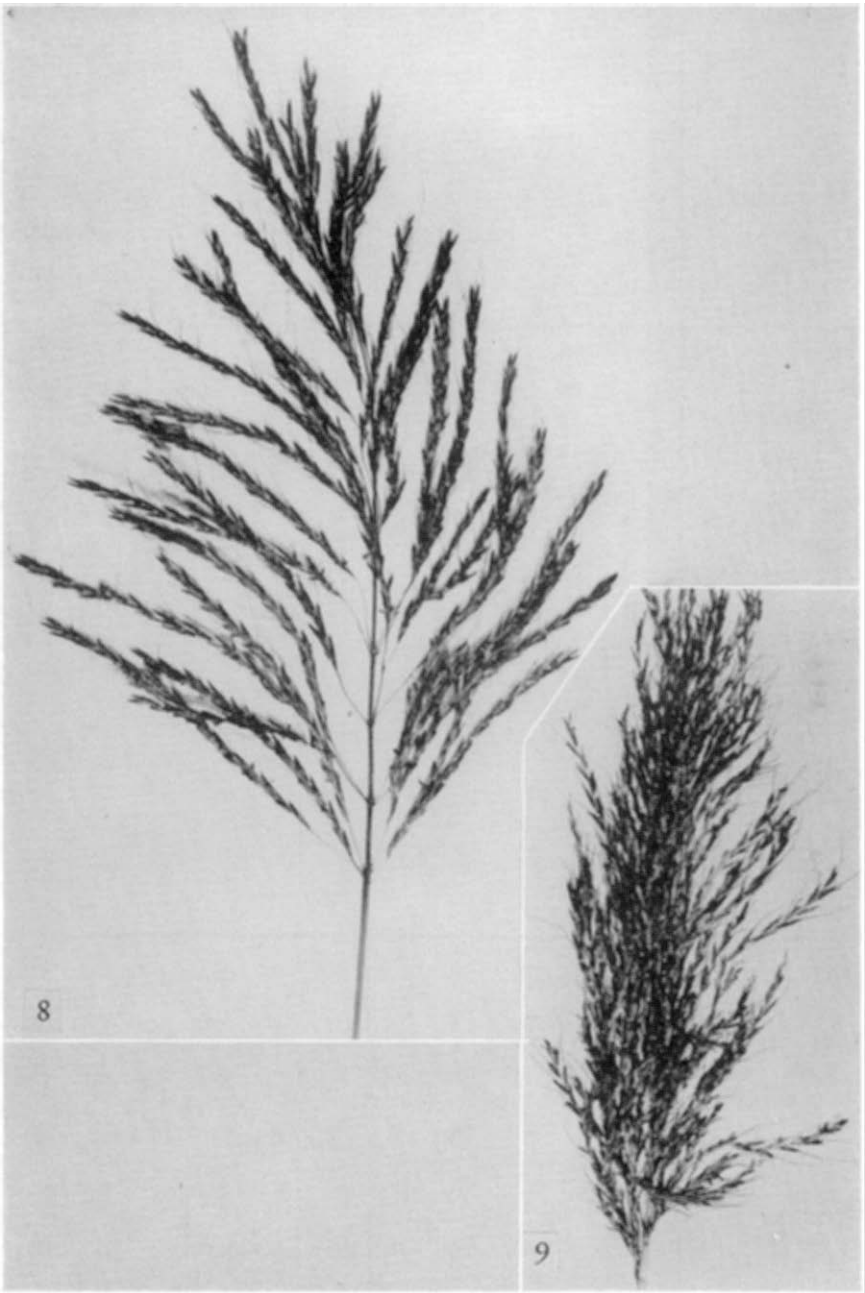


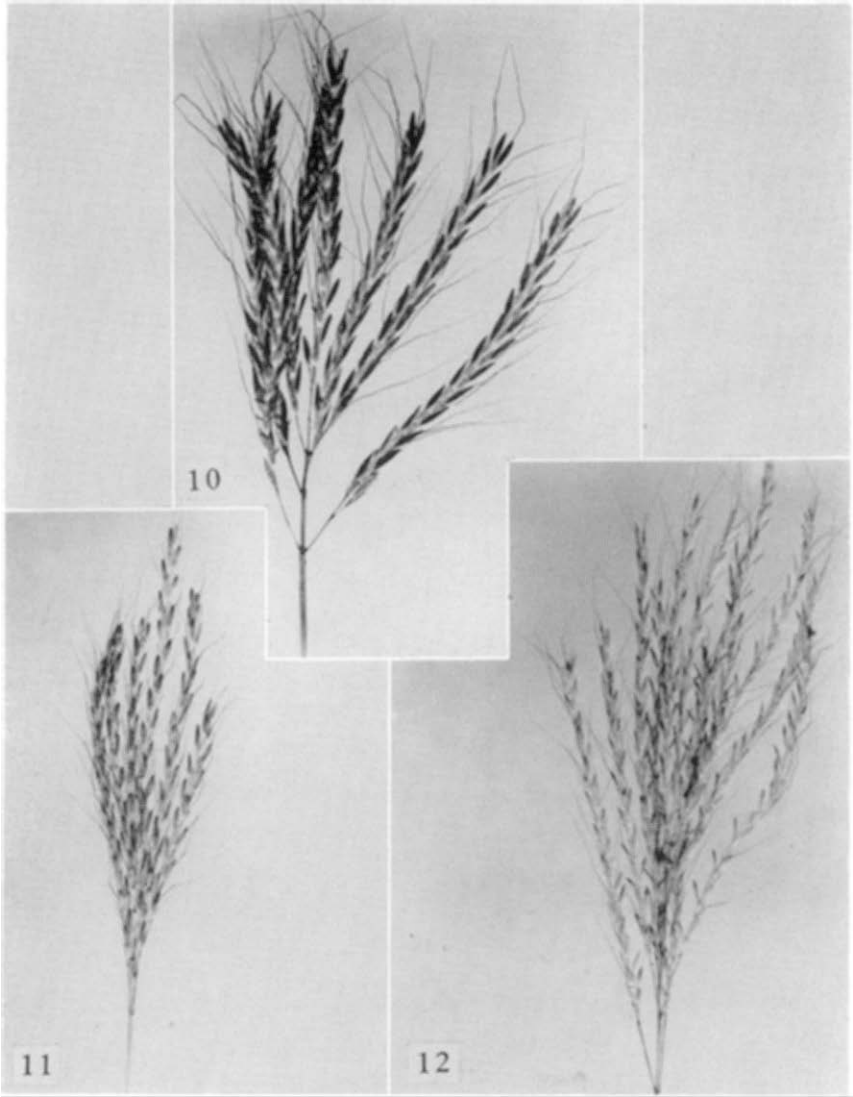
Fig. 7.—Inflorescence of *Bothriochloa venusta* (0.8x magnification).

A very large open inflorescence of A-2655 from British Guiana. Some secondary branching evident.



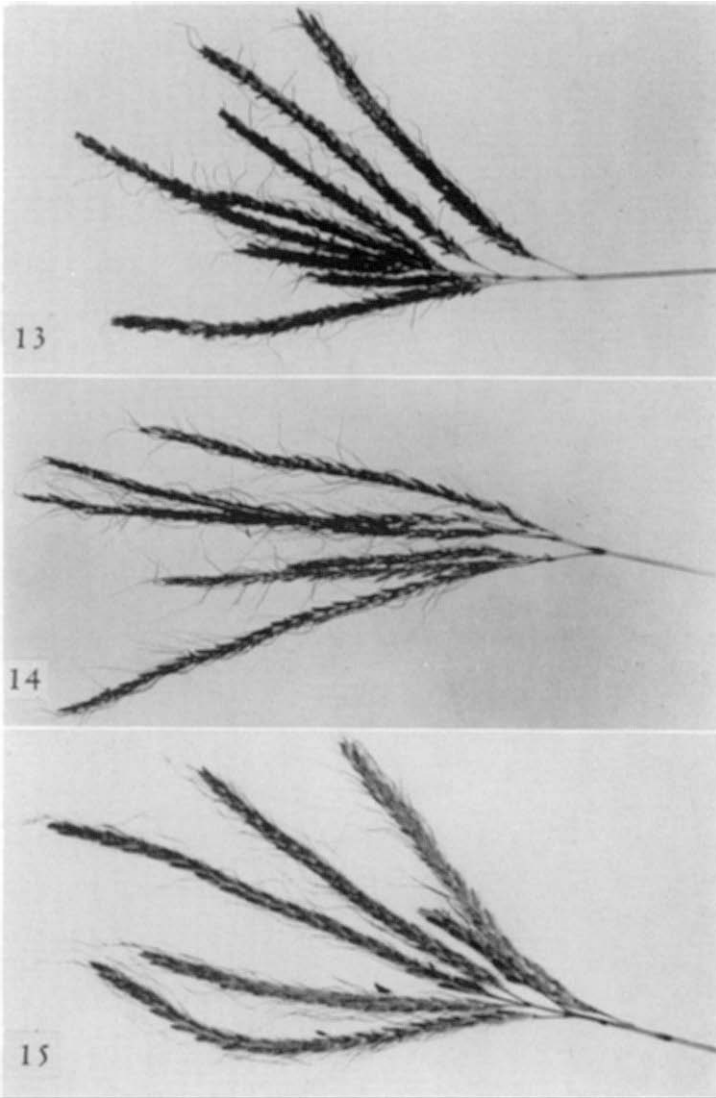
Figs. 8-9.—Inflorescences of the *B. intermedia* complex (0.8x mag.)

Fig. 8.—An inflorescence of *B. intermedia*, A-2654 from Coimbatore India, somewhat more compact than *B. venusta*, but relatively open and with lower racemes shorter than the primary axis. Fig. 9.—An inflorescence of *B. caucasica*, A-2562 from Tiflis Russia, compact and with relatively short racemes compared to the primary axis. Much secondary branching.



Figs. 10-12.—Inflorescences of *Bothriochloa* (0.8x mag.)

Fig. 10.—Inflorescence of *B. pertusa*, A-4090 from South Africa. Note the very short primary axis and the prominent pits in the spikelets. Fig. 11.—Common *B. ischaemum*, A.3465 from Turkey, with short primary axis and absence of pits in spikelet. Fig. 12.—An oriental *B. ischaemum*, (King Ranch variety from Amoy, China) with inflorescence somewhat larger than common and with the primary axis considerably longer.



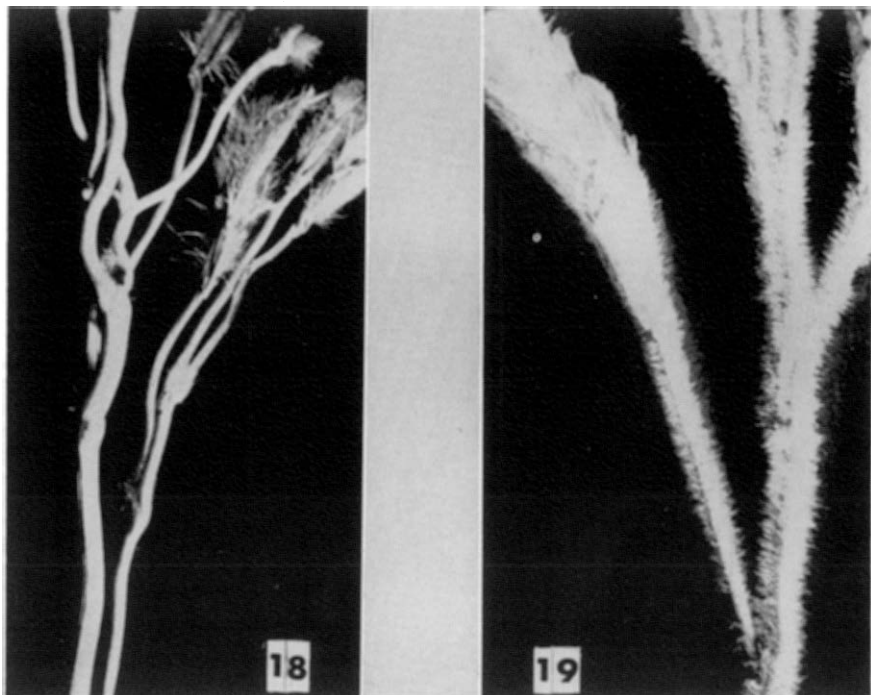
Figs. 13-15.—Inflorescences of the *Dichanthium annulatum* complex (0.8x mag.)

Fig. 13.—Tropical type (A-3965 from Calcutta, India) with short primary axis, short racemes and truncate spikelets. Fig. 14.—The Mediterranean type (A-2565 from Israel) with racemes longer and more slender than the tropical type and spikelets more pointed. Fig. 15.—South African type (A-4031 from Pretoria, South Africa) with racemes and spikelets somewhat larger than the other types and also much more hairy.



Figs. 16-17.—Inflorescences in *Dichanthium* (0.8x mag.)

Fig. 16.—*D. caricosum*, A-1527, an introduction naturalized in south Texas, with short primary axis, very obovate spikelets and glabrous peduncles. Fig. 17.—Two entries of *D. sericeum*, the smaller inflorescence is A-3723 from N.S.W. and the larger is A-1349, also from Australia.



Figs. 18-19.—Pubescence of peduncle in *Dichanthium*

Fig. 18.— *D. annulatum*, A-3965 from India, with glabrous peduncles. Fig. 19.—*D. aristatum*, A-2661 from Pretoria, South Africa, with very hairy peduncles.

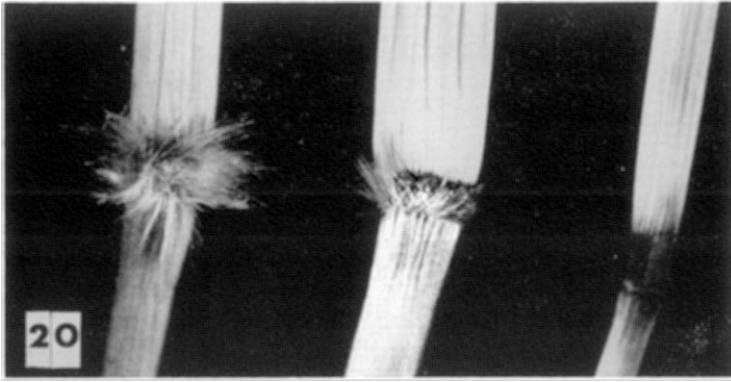


Fig. 20.—Degrees of nodal pubescence from completely glabrous in *B. ischaemum*, A-3465 from Turkey, to ring of short hairs in *B. ischaemum*, A-2582 from Koashung, Formosa, to the dense ring of extremely long hairs in *D. annulatum*, A-4390 from Zerkine, Tunisia.

part their differentiation is not very satisfactory. *B. intermedia* and *B. caucasica* can be readily separated in the materials studied (Figs. 8, 9).

B. intermedia A. CAMUS

Lower racemes shorter than axis of florescence. Secondary branching frequent. Inflorescence usually deep red, hairs of racemes inconspicuous. Sessile spikelets with or without pits. Plants erect or decumbent, usually large, over one meter tall, leaves broad, pungent.

This is a large, highly polymorphic group which is not adequately sampled in the present collection. There is evidently some gradation toward *B. ischaemum* in one direction and toward the genus *Capillipedium* in another. Absence of diploid forms has made the establishment of affinities very difficult and uncertain to date.

There is apparently considerable variation in both quality and quantity of forage produced by this complex. Some entries have very desirable agronomic qualities whereas the others do not. Tests have shown that cattle will consume the highly pungent forage of some entries. Only a very few have been tested for winter hardiness at Stillwater but at least two entries appear to have some hardiness.

Twelve entries have been studied cytologically and ten of these were tetraploids and two hexaploids. All of the tetraploids, except one, were fairly regular in their meiotic behavior but not completely so. The two hexaploids and one tetraploid were very irregular in their meiotic divisions. All three of these were from Australia.

Accessions Studied.—India (4); Australia (3); Malaya (1); Kenya (1), and three whose origin is unknown.

B. caucasica C. E. HUBB.

Similar to the above with the following exceptions: Fewer spikelets per raceme and spikelets somewhat smaller. Sterile lemma somewhat broader than the above. Fine, slender, and small plants compared to *B. intermedia*. Found mostly in the Caucasus area of Russia. A very promising forage grass in the central plains area of the United States.

It is a tetraploid with slightly irregular meiotic divisions.

Accessions Studied.—Tiflis, Russia (1); Kew, England (1), original source not known.

3. *Bothriochloa pertusa* complex

Common Names.—Hurricane grass, Pinhole grass, Khus-Khus grass, Marvel grass, and numerous provincial names in India. A type introduced into Cuba is called Camagueyana.

Scientific Names.—*Bothriochloa pertusa* A. Camus (1931); *Amphilophis pertusa* Stapf (1917); *Andropogon pertusus* Willd. (1918); *Bothriochloa insculpta* A. Camus (1931); *Amphilophis insculpta* Stapf (1917); *Andropogon insculptus* Hochst. (1838-43); *Andropogon pertusus* var. *capensis* Hack. (1889); *Andropogon pertusus* var. *insculptus* Hack. (1889).

Geographic Distribution.—Widely distributed in the Old World tropics, in two discontinuous areas. Except for its rare occurrence on the Cape Verde Islands, its presence in Africa appears to be confined to the southern and eastern portions going as far north as Ethiopia and Eritrea. It is found near Madagascar on the islands of Rodriguez and Reunion and is also reported from eastern Arabia. It occurs throughout most of the drier parts of India, Afghanistan, and Ceylon, throughout the Indo-Malaya area, especially in Assam and Burma, and has been reported in South China. It is also found in New Caledonia where it was probably introduced, and has also been introduced into most of the islands of the West Indies.

Readily Distinguished Types.—Although numerous varieties have been named on morphological grounds the differences are often small, and apparently none is fully reliable. Readily distinguished from other species by the relatively short primary axis of the inflorescence and deep pits (from 1 to 3) in either the sessile or pedicellate spikelet, or both (Figs. 3, 10). Sessile spikelet with a tuft of hairs at apex and otherwise glabrous to quite hairy on lower two-thirds, often quite polished but occasionally very dull. Both sessile and pedicellate spikelets similar in shape. Most entries are stoloniferous and rooting at the nodes, but some are decumbent and root only rarely at nodes. Nodes usually have a very dense ring of long hairs, leaves may be either completely glabrous to densely covered with short hairs on both sides, with all grades in between.

This is an extremely variable complex which is inadequately represented by the sample studied. Even the two most easily distinguishable types, *B. pertusa* A. Camus and *B. insculpta* A. Camus, cannot be separated in our materials in which all grades of intermediates are found in the three major criteria used to distinguish them.

It is very highly valued as a forage grass in India and Africa and has shown great promise in the southern part of the United States. No entries grown so far at Stillwater are winter hardy.

Both tetraploids and hexaploids were found, the latter being much more common in Africa and not found in India. Some meiotic irregularities exist in both, but they are much greater in the hexaploids.

Accessions Studied.—Southern Rhodesia (7); Kenya (3); South Africa (2); Ethiopia (1); Belgian Congo (1); Tanganyika (1); Southern India (1); Ceylon (1); Cuba (introduced) (1), and Trinidad (introduced) (1).

4. *Bothriochloa ischaemum* Keng.

Common Names.—Turkestan bluestem, yellow bluestem, yellow beardgrass, East Indies bluestem; varieties include Elkan, King Ranch bluestem, K. R. bluestem, Texas Yellow beardgrass, etc.

Scientific Names.—*Bothriochloa ischaemum* Keng (1936); *Amphilophis ischaemum* Nash (1912); *Andropogon ischaemum* L. (1753); *Andropogon angustifolius* Sm. (1823).

Geographic Distribution.—The distribution of this species is widespread throughout the subtropical and temperate regions of Eurasia. It is found occasionally in the Atlas mountains of North Africa, throughout southern Europe, Western Siberia, and Central Asia, Mongolia and North China. Its northern limit is about 53° latitude in Europe (Belgium and Germany) and 56° in the Upper Dnieper region of Russia. Its southern Asiatic boundaries extend from Syria and Lebanon, through Iraq, Iran, Afghanistan, the Himalayas of North India, eastern Turkestan, and into South China.

Readily Distinguished Types.—Two types are recognizable, common and oriental (Figs. 11, 12). Although many varieties have been named in the past, only these two appear morphologically distinct in our studies.

COMMON.—Grooves in the pedicels fairly well developed, joints and pedicels with long silvery hairs, lower glume of sessile spikelet sparsely covered with short simple hairs on lower two-thirds, upper portion glabrous. Glumes of the sessile spikelets slender and pointed, without pits but with a slight tendency toward pitting (dishing). Lower racemes longer than axis of the inflorescence with a raceme/axis ratio greater than two. The ratio of the awn to the glume of sessile spikelet is less than 3.8.

Plants erect, bunch grasses, with nodes glabrous to minutely pubescent (sometimes varying on the same plant), leaves completely glabrous or with a few short hairs. For the most part stemmy with few leaves and low productivity and considered rather poor forage where they occur. Completely winter hardy at Stillwater and generally resistant to foliage diseases.

Mostly tetraploids but with two hexaploids (both from Turkey) in this collection.

Accessions Studied.—Turkey (18); France (4); Czechoslovakia (3); Yugoslavia (3); Belgium (3); Spain (1); Italy (1); Germany (1); Austria (1); Hungary (1); Iraq (1); India (1); China (1).

ORIENTAL.—Similar to above with the following exceptions: Primary axis of the inflorescence longer than in the common type with the raceme/axis ratio between 1.0 and 2.0. The awn of the sessile spikelet somewhat longer with the awn/glume ratio between 3.8 and 4.8. Glume not pitted but often strongly dished. Plants decumbent, one accession with slight tendency to root at the nodes, nodes distinctly short haired, never smooth except in old material where hairs have sloughed. Leaves more hairy than common type, often with several long hairs at base of the blade.

Decidely more robust, leafier, more productive, intermediate in winter hardiness and quite susceptible to leaf rust. Considered good forage wherever it has been tried in this country. Pentaploid (King Ranch bluestem—Texas Yellow beardgrass) and hexaploid types have been found.

Accessions Studied.—Chinese Mainland (4); Formosa (1).

5. *Bothriochloa venusta* A. Camus

Common Names.—None.

Scientific Names.—*Bothriochloa venusta* A. Camus (1931); *Amphiphlois venusta* A. Camus (1921); *Andropogon venustus* Thw. (1889).

Geographic Distribution.—Apparently restricted to the island of Ceylon at low elevation.

Readily Distinguished Types.—Since only one entry has been grown in this study little can be said about variation in the species. Except for the absence of a translucent groove in both rachis and pedicel, it is much like *B. intermedia* (Fig. 7). It is a rather large, leafy, robust plant with a distinct ring of hairs at the nodes of the culm and with short

racemes compared to inflorescence length. In the accession studied, the first glume of the sessile spikelet is without a pit and somewhat less hairy than in *B. ischaemum*.

This entry has some winter hardiness and appears to be a good forage producer. The species is well thought of in Ceylon. The entry studied is a tetraploid with forty somatic chromosomes, and came from British New Guiana where it has been introduced.

6. *Dichanthium sericeum* A. Camus

Common Names.—Queensland bluegrass, silky bluestem, silky bluegrass, etc.

Scientific Names.—*Dichanthium sericeum* A Camus, (1921); *Andropogon sericeus* R. Br. (1810).

Geographic Distribution.—This species is abundant throughout Australia and is at least fairly common in many of the Pacific Islands.

Readily Distinguished Types.—Although differences between entries were sometimes conspicuous, no special types are recognized at present. Racemes densely covered with long, white silky hairs, sessile or very shortly pedunculate (Fig. 20); lower glume of sessile spikelet oblong, several nerved, covered with long, silvery hairs with an arc of extremely long hairs at apex, many of which arise from a tubercle.

Plants erect and with a conspicuous ring of hairs at the nodes. It is an extremely variable species in which all degrees of hairiness of stems, leaves and peduncles are found from glabrous to long soft hairy forms. The coloration of the plants is also extremely variable, from light green to metallic blue. The general growth habit of the plant varies from small, slender leaved, and fine stemmed plants, to large, vigorous, leafy plants. Cleistogamy appears to be fairly common under Oklahoma conditions.

This group probably represents a complex of types and may well grade into such other species as *D. humilius*, *D. acutiusculum*, *D. affine* and *D. setosum*.

Some types are reported of considerable forage prospect in the southwestern part of the United States. All entries studied cytologically have been found to be diploid.

Accessions Studied.—Australia (12).

7. *Dichanthium annulatum* complex

Common Names.—Marvel grass, Diaz bluestem, Kleberg bluestem, Brahman grass, Pretoria bluestem.

Scientific Names.—*Dichanthium annulatum* Stapf (1917); *Andropogon annulatus* Forsk. (1775); *Dichanthium papillosum* Stapf (1917); *Andropogon papillosus* Hochst. (1838-43); *Andropogon annulatus* var. *papillosus* Rendle (1899.)

Geographic Distribution.—The complex is widespread through the Old World tropics, being found in North Africa, East Africa, and South Africa as well as Madagascar and adjacent islands. It occurs only very sparsely in West Africa, but is found in Saudi Arabia, Israel, Lebanon, Syria, Iraq, Iran, Pakistan, throughout India and Ceylon, through the Indo-Malaya area, and into China. Also abundant in Australia and occasionally on some of the Pacific Islands.

Readily Distinguished Types.—Tropical, Mediterranean, and South African (Figs. 13, 14, 15), as described below.

TROPICAL.—Rachis and pedicel without a groove, peduncle usually glabrous, joints and pedicels with very few hairs. Primary axis of the inflorescence very short, racemes usually short, stubby in a sub-digital arrangement. Glumes of sessile spiklet broad, truncate at tip, often obovate, densely covered with long hairs, most of which arise from a tubercle, hairs often recurved, no tendency to pitting. Awn of the lemma much longer and more conspicuous than in *B. ischaemum*.

Plants erect or decumbent to prostrate, some creeping by stolons; nodes with a conspicuous ring of long white hairs, leaves broad, usually light green in color, glabrous to sparsely pubescent, either on upper or lower surface or both; hairs, when present, arising from a tubercle, ligule conspicuous. Anthocyanin often conspicuous in stem and leaves.

Highly valued for forage in areas where it is native, and shows promise in the southwestern United States, little hardiness at Stillwater. Diploids and tetraploids were found.

Accessions Studied.—India (10), Unknown (4).

MEDITERRANEAN.—Similar to above with following exceptions: Glumes of sessile spiklet more narrow and pointed at tip, racemes longer, slender and often arranged in a more open windmill pattern. Plants relatively tall, erect or slightly decumbent, leaves more numerous and more narrow and usually glabrous or with very few hairs.

Some entries are very leafy and tender as well as being extremely productive. These are the best looking forage types at Stillwater and are considered excellent forage in their native habitats. Very little winter hardiness. All entries observed have been tetraploids.

Accessions Studied.—Tunisia (2), Israel (2), Iraq (2), Egypt (1).

SOUTH AFRICAN.—These types are usually referred to *D. papillosum*. Similar to above with the following exceptions: Glumes of the sessile spiklets considerably more hairy than others, with a semilunar ring of long hairs at the apex usually arising from tubercles, not always conspicuous. Racemes of the tropical type but usually more numerous.

Plants erect to semidecumbent, usually much more robust and stemmy, leaves somewhat longer and wider than above. Leaves and stems usually, but not always, metallic blue in color. All flower very late at Stillwater. Apparently restricted to South Africa and neighboring countries.

Although a rather high forage producer at Stillwater the texture of the forage does not appear as desirable as other types. Highly valued in south Texas where some accessions are now called Pretoria bluestem. Of the five entries studied cytologically, four were hexaploids and one tetraploid.

Accessions Studied.—South Africa (4), Southern Rhodesia (1), Unknown (1).

8. *Dichanthium caricosum* complex

Common Names.—Angleton grass, Marvel grass, Hay grass, Medio bluestem.

Scientific Names.—*Dichanthium caricosum* A. Camus (1921); *Andropogon caricosus* L. (1763); *Dichanthium nodosum* Willem. (1796); *Andropogon caricosus* var. *mollicomus* Hack. (1889); *Andropogon mollicomus* Kunth. (1830); *Dichanthium aristatum* C. E. Hubb. (1939); *Andropogon aristatum* Poir. (1810); *Andropogon nodosus* Nash (1912).

Geographic Distribution.—Widely distributed throughout India and Ceylon, through Indo-Malaya, China and some of the Pacific islands where they were probably introduced. Also found in South Africa and adjacent countries as well as Madagascar and surrounding islands.

Readily Distinguished Types.—Two distinct types, typical and *mollicomus*, are easily recognized, and a third, *aristatum*, may be distinct. (Figs. 16, 18, 19).

TYPICAL.—Racemes solitary to numerous, subdigitate, peduncles glabrous, joints and pedicels sparsely hairy on one margin; sessile spikelets subequal to much larger than the pedicellate spikelet, first glume of the sessile spikelet either glabrous or with scattered long white hairs arising from a tubercle, no tendency toward pitting, somewhat more broad at the apex than *D. annulatum*. Awns from the lemma long, similar to *D. annulatum*, and usually the lowermost sessile spikelets without awns, but not always.

Plants mostly creepers, rooting freely at the nodes, some are also decumbent. Nodes of culms mostly glabrous but some with distinct band of short velvety hairs. Leaves green to pink to deep purple, glabrous or with varying amounts of short hairs arising from tubercles, ligule minute or wanting.

Considered valuable forage grasses in their native habitat and appear under our conditions to also have some promise as turf grasses. All entries studied have been found to be tetraploids.

Accessions Studied.—Malaya (1); Trinidad (introduced) (1); South Texas (introduced) (2).

MOLLICOMUS.—Similar to above with the following exceptions: Peduncles are densely covered with short stiff hairs, pedicellate spikelet larger and broader than the sessile; sessile spikelet with scattered long hairs throughout and none arising from a tubercle.

Some entries appear to be excellent forage grasses, very productive with abundant fine leaves, others are less productive and some are quite stemmy. Little winter hardiness. Two varieties now grown in south Texas are Angleton and Medio bluestems. They can be separated by the following differences: Medio bluestem—racemes 1-4, usually 2, awns rather deciduous, falling at maturity. Angleton bluestem—racemes usually 4 or more, awns persistent.

Cytologically all entries are tetraploids with 40 chromosomes.

Accessions Studied.—India (3), uncertain (6).

ARISTATUM.—Whether this is really distinct from *mollicomus* or not is questionable. It appears to be a more robust plant, larger in all respects and more erect in growth habit; no creepers have been found.

Also, it is isolated geographically, being restricted to southeast Africa and the Madagascan islands. It has considerable forage potential because of its productivity, but little winter hardiness. All entries were found to be tetraploids.

Accessions Studied.—South Africa (3), Trinidad (introduced) (1).

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APPENDIX: Taxonomic Summary.

Species	Taxonomic Characteristics										
	Groove in pedicel	Pits in glumes	Hairs at nodes	Conspicuous hairs on upper 1/3 of glumes	Glumes broad	Glumes narrow	Racemes longer than axis	Racemes shorter than axis	Hairs on peduncle	Plants large, robust	Principal geographic range
<i>Bothriochloa decipiens</i>	+++	+++	-	-	-	++	++	-	-	-	Australia
<i>intermedia</i> complex											Afro-India to
<i>intermedia</i>	++	variable	variable	-	-	++	-	++	-	+++	Australia
<i>caucasica</i>	++	-	-	-	-	++	-	+++	-	-	S. Russia
<i>venusta</i>	-	-	++	-	-	++	-	+	-	++	Ceylon
<i>pertusa</i> complex	++	+++	+++	-	-	++	variable	-to+	-	-	Afro-India to Indo-Malaya
<i>ischaemum</i> common	++	-	-to+	-	-	++	++	-	-	-	Temperate Eurasia
oriental	++	-	++	-	-	++	++	-	-	+	S.E. China & Formosa
<i>Dichanthium sericeum</i>	-	-	+++	+++	-	+	+++	-	-to++	-	Australia
<i>annulatum</i> complex											
Mediterranean	-	-	+++	++	+	-	+++	-	-	-	Mediterranean
tropical	-	-	+++	++	++	-	+++	-	-	-	India and Indo-Malaya
South African	-	-	+++	+++	++	-	+++	-	-	++	So. Africa
<i>caricosum</i> complex											
typical	-	-	-to++	++	+++	-	++	-	-	+	India and Indo-Malaya
<i>mollicomus</i>	-	-	-to++	++	+++	-	++	-	+++	+	India and Indo-Malaya
<i>aristatum</i>	-	-	-to++	++	+++	-	++	-	+++	++	South Africa