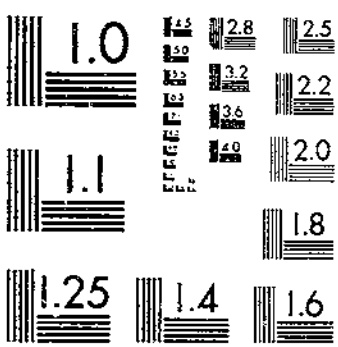
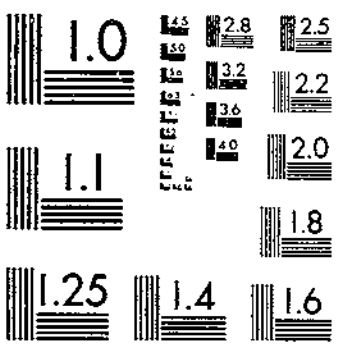
TB 811 (1942) USDA TECHNICAL BULLETINS UPDATA
A COMPARATIVE ANALYSIS OF THE VEGETATIVE CHARACTERISTICS OF SOME VARIANTS
ARTSCHWAGER, E 1 OF 1

START



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TECHNICAL BULLETIN No. 811 • MAY 1942

A Comparative Analysis of the Vegetative Characteristics of Some Variants of Saccharum spontaneum

By
ERNST ARTSCHWAGER
Pathologist
Division of Sugar Plant Investigations
Bureau of Plant Industry

UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

For sale by the Superintendent of Documents, Washington, D. C. • Price 10 cents

Technical Bulletin No. 811 • May 1942

UNITED STATES
DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

A Comparative Analysis of the Vegetative Characteristics of Some Variants of Saccharum spontaneum[1]

By Ernst Artschwager, *pathologist, Division of Sugar Plant Investigations, Bureau of Plant Industry*[2]

CONTENTS

INTRODUCTION

During recent years the increasing utilization of wild forms of *Saccharum* in sugarcane-breeding programs has brought about an extensive interest in *S. spontaneum* L. This interest has resulted in assembling at certain sugarcane-breeding stations numerous clones of *S. spontaneum* from various parts of its indigenous range. The number of clones of this species, now more or less readily available to sugarcane technologists, has become so large that a comparative analysis of the characteristics of the more divergent ones is becoming more and more acutely necessary. The vegetative characteristics have been stressed in this report because they are of greater practical significance to sugarcane technologists than the floral ones.

The earlier descriptions of *S. spontaneum* are of a botanical nature and, consequently, are very short and general, and concern primarily the floral characteristics. Of the more recent descriptions of forms of *S. spontaneum*, those by Bremer (*4*, *5*)[3] and Panje (*11*) are most

[1] Submitted for publication May, 1941.
[2] Acknowledgment is made to Mrs. Eugenia Artschwager for preparation of drawings.
[3] Italic numbers in parentheses refer to Literature Cited, p. 54.

327603°—42——1

complete from the above-mentioned points of view. These and other more recent studies (*3*) indicate that *S. spontaneum* is a highly complex group of plants with a wide range of characteristics. This investigation was undertaken so as to obtain a better conception of the morphological relationships of certain elements of this complex group of plants.

MATERIALS AND METHODS

Materials for study came from the United States Sugar Plant Field Station at Canal Point, Fla., having been imported during the past decade from various parts of Asia and the East Indies. Altogether 23 forms were investigated. As a precaution against confusion in names, all clones imported as cuttings are assigned an importation number. Table 1 gives information on date of importation and origin.

TABLE 1.—*Date of importation or collection of clones of Saccharum spontaneum investigated and place of origin*

Clone	Importation No.[1]	Year imported or collected	Origin
Aegyptiacum	970	1937	Egypt.
Algiers	687	1930	Algeria, Africa.
Burma	948	1935	Burma.
Coimbatore Local	238	1928	Coimbatore, India.
Dacca	619	1930	Near Dacca, India.
Djatiroto	569	1929	Java.
Formosa 4	719	1931	Taiwan, Formosa, Japan.
Formosa	928	1936	Do.
Gehra Bon	618	1930	Assam, India.
Kepandjen	558	1929	Java.
Kloet	564	1929	Do.
Lahore	616	1930	Lahore, India.
Pasoerocan	555	1929	Java.
Rellagadi	617	1930	From Godavari River, India.
S. H. 244	956	1937	Province of Bihar, India.
S. H. 249	957	1937	Do.
Tabongo	578	1929	Northern Celebes.
28 N. G. 101	652	1930	Kemp Welch River, Papua.
28 N. G. 291	875	1935	Eriana Swamp, Papua.
28 N. G. 292	876	1935	Near Port Moresby, Papua.
28 N. G. 293	877	1935	Vailala River, Papua.
U. S. 4520		1936	Amu Darya River, Turkmenistan, U. S. S. R.
U. S. 4523		1936	Do.

[1] Assigned by Division of Sugar Plant Investigations.

To make the data uniform and accessible for statistical studies, the illustrated outline (*1*), prepared chiefly for use in taxonomic description of noble canes, was used. The hair groups of Jeswiet (*10*) have been retained except for a few changes necessary to permit a more ready evaluation of certain characters. Thus, hair group 51 on the inner dewlap surface was broken up into 51 and 51a, the former designating the long marginal tufts and the latter referring to the medium-long surface hairs, which, except for their length, closely resemble those of group 52. Likewise, group 58 was split into 58 and 58a, with 58 designating the short pubescence on the outer surface of the dewlaps and 58a referring to the long hairs found only in certain clones and occurring either as marginal tufts or forming a complete or partial band of cilia along the lower dewlap margin. The hair groups on the prophyll were reduced by omitting those that are obviously components of larger and more fundamental units (*2*).

Studies on the epidermis were made from peels of stem and leaf material after treatment with nitric acid. Although notes were taken on the detailed structure of the leaf epidermis, only stomatal grooves and giant spines were considered in the characterization of the clones.

Group 56 on the upper sheath margin, although very prominent in some clones, is absent or most inconspicuous in others. As the relative development of this group forms one of the chief systematic characters in the construction of a key for the separation of clones, one should examine fresh and young material of all borderline forms, since in older leaves the sheath margins are already discolored and disintegrating.

All illustrations were prepared from fresh material. The prophylls were magnified from six to eight times and the other structures from two to five times.

BRIEF GENERAL MORPHOLOGY

The indigenous clones of *Saccharum spontaneum* of Asia and the East Indies are numerous and varied. All are perennial, gregariously growing grasses with culms bunched in stools or evenly scattered. They comprise forms ranging from 18 inches to more than 20 feet in height. The culms are slender, sometimes robust; erect, ascending, or semiprostrate; very hard but pithy and often hollow in the center. The color of the culm varies in young and old cane, and the surface is almost always covered with a thick layer of wax.

The internodes are terete or somewhat oval in cross section. Their shape is mostly cylindrical, often somewhat conoidal, being widest at the growth ring and tapering gradually toward the top, with a distinct constriction a short distance below the sheath base. The internodes are usually long, occasionally short as in Rellagadi. The inner tissue is composed of vascular bundles embedded in parenchyma. The bundles are very crowded in the region of the periphery, where they form a solid ring with their heavy sheaths discrete or confluent. This outermost ring of vascular bundles is separated from the epidermis by a narrow cortex composed of several rows of very thick-walled, heavily lignified cells and a single row of chlorophyll-bearing cells, which is discontinuous in places where some peripheral bundles abut directly on the thick-walled cortex.

The epidermis of the culms of some varieties shows a regular alternation of cork-silica pairs with long epidermal cells (epidermal pattern 1). In many forms silica cells are almost or completely absent (epidermal pattern 2), but in the majority of clones silica cells are present in approximately one-half of the short groups (epidermal pattern 3). The cork cells are most often squarish or rhomboid, sometimes elongate-rectangular or reniform. Long, pointed cork cells, so prominent in many of the noble canes, are absent in most clones of *S. spontaneum* or, at best, are few, short, and inconspicuous. The stomates of the culms, though never wanting, are few compared to those occurring in leaves. They vary in their distribution from less than one in a microscopic field (covered by a 16 mm. objective and × 6 ocular) to a dozen or more.

The node in the clones of *S. spontaneum* is always thicker than the internode; it contains the root band and is separated from the internode by a narrow or fairly broad band, which in young stems is bright

green and flush, and in older culms more or less swollen and concolorous with the internode, or olive yellow. This growth ring is sometimes unequal in width all around wherever the culm is not erect, as happens in most ascending or semiprostrate forms.

The root band may be shallow or tall and is usually lighter in color than the internode. Its shape is cylindrical or more often obconoidal on the side opposite the bud. It contains, with one exception (28 N. G. 293), one or two rows of root primordia (fig. 1, *A–C*). When

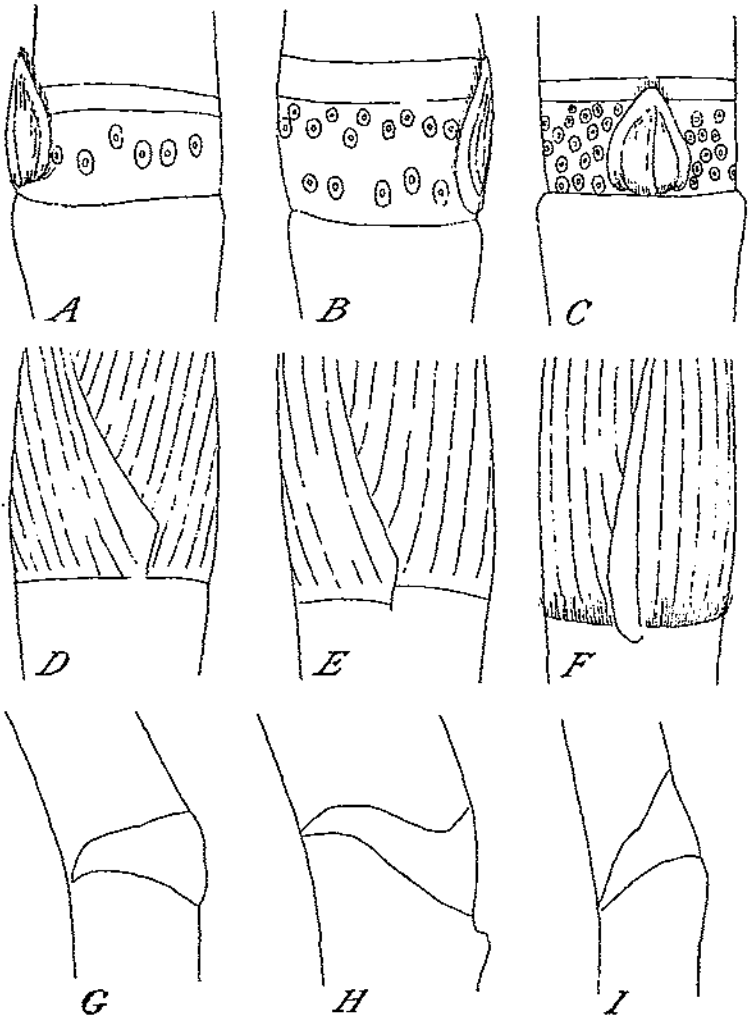


FIGURE 1.—*A*, Narrow root band with one row of sparse root primordia; *B*, broad obconoidal root band with two rows of root primordia; *C*, broad root band with four to five rows of crowded root primordia; *D*, sheath base straight, parenchymatous margin with triangular flap; *E*, sheath base very slightly decurrent; *F*, sheath base straight and ciliate, parenchymatous sheath margin free at base and forming a small appendage; *G*, deltoid dewlap with curved margins; *H*, ligulate type of dewlap; and *I*, wedge-shaped dewlap with tip pointing downward toward center of midrib.

three rows appear to be present, they are usually staggered and not well defined. The root primordia of the lower row are invariably larger than those of the upper.

The buds are arranged alternately, each node bearing a single bud. They are usually inserted directly above the sheath base, sometimes slightly or appreciably higher. The tip of the prophyll reaches the growth ring and sometimes projects some distance beyond. All buds are relatively small except in a few of the more robust types. Their form is ovate, obovate, pentagonal, or squarish, with wings usually very hairy and sides most often smooth.

The leaves are two-ranked and consist of sheath and blade. The sheath forms an open tube extending 1½ times around the base of the internode with the outer margin overlapping the inner and with the inner margin reaching close to the bud. The sheath is thick medially, but becomes gradually thinner toward the margins where it is membranaceous. The sheath base is straight (fig. 1, *D*), rarely decurrent (fig. 1, *E*), or appendaged (fig. 1, *F*), and it is surrounded, in some clones, by a complete or partial ring of cilia (fig. 2, *D*). The surface of the sheath is smooth or covered more or less completely by a vestiture of early deciduous or persistent hairs. The sheath margins below the blade joint may be conspicuously or sparsely ciliate (hair group 56) with the hairs either completely marginal or distributed as a narrow band over the width of the broad parenchymatous margin. Many clones lack hair group 56; in some the group is prominent only on the overlying margin. The leaf sheaths of clones of *S. spontaneum* are persistent and more or less straw-colored when old. Young sheaths are usually green or partly flushed with purple; in some cases they are purple interiorly at the region of the sheath base.

The blades vary in length from 100 to 200 cm. They are usually linear and taper toward the apex into a long, fine point. In some forms the blade is reduced to the width of the midrib for its entire length, in others it becomes quite narrow only in the region of the blade joint. The leaves of some of the East Indian clones have relatively broad blades, approaching those of the more narrow-leaved noble canes. The midrib is either massive or shallow, channeled on the upper surface and convex below; it is widest at the base and gradually tapers toward the apex. The blade is usually gently curved along its entire length except in the small, more or less grasslike forms; its texture is rather rough, sometimes leathery, due to the presence of stomatal grooves and rows of converging spines on the lower and giant spines (fig. 3) on the upper epidermis.

The blade joint is that part of the leaf where the blade joins the sheath. Its inner surface forms the throat, the outer surface the collar. The latter is composed of two wedge-shaped or ligulate areas known as dewlaps or joint triangles (fig. 1, *G*, *H*, *I*), often referred to as ligular bands or transverse marks. They may be yellow or greenish and are often discolored. The surface may be practically smooth or hairy and is often more or less heavily waxed. The inner surface of the dewlaps is usually quite hairy, especially near the outer margin where the hairs form the conspicuous marginal tufts (fig. 4, *L*, *M*).

The blade is separated from the sheath by the ligule, a membranaceous appendage that, in some forms, becomes decurrently continuous with the broad membranaceous margins of the sheath (fig. 4, *A*, *B*). The shape of the ligule is deltoid (fig. 4, *C*, *D*, *E*), crescenti-

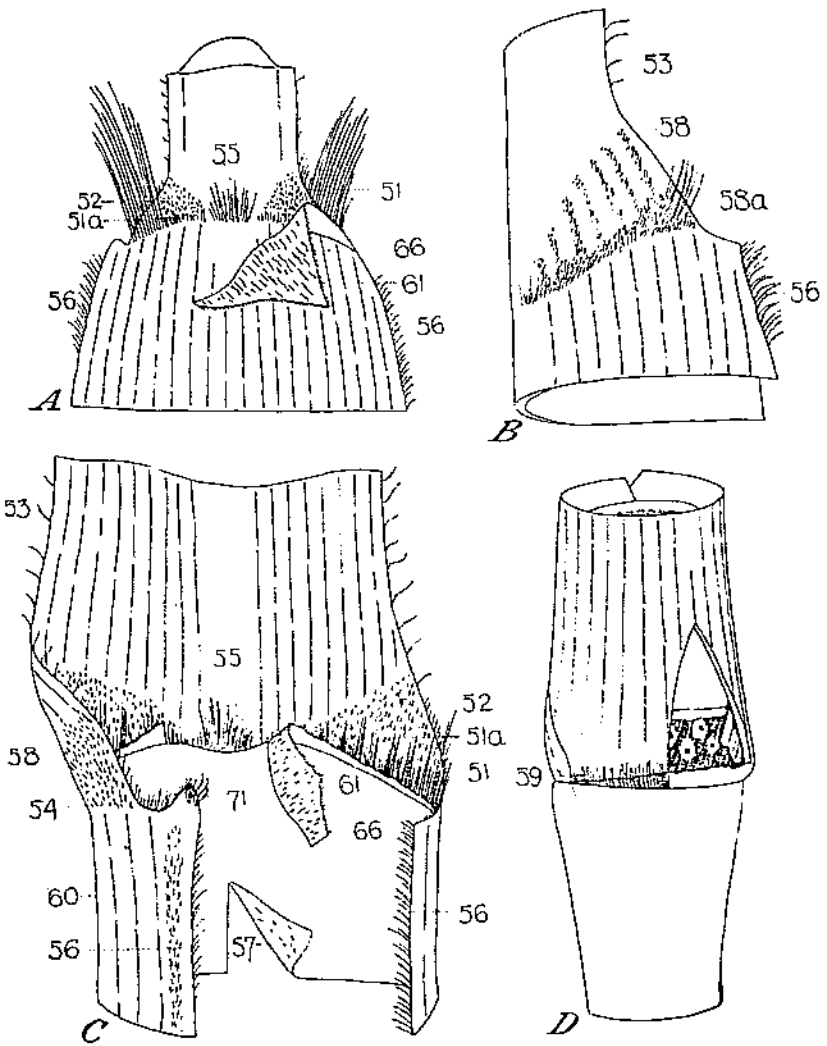


FIGURE 2.—*A*, Inner surface of blade joint of an Indian clone of *S. spontaneum*, ligule folded back to expose the different hair groups (numbered); *B*, side view of outer surface of same blade joint, the dewlap area is outlined by hair group 58; *C*, inner surface of blade joint of a broadleaved East Indian clone; and *D*, sheath base of an Indian clone of *S. spontaneum* with sheath partly cut away to expose root band, growth ring, and prophyll.

form (fig. 4, *I*, *K*, *L*), or of an intermediate type (fig. 4, *H*, *G*). In the deltoid ligule the height is only slightly less than the width at the base, while in the crescentiform ligule the width is several times the height. Some deltoid ligules have a rounded, more or less dome-shaped tip (fig. 4, *E*), others are shallow rhomboid (fig. 4, *G*), and in one clone, Kepandjen (fig. 4, *F*), the ligule is inverted-deltoid, a character by which this clone can be distinguished from all other forms. The base of the ligule is usually curved, in some instances (Lahore) it is

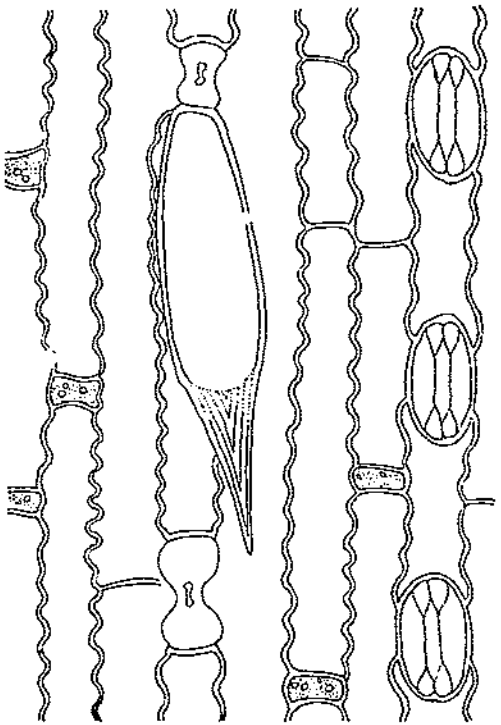


FIGURE 3.—Upper epidermis from leaf blade of Lahore, showing giant spine in central zone of upper epidermis.

distinctly horseshoe-shaped. In the crescent-shaped type, the basal line is widely curved with a depression in the middle. The surface of the ligule is smooth at the adaxial side but pubescent dorsally and ciliate along the free upper margin. The latter early becomes brokenly indented and scarious.

With the exception of clone 28 N. G. 293, the clones of *S. spontaneum* lack auricles of the type found in noble canes. Auricles are usually wanting but, when present, are very small or of the transitional type, in which an auricle effect is simulated by an abrupt termination of the broad parenchymatous sheath margin.

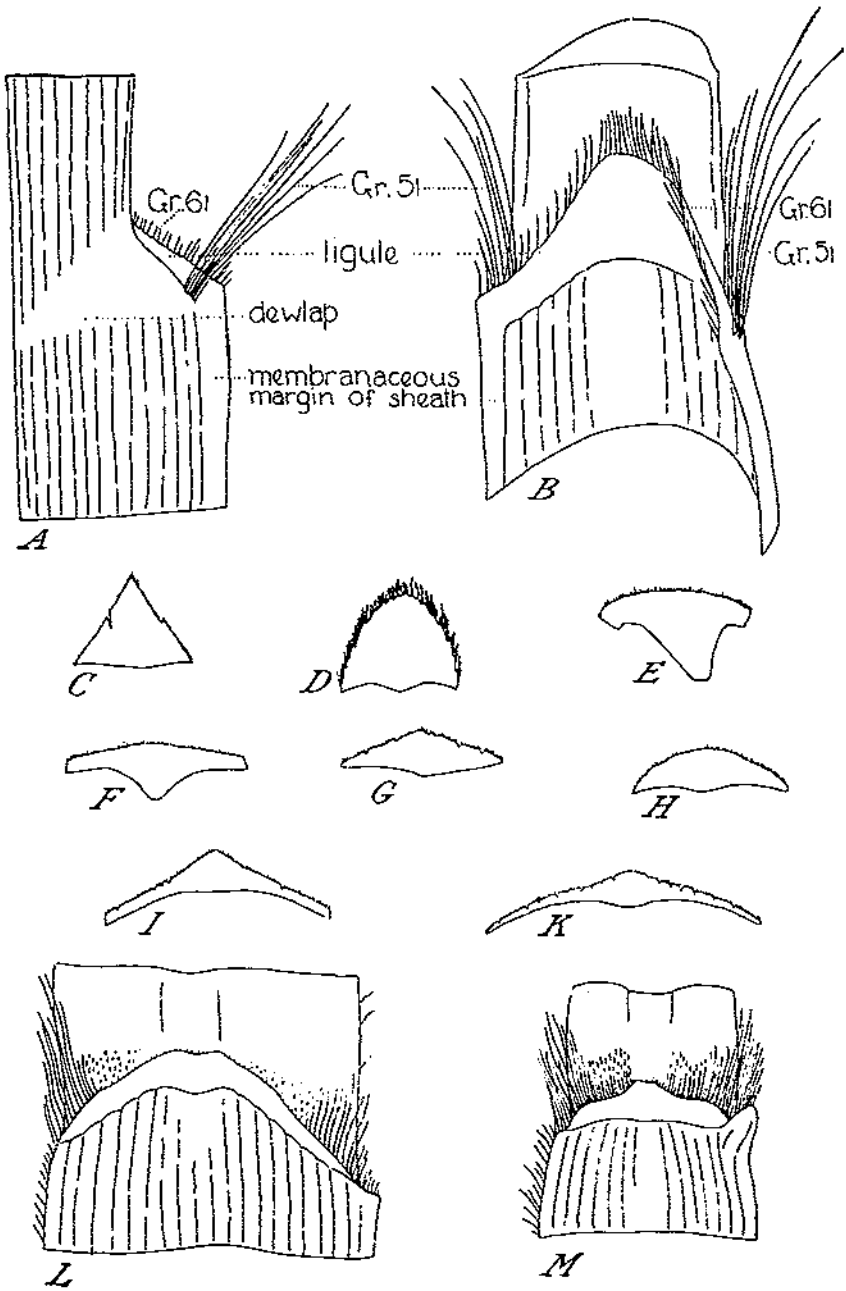


FIGURE 4.—*A*, Outer side view of blade joint of U. S. 4520 showing ligule decurrently continuous with parenchymatous sheath margin; *B*, inner surface of blade joint of U. S. 4520 showing hair groups and relation of flanges of ligule to the sheath margins; *C*, *D*, types of deltoid ligules; *E*, *F*, inverted deltoid ligules; *G*, flat rhomboid ligule; *H*, shallow crescent-shaped ligule with rounded upper margin; *I*, *K*, types of crescent-shaped ligules; *L*, inner surface of blade joint (Kloet) showing asymmetrical, steeply sloping ligule; and *M*, inner surface of blade joint of Tabongo showing strap-shaped ligule and small inner auricle.

CLONE AEGYPTIACUM

(Fig. 5)

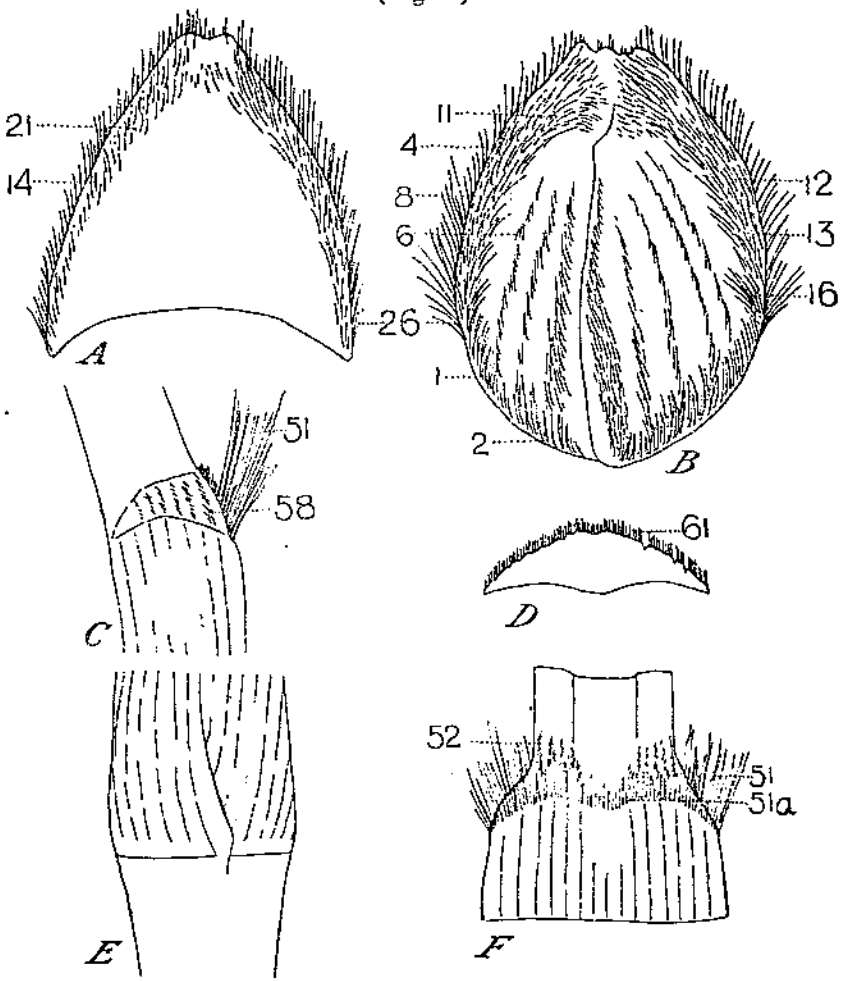


FIGURE 5.—Clone Aegyptiacum: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

ORIGIN.—Imported from Egypt in 1937.

CULMS.—Yellowish-green and heavily waxed; internodes medium long (22 cm.), cylindrical, and constricted below sheath base, about 11 mm. across, pithy and hollow in center; stem-epidermis pattern 2, cork cells squarish, a few short-pointed, usually solitary, long cells that are somewhat curved, 12μ in average width, stomates sparse; growth rings narrow or medium wide and slightly swollen, root bands 7 mm. high, cylindrical and with one row of root primordia; prophylls

of buds medium large (9 mm.), ovate with wing attached slightly below middle of prophyll, apical appendage often prominent, apex of wing massive and usually notched, both sides and wing hairy.

LEAVES.—Leaf sheaths fairly short (26 cm.), persistent and, when young, densely strewn with deciduous spines; sheath base straight, overlying margin somewhat decurrent; base fringed (group 59) or inconspicuously hairy; blades up to 160 cm. long and 10 mm. wide at middle, reduced to a massive midrib in region of blade joint, lower epidermis with deep and prominent stomatal grooves; dewlaps deltoid but with upper and lower margin convex, outer dewlap surface medium hairy (hair group 58) or fairly smooth, hair group 58a small and marginal and only seen in young organs; inner dewlap surface with small marginal tufts (hair group 51) and a narrow band of medium-long surface hairs (group 51a) extending across midrib; hair group 52 inconspicuous but also extending across midrib; ligules shallow and deltoid (4 mm. high at center) but with free margin rounded and occasionally with notch in center, prominently ciliate (hair group 61), dorsal pubescence (hair group 66) also conspicuous.

DIFFERENTIATING CHARACTERISTICS.—Blade narrow and reduced to width of midrib at region of blade joint; one row of root primordia; narrow band of hairs (group 51a) extending across midrib; young sheaths densely strewn with deciduous hairs. The chromosome number is $2n=90$ to 92 and $n=45$ according to Starrett.[4]

CLONE ALGIERS

(Fig. 6)

ORIGIN.—Imported in 1930 as a cutting from Baraguá, Cuba, under the name "*S. biflorum.*" The name "Algiers" was assigned on the assumption that this cane originated in Algeria, Africa, and came indirectly from the Harvard Botanical Gardens at Cienfuegos, Cuba, since Grey (7) reports having obtained a desert cane called *S. biflorum* from Algiers in March 1921.

CULMS.—Light-green and heavily waxed; internodes medium long, cylindrical, somewhat depressed below sheath base, about 9 mm. across, pithy and hollow in center; stem-epidermis pattern 2, cork cells somewhat elongate-squarish, solitary or in twos, cell width 15μ, stomates medium abundant; growth rings narrow or medium wide and swollen, orange to orange-yellow; root bands 6 to 7 mm. high, obconoidal on side opposite bud, with 1 or 2 staggered rows of root primordia; prophylls of buds obovate with conspicuous basal and terminal appendages, the latter often beaked; wing inserted at or slightly above middle of prophyll, massive, with tip broadly rounded and emarginate, sides and wing practically glabrous.

LEAVES.—Leaf sheaths very long (up to 40 cm.), persistent and densely strewn with long, stiff, often deciduous spines; sheath base not decurrent but with wide parenchymatous margin; blades dark-green and with prominent veins, 147 cm. long and 1.6 cm. wide at middle, narrowing down to a fairly massive midrib and narrow blade portion in region of blade joint; lower epidermis with narrow and prominent but shallow stomatal grooves; dewlaps semicrescentiform,

[4] Unpublished studies, in the files of the Division of Sugar Plant Investigations, by Ruth C. Starrett, assistant cytologist.

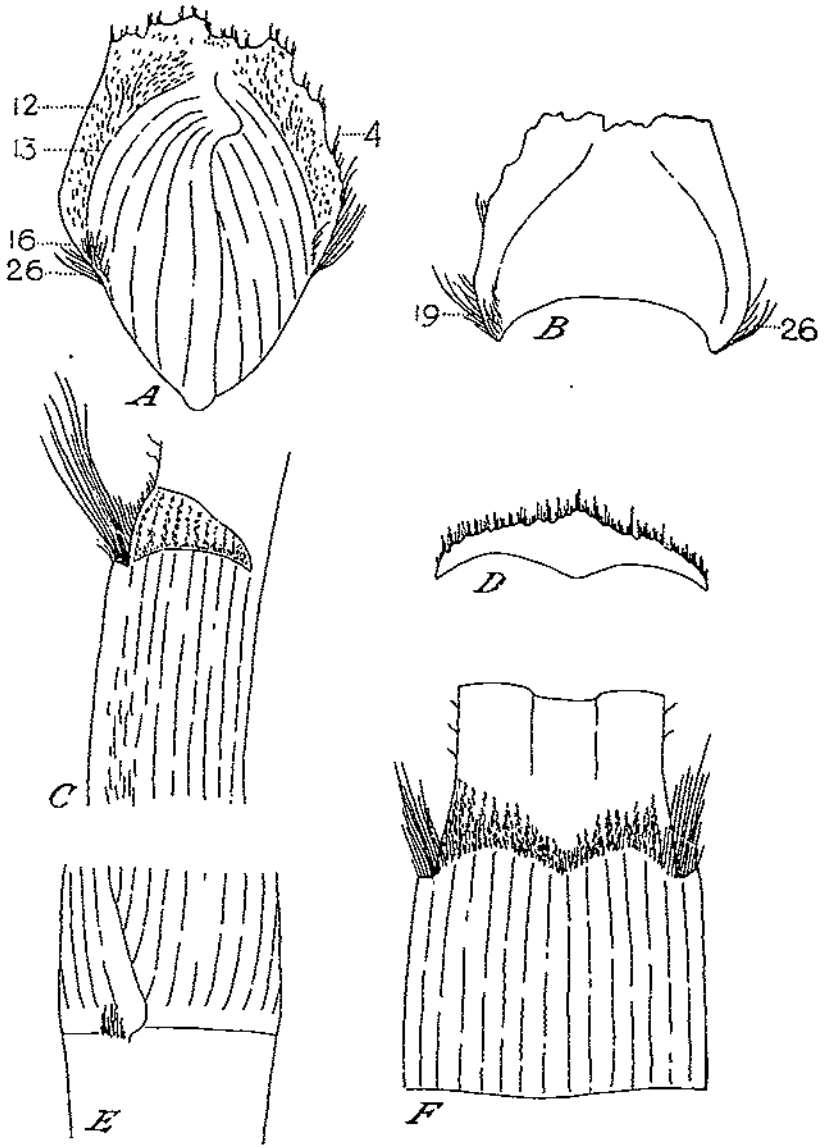


FIGURE 6.—Clone Algiers: *A*, Anterior side of prophyll with hair groups; *B*, posterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

outer surface medium hairy (group 58) and heavily waxed. Sometimes long sheath hairs extend to base of dewlap forming a pseudo 58a, inner surface with fairly prominent marginal tufts (group 51) and medium long surface hairs (group 51a). The latter intermingle with the shorter hairs of group 52 and form a dense patch that extends through center of midrib; ligules shallow-deltoid or narrow-crescenti-

form with very long marginal fringe (group 61) and conspicuous dorsal pubescence (group 66). There are small deltoid inner auricles and pseudo-transitional outer auricles.

DIFFERENTIATING CHARACTERISTICS.—Obovate prophylls with large basal and apical appendage, massive emarginate wings, practically glabrous; very conspicuous hair groups 61 and 66.

CLONE BURMA

(Fig. 7)

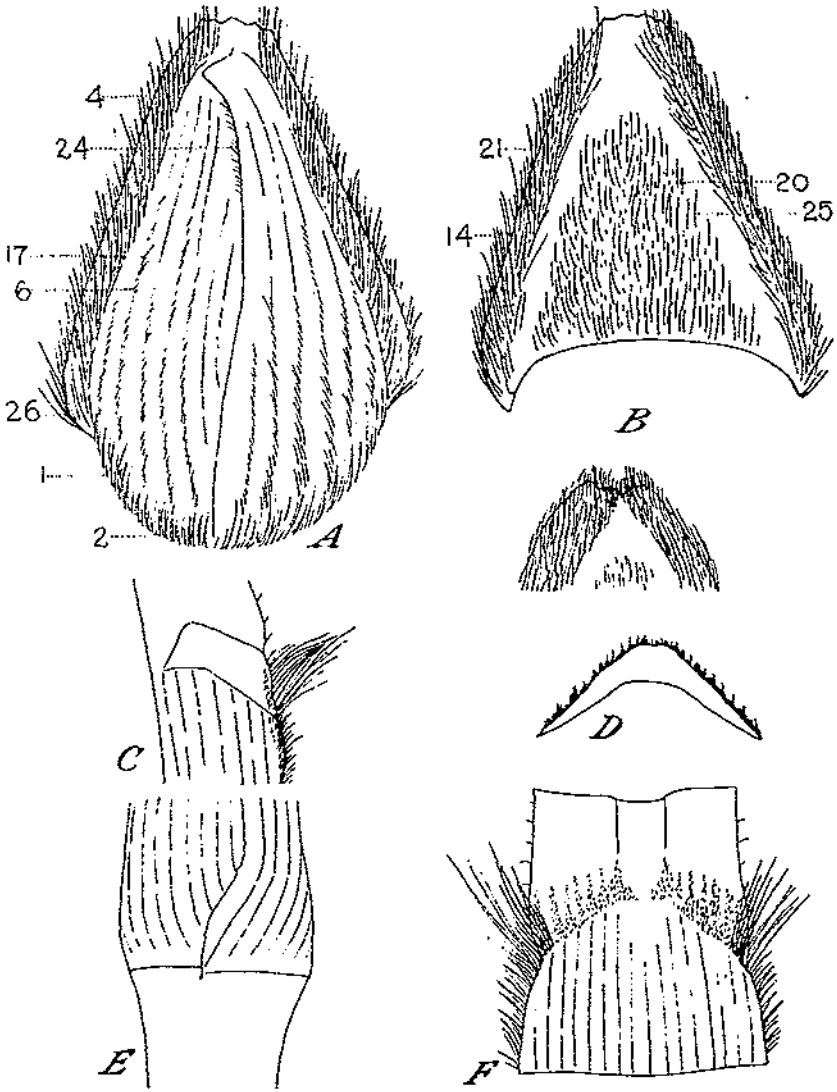


FIGURE 7.—Clone Burma: *A*, Anterior side of prophyll with hair groups; *B*, posterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

ORIGIN.—Imported from India in 1935 but originally found in Burma.

CULMS.—Dark-green and lightly waxed; internodes very long (up to 39 cm.), distinctly conoidal and constricted below sheath base, about 16 mm. across at widest part, pithy in center; stem-epidermis pattern 2, cork cells squarish or rhomboidal, a few short-pointed, mostly solitary, long cells straight, averaging 11μ in diameter, stomates medium abundant; growth rings medium wide or wide and swollen; root bands high (13 mm.), cylindrical on bud side and distinctly obconoidal on side opposite bud, with two uniform rows of large root primordia; prophylls of buds large, ovate, with wing inserted below middle of prophyll and very hairy.

LEAVES.—Leaf sheaths long (35 cm.), persistent and, when young, strewn with short deciduous hairs, both sheath margins prominently fringed (hair group 56), sheath base straight; blades short (115 cm.) and about 3.1 cm. wide at middle, midrib shallow, stomatal grooves wanting but there are present scattered converging spines flanking the rows of stomates; dewlaps squarish, outer surface smooth, inner surface with small marginal tufts (hair group 51) and a medium-prominent hair group 52 that extends partly across midrib; ligules shallow-deltoid, about 3.5 mm. high, with steeply sloping flanges, free edge of ligules with bunched cilia (hair group 61) and more or less inconspicuous dorsal pubescence (hair group 66).

DIFFERENTIATING CHARACTERISTICS.—Very long, only lightly waxed internodes; obconoidal root bands; absence of stomatal grooves. The chromosome number is $2n=80$ to 84 according to Starrett [5] and 96 according to Janaki-Ammal and Singh (*9*).

CLONE DACCA

(Fig. 8)

ORIGIN.—Imported from India in 1930; originally found near Dacca.

CULMS.—Light-green and heavily waxed; internodes medium long or short (22 cm.) somewhat bobbin-shaped or conoidal and constricted below sheath base, 14 mm. across and hollow in center, stem-epidermis pattern 2, cork cells squarish, a few short-pointed and mostly solitary, width of long cells 12.5μ, stomates fairly abundant; growth rings medium wide and somewhat swollen; root bands 9 mm. high, somewhat tumescent or obconoidal on side opposite bud, with two rows of sparse root primordia; prophylls of buds relatively large (11 mm.) obovate, with wing attached near middle of prophyll, notched along edges and often with prominent apical appendage, both wing and sides very hairy.

LEAVES.—Leaf sheaths long (up to 36 cm.), persistent and smooth, overlying sheath margin prominently ciliate (hair group 56) for a distance of 22 cm., underlying sheath margin also prominently ciliate but for a shorter distance; sheath base straight and partly or completely fringed (hair group 59), broad parenchymatous margin at sheath base free but not decurrent; blades up to 142 cm. long and 2.5 cm. wide at middle, becoming reduced in width above blade joint, lower epidermis with prominent stomatal grooves; dewlaps narrow-deltoid with base line straight or pointing slightly downward, outer

[5] See footnote 4, p. 10.

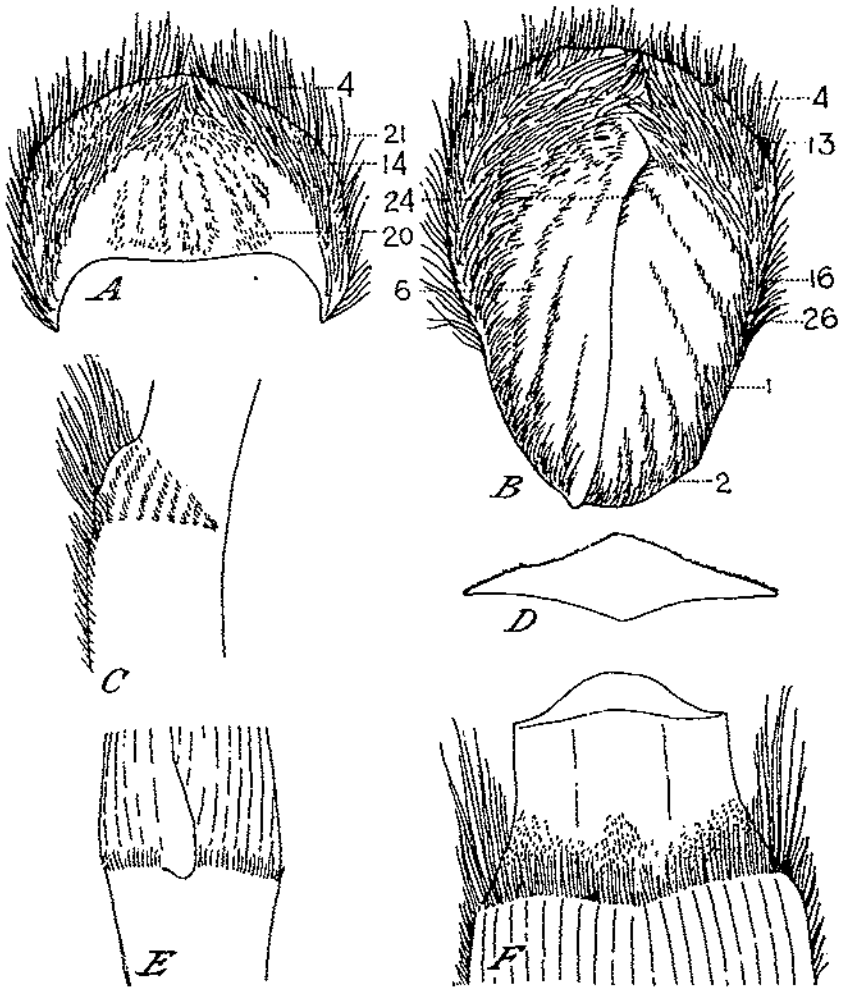


FIGURE 8.—Clone Dacca: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

surface slightly hairy but heavily waxed, hair group 58a small and marginal and seen only on young organs, inner dewlap surface with prominent corner tufts (hair group 51) and long surface hairs (group 51a) extending across midrib, hair group 52 inconspicuous and mostly covered up by the longer hairs of group 51a; ligules flat rhomboid, about 5 mm. high at center and inconspicuously fringed (group 61), dorsal pubescence (group 66) also inconspicuous.

DIFFERENTIATING CHARACTERISTICS.—Prophylls obovate and very hairy; prominent hair group 56 on both sheath margins. The chromosome number is $n=42$ according to Starrett,[6] $2n=72$ according to Bremer (*5*), and 80 according to Janaki-Ammal (*8*).

[6] See footnote 4, p. 10.

CLONE DJATIROTO

(Fig. 9)

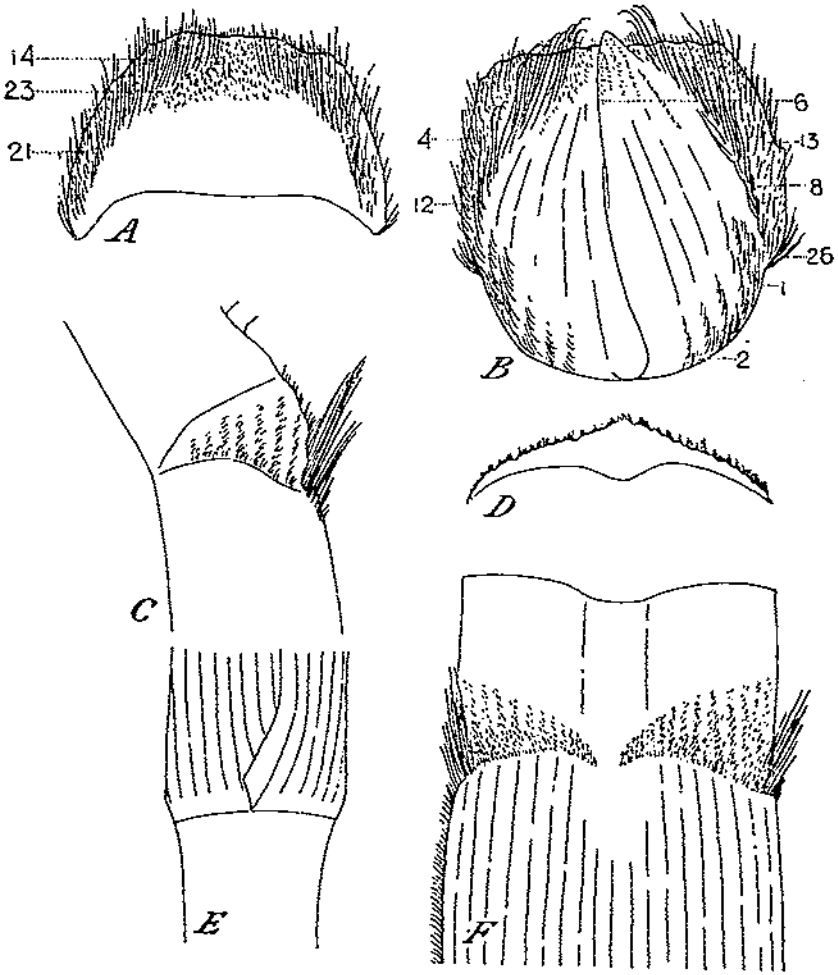


FIGURE 9.—Clone Djatiroto: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

ORIGIN.—Imported from Java in 1929.

CULMS.—Apple-green and heavily waxed; internodes medium long (26 cm.), slightly conoidal and strongly depressed below sheath base, 14 mm. across and pithy in center; stem-epidermis pattern 2, cork cells rhomboidal or squarish and always solitary, width of long cells 12μ, stomates abundant; growth rings narrow and swollen; root bands up to 7 mm. high, cylindrical, with 2 rows of fairly crowded and regular root primordia with those in lower row larger than those in

upper; prophylls of buds medium large, distinctly squarish, with wing inserted slightly below middle of prophyll, tip truncate and notched.

LEAVES.—Leaf sheaths very long (up to 38 cm.), persistent and smooth, with overlying sheath margin prominently ciliate (hair group 56) for a distance of 4.5 cm., sheath base straight; blades up to 138 cm. long and 3.9 cm. wide at middle, midrib shallow, lower epidermis with shallow, at times incompletely developed stomatal grooves; dewlaps deltoid or somewhat squarish with strongly convex upper margin; outer dewlap surface medium-hairy (group 58), inner surface with small marginal tufts (group 51) and prominent group 52 that extends nearly or completely across midrib; ligules crescent-shaped with very long marginal cilia (group 61) and prominent dorsal pubescence (group 66). There is a small inner auricle with hair group 71.

DIFFERENTIATING CHARACTERISTICS.—Relatively broad blade with shallow stomatal grooves; prominent though short group 56 on overlying sheath margin; small inner auricle; prophylls pentagonal or squarish with broad truncate wings. The chromosome number is $2n=112$ according to Bremer (*4*).

CLONE FORMOSA 4

(Fig. 10)

ORIGIN.—Selection from seed imported from Taiwan, Formosa, Japan, in 1931.

CULMS.—Yellow-green and heavily waxed; internodes medium long (24 cm.), cylindrical and constricted below sheath base, 11 to 14 mm. across, pithy and slightly hollow in center; stem-epidermis pattern 3a, cork cells rhomboidal or squarish, usually solitary, average width of long cells 15μ, stomates numerous; growth rings narrow and slightly swollen; root bands 7 mm. high, cylindrical, obconoidal on side opposite bud, with two regular rows of widely spaced root primordia; prophylls small (8 mm.) and inserted some distance above sheath base, broadly ovate, with wing attached below middle of prophyll, tip somewhat truncate, multiple-notched or cleft, wing very broad and fringed with short hairs (group 4).

LEAVES.—Leaf sheaths long or very long (up to 40 cm.), persistent, smooth, occasionally strewn with short deciduous hairs, sheath base slightly decurrent or straight, sometimes partially fringed (group 59), overlying sheath margin with a short but dense group 56; blades relatively short (up to 114 cm.) and 1.6 cm. wide at middle, midrib prominent but shallow, lower epidermis with narrow and medium deep stomatal grooves and upper epidermis with an occasional giant spine; dewlaps wedge-shaped; outer surface with fairly prominent group 58 and marginal group 58a, inner surface with prominent corner tufts (group 51) and rather long surface hairs (group 51a) completely covering up group 52 and extending almost clear through center of midrib; ligules medium high and crescentiform with long marginal fringe (group 61) and prominent dorsal pubescence (group 66).

DIFFERENTIATING CHARACTERISTICS.—This clone differs from the succeeding clone Formosa, by having a longer leaf sheath, a marginal hair group 58a, and absence of an inner auricle.

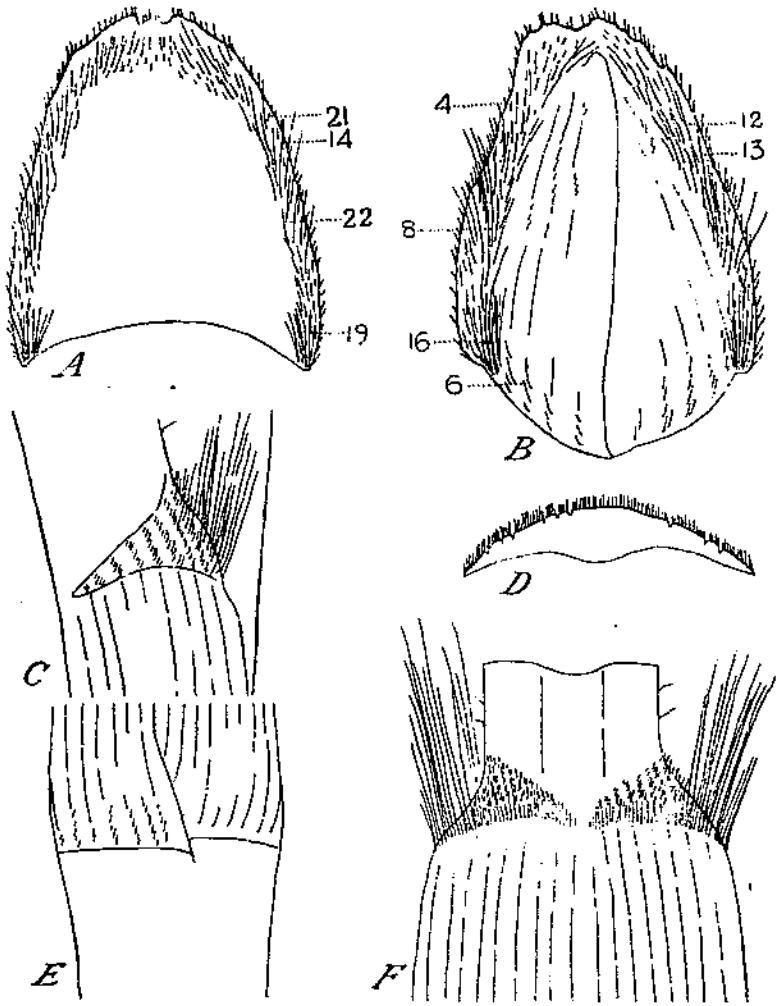


FIGURE 10.—Clone Formosa 4: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

CLONE FORMOSA

ORIGIN.—Imported from Taiwan, Formosa, Japan, in 1936.

CULMS.—Yellowish-green and heavily waxed; internodes short (about 20 cm.), slightly bobbin-shaped, 10 mm. across and hollow in center; stem-epidermis pattern 2, cork cells squarish, solitary or in groups of two or more, average width of long cells 10μ, stomates fairly abundant; growth rings narrow and swollen; root bands about 9 mm. high, cylindrical, with two staggered rows of root primordia; prophylls

of buds up to 11 mm. tall, ovoid, with massive wing inserted at or slightly below middle of prophyll, cleft at apex; pubescence mostly restricted to region of juncture and margin.

LEAVES.—Leaf sheaths relatively short (up to 25 cm.), persistent and smooth; overlying sheath margin prominently ciliate (group 56) for a distance of 4 to 7 cm. and with the hairs covering entire width of parenchymatous margin; underlying sheath margin with short and inconspicuous group 56; the latter, however, may extend for a distance of several centimeters, being most prominent just below the dewlap and gradually thinning out farther down; blades relatively very short (101 cm.) and only 1.1 cm. wide at middle, midrib broad and shallow, lower epidermis with prominent stomatal grooves; dewlaps small, wedge-shaped, with tips pointing downward, outer surface practically smooth, inner surface with prominent corner tufts (group 51), the base of which may cover up to one-third of the width of the dewlaps; medium short surface hairs (group 51a) and the short hairs of group 52 form a dense but rather narrow band across midrib; ligules shallow rhomboid or crescentiform with medium conspicuous marginal fringe (group 61) and inconspicuous dorsal pubescence (group 66); there is present a small inner auricle the pubescence of which (group 71) is continuous with the hairs of group 56.

DIFFERENTIATING CHARACTERISTICS.—Hair group 56 on overlying sheath margin forms a narrow strip for a distance of 4 to 7 cm.; on underlying sheath margin the group is inconspicuous and the hairs are continuous with those on inner auricle (group 71).

CLONE GEHRA BON

(Fig. 11)

ORIGIN.—Imported from Assam, India, in 1930.

CULMS.—Yellow-green and heavily waxed; internodes short (19 cm.), cylindrical, 9 mm. across, hollow in center; stem-epidermis pattern 3a, cork cells rhomboid or reniform and broader than long, mostly solitary, average width of long cells 12μ, stomates fairly abundant; growth rings narrow and swollen; root bands 7 mm. high and somewhat obconoidal, with two rows of root primordia; prophylls of buds small, ovate, with wings attached below middle of prophyll, tip notched.

LEAVES.—Leaf sheath relatively long (33 cm. and up to 39), persistent, smooth and heavily waxed; some sheaths have an inconspicuous group 56 on overlying margin with the hairs sparse and beginning a little distance below the blade joint; sheath base straight, sometimes with slightly decurrent margin; blades long (164 cm.) and 1.2 cm. wide at middle, becoming reduced to midrib at region of blade joint, midrib small but massive, lower epidermis with prominent stomatal grooves; dewlaps broadly triangular with base line horizontal or occasionally with outer margin decurrent; outer dewlap surface smooth, but occasionally small marginal tufts (hair group 58a) are present on youngest sheaths; inner dewlap surface with prominent marginal tufts (group 51) and prominent group 52, the latter extending across midrib. In center of midrib hairs may be longer and denser, forming

a more or less definite group 55; ligules very high (up to 7 mm.), deltoid, with horizontal or slightly curved base line; marginal fringe (group 61) and dorsal pubescence (group 66) prominent. Since the

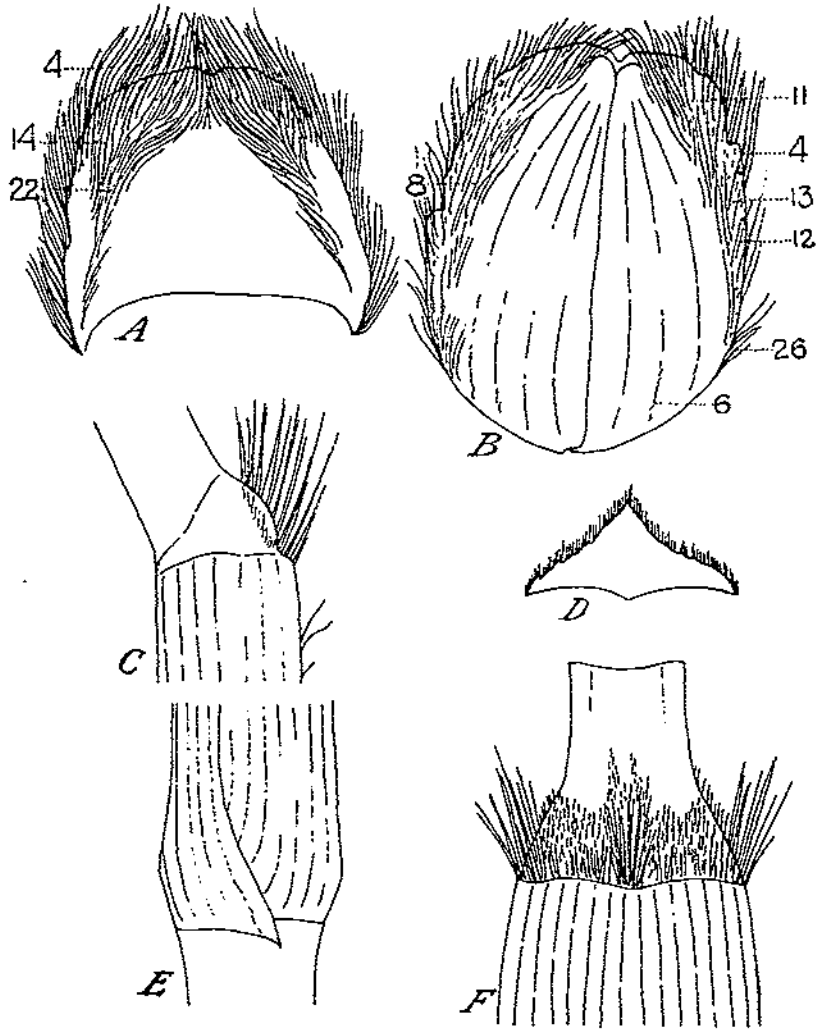


FIGURE 11.—Clone Gehra Bon: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

ligule is wider than the blade, the flanges become decurrently continuous with membranaceous sheath margin.

DIFFERENTIATING CHARACTERISTICS.—Very high deltoid ligule, the flanges of which become decurrently continuous with membranaceous margins of sheath.

CLONE KEPANDJEN

(Fig. 12)

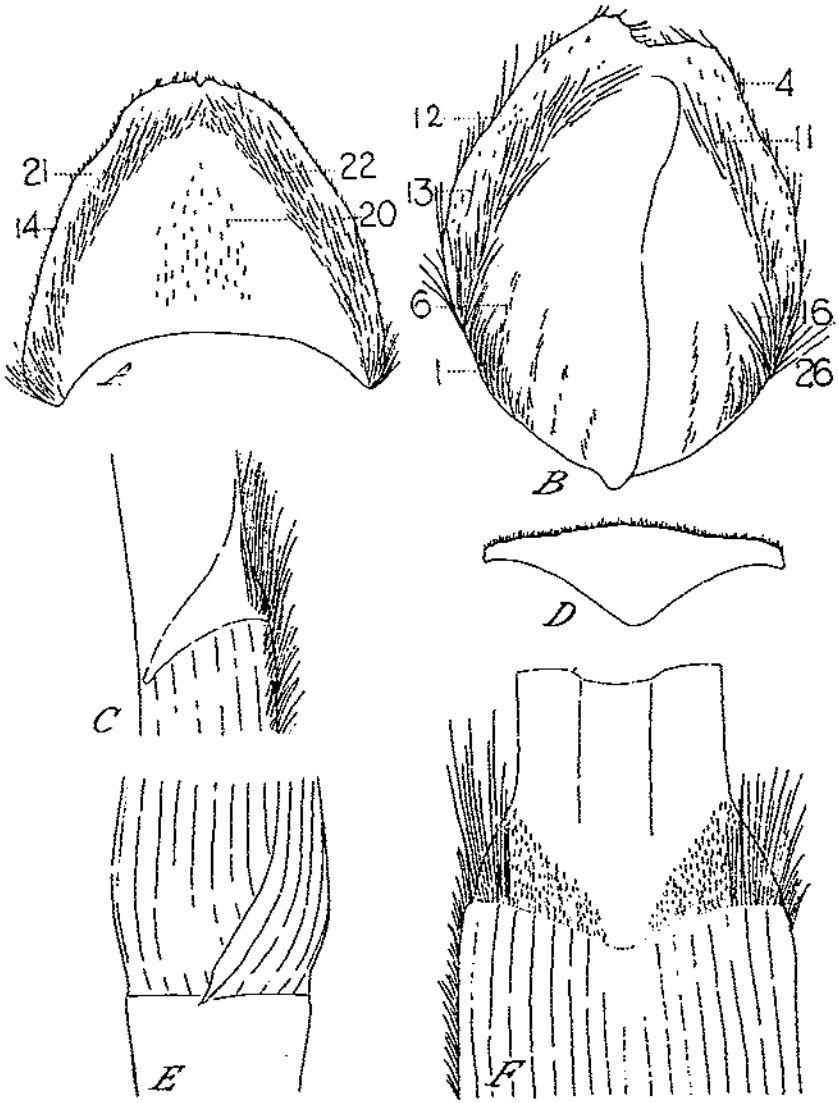


FIGURE 12.—Clone Kepandjen: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

ORIGIN.—Imported from Java in 1929.

CULMS.—Dark-green and heavily waxed; internodes short, cylindrical or somewhat conoidal and constricted below sheath base, terete or slightly oval in cross section, about 14 mm. across, center pithy; stem-epidermis pattern 3, cork cells squarish and solitary, average

width of long cells 14μ, stomates abundant; growth rings narrow or medium wide and swollen; root bands 7 mm. high, somewhat tumescent, with two rows of root primordia, those in the lower row much larger than those in the upper; prophylls of buds ovate, about 8 mm. high, wing attached below middle of prophyll, tip broadly truncate with shallow cleft or notch.

LEAVES.—Leaf sheaths about 30 cm. long, persistent and, when young, strewn with deciduous hairs; overlying sheath margin with a short but prominent group 56 inserted as a narrow band, which lower down on the sheath becomes restricted to marginal cilia; sheath base straight, its membranaceous margin somewhat appendaged; blades up to 165 cm. long and 2.5 cm. broad at middle, leaf carriage a very symmetrical fan, lower epidermis with deep and narrow stomatal grooves; dewlaps wedge-shaped with tip pointing downward, outer surface mostly smooth except for an inconspicuous marginal group 58a, inner dewlap surface with small marginal tufts (group 51) and sparse group 52 that advances almost to the center of the midrib; ligules inverted-deltoid with straight or slightly convex upper margin bearing short or medium-high cilia (group 61) and short more or less adnate dorsal hairs (group 66). There is a small deltoid inner auricle bearing hair group 71 and often a transitional outer auricle the width of the broad parenchymatous sheath margin.

DIFFERENTIATING CHARACTERISTICS.—Inverted deltoid ligule associated with wedge-shaped, steeply downward-sloping dewlaps. The chromosome number is $2n=112$ according to Bremer (*4*) and $n=54$ according to Starrett.[7]

CLONE KLOET

(Fig. 13)

ORIGIN.—Imported from Java in 1929.

CULMS.—Apple-green and heavily waxed; internodes long, bobbin-shaped to conoidal and constricted below sheath base, 16 mm. across, center pithy; stem-epidermis pattern 3a, cork cells squarish and solitary, average width of long cells 16μ, stomates abundant; growth rings narrow or fairly wide and swollen; root bands 9 mm. high, cylindrical or slightly tumescent, with one or two rows of root primordia; prophylls of buds large, elongate-ovate, with wing inserted below middle, tip rounded, wing very hairy.

LEAVES.—Leaf sheaths medium long (30 cm.), persistent and smooth, overlying sheath margin with medium prominent hair group 56; sheath base straight; blades short and very wide (up to 4.7 cm.), midrib flat, lower epidermis with medium deep stomatal grooves; dewlaps typically ligulate, rather narrow and sloping, outer surface practically smooth except for an inconspicuous group 58a, inner surface with prominent marginal tufts (group 51) and with group 52 extending to outer margin of midrib; ligules crescentiform, shallow and asymmetrical, with fairly high marginal fringe (group 61) and dense but slightly adnate dorsal pubescence (group 66).

DIFFERENTIATING CHARACTERISTICS.—Short and broad lamina, shallow crescentiform ligule, prominently fringed; ligulate dewlaps of the type often found in noble canes. The chromosome number is $2n=118$–122 and $n=60$ according to Starrett.[7]

[7] See footnote 4, p. 10.

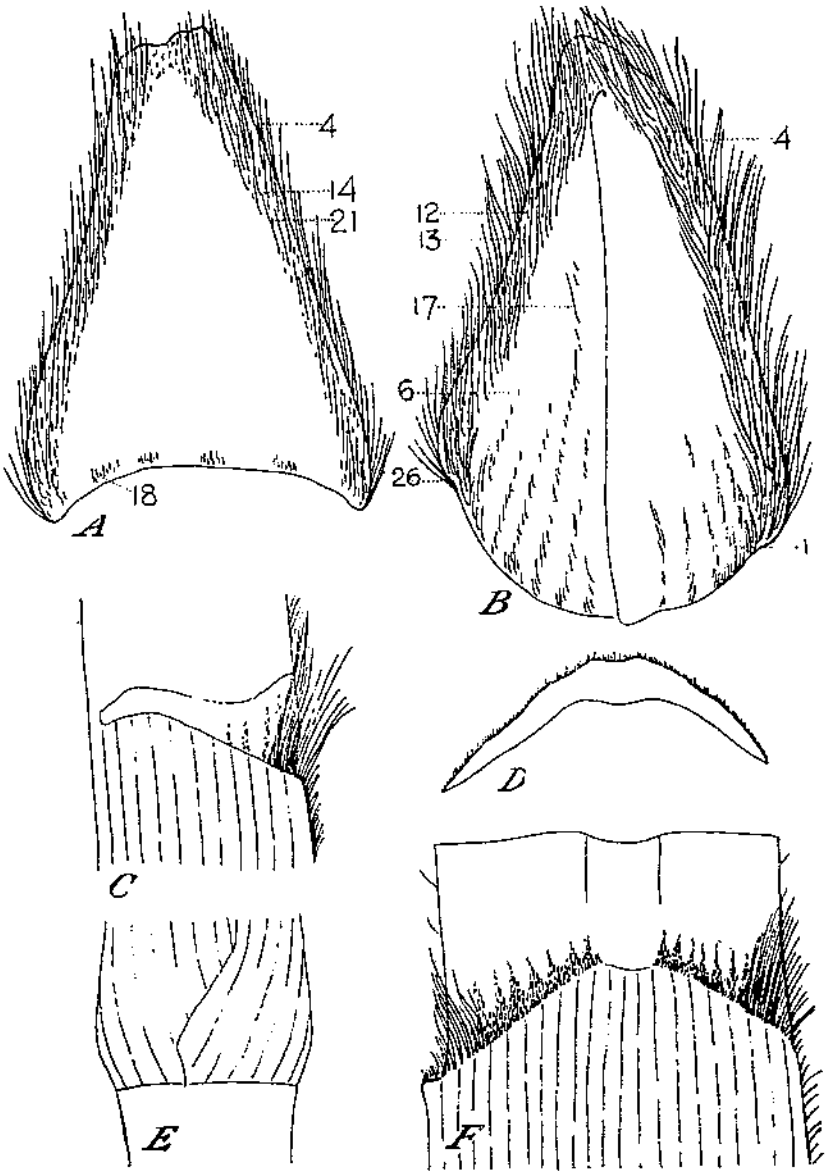


FIGURE 13.—Clone Kloet: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

CLONE LAHORE

(Fig. 14)

ORIGIN.—Imported from Lahore, India, in 1930.

CULMS.—Green, later straw-colored and medium heavily waxed; internodes short, cylindrical, about 4 mm. across and hollow in

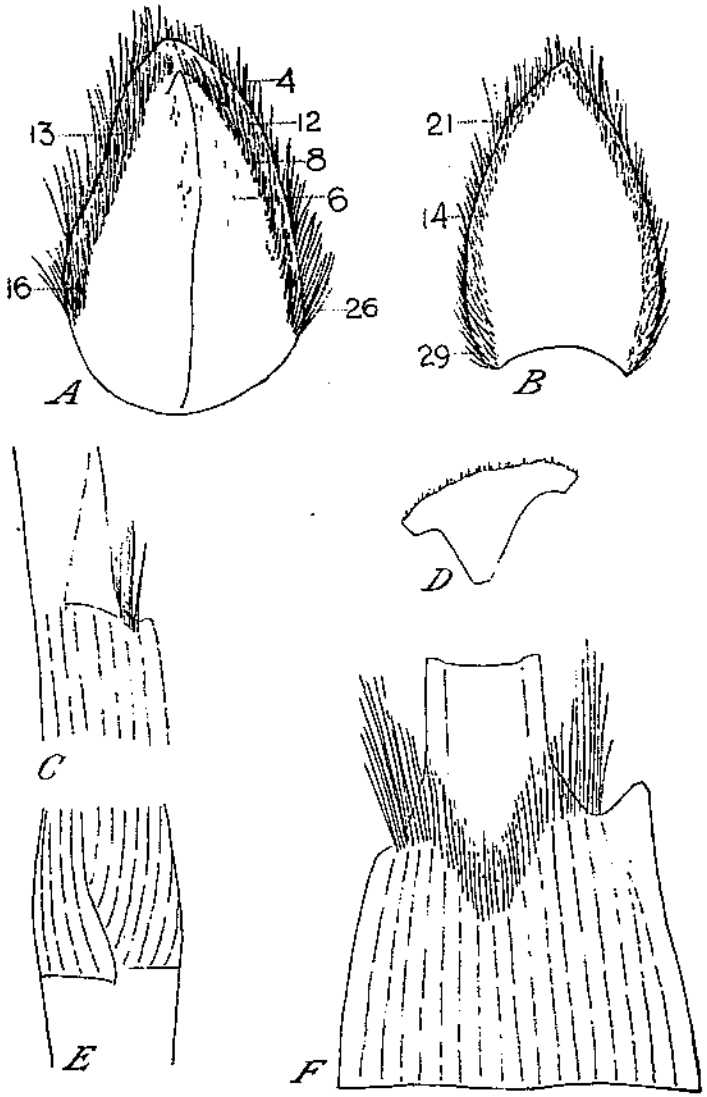


FIGURE 14.—Clone Lahore: *A*, Anterior side of prophyll with hair groups; *B*, posterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

center; stem-epidermis pattern 3, cork cells squarish, average width of long cells 12μ; growth rings narrow and swollen; root bands 4 mm. high, obconoidal with one row of sparse root primordia; prophylls of buds small, elongate-triangular with broad wing attached well below middle of prophyll, most prominent hair groups in region of juncture.

LEAVES.—Leaf sheaths medium long (up to 29 cm.), persistent and smooth; sheath base straight or slightly decurrent; blades up to 161 cm. long and reduced to width of a narrow midrib for entire length; prominent stomatal grooves in lower epidermis and giant spines in upper; dewlaps hardly differentiated from blade joint, at best inconspicuous; outer surface slightly hairy (group 58); inner surface with prominent marginal tufts (group 51) and long surface hairs (group 51a) extending across midrib; ligules with deeply depressed horseshoe-shaped base line and slightly rounded free margin bearing medium long or short lashes (group 61), dorsal pubescence of ligule (group 66) fairly conspicuous with hairs long and adnate only in lower region. The ligule being wider than the midrib, its flanges become decurrently continuous with membranaceous margins of sheath.

DIFFERENTIATING CHARACTERISTICS.—Plants very small, grasslike, with lamina reduced to width of narrow midrib; long surface hairs (group 51a) extend across entire midrib. Dewlaps inconspicuous and hardly differentiated from blade joint. The chromosome number is $2n=80$ according to Starrett[8] and $2n=48$ according to Janaki-Ammal (*8*).

CLONE COIMBATORE LOCAL

(Fig. 15)

ORIGIN.—Imported from Coimbatore, India, in 1928.

CULMS.—Dark-green and heavily waxed; internodes cylindrical and slightly constricted below sheath base, 10 mm. across and hollow in center; stem-epidermis pattern 3a, cork cells squarish, solitary or occasionally in groups of two or more, average width of long cells 11.5μ, stomates abundant; growth rings medium wide and swollen, root bands about 7 mm. high, somewhat obconoidal, with two staggered rows of sparse root primordia; prophylls of buds small, ovate, with broad truncate wing, giving entire prophyll a squarish shape; wings very hairy.

LEAVES.—Leaf sheaths medium long (30 cm.), persistent and smooth, overlying sheath margin inconspicuously ciliate (group 56); a few hairs may also be present on underlying sheath margin in connection with a transitional type of auricle; sheath base slightly decurrent and appendaged; blades up to 123 cm. long and 1.2 cm. wide at middle, becoming reduced to width of midrib above blade joint, lower epidermis with prominent stomatal grooves and giant spines; dewlaps very small, somewhat deltoid, outer dewlap surface slightly hairy (group 58), inner surface with prominent corner tufts (group 51) and medium long surface hairs (group 51a) forming a broad band across midrib; ligules high, deltoid, with horizontal and slightly curved base line, free margin with fairly prominent cilia (group 61) and conspicuous dorsal pubescence (group 66).

DIFFERENTIATING CHARACTERISTICS.—Buds squarish, inconspicuous group 56 on overlying sheath margin. The chromosome number is $2n=92$ and $n=40$ according to Starrett[8] and $2n=64$ according to Dutt and Subba Rao (*6*).

[8] See footnote 4, p. 10.

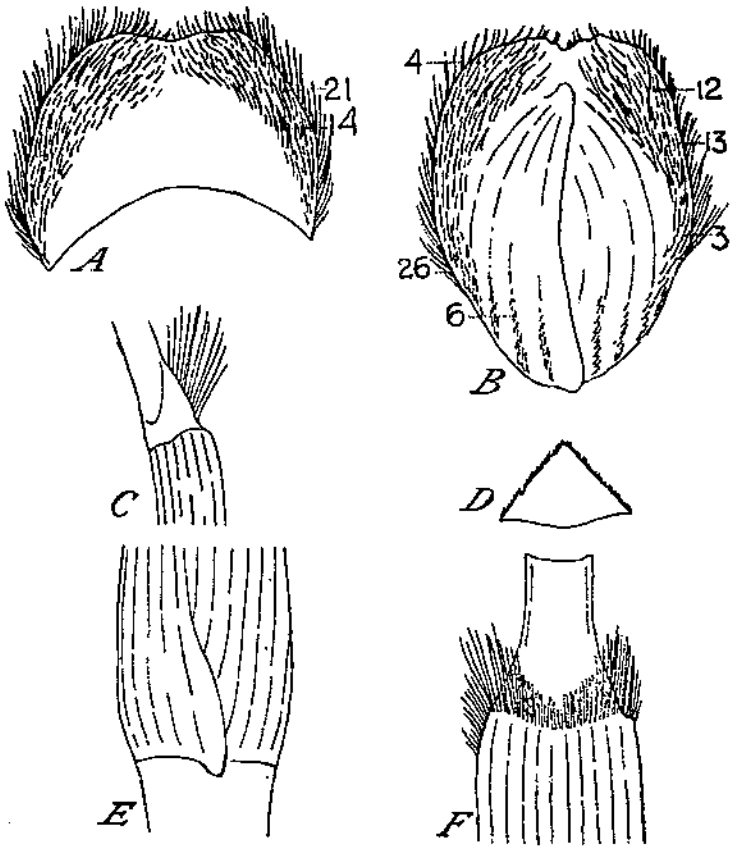


FIGURE 15.—Clone Coimbatore Local: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

CLONE PASOEROEAN

(Fig. 16)

ORIGIN.—Imported from Java in 1929.

CULMS.—Light-green and heavily waxed; internodes long (31 cm.), slightly conoidal and constricted below sheath base; 16 mm. across with pithy and slightly hollow center; stem-epidermis pattern 3, cork cells squarish and solitary, average width of long cells 12.5μ, stomates fairly abundant; growth rings narrow or wide and swollen; root bands 8 mm. high, obconoidal on side opposite bud and with two, sometimes three, staggered rows of root primorida; prophylls of buds medium large (11 mm.), ovate or elongate-triangular, with wing inserted below middle of prophyll, tip round or round-mucronate.

LEAVES.—Leaf sheaths relatively long (30 cm.), persistent, and strewn with brittle, appressed acicular hairs; both overlying- and

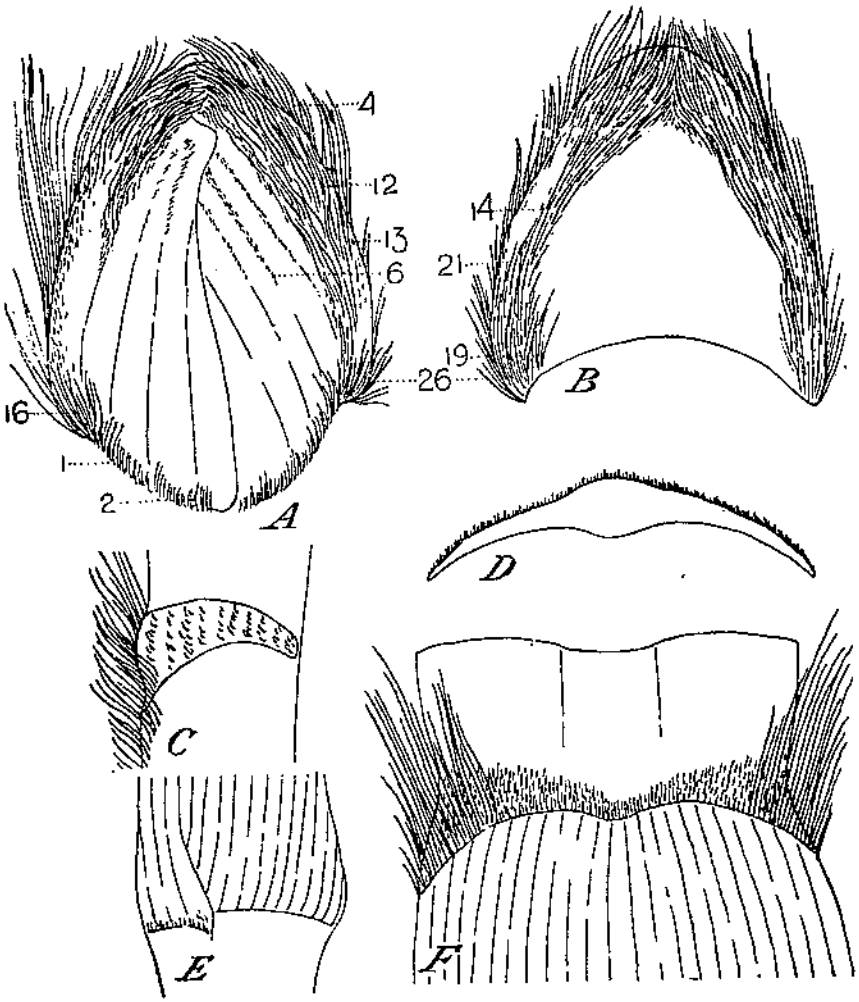


FIGURE 16.—Clone Pasoeroean: *A*, Anterior side of prophyll with hair groups; *B*, posterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

underlying-sheath margins prominently fringed (group 56), sheath base slightly decurrent and partly fringed with medium-long erect hairs (group 59); blades up to 125 cm. long and 3 cm. wide at middle, lower epidermis with incompletely developed stomatal grooves; dewlaps distinctly ligulate, outer surface slightly hairy (group 58) but with prominent marginal tufts (group 58a) that are continuous with the hairs of group 56 and the sheath hairs in general; inner surface of dewlaps with prominent marginal tufts (group 51), the basal line of which may cover one-third of width of dewlap, semilong surface hairs (group 51a) and short hairs of group 52 form a narrow band across midrib; ligules shallow-crescentiform with short marginal

fringe (group 61) and medium prominent dorsal pubescence (group 66).

DIFFERENTIATING CHARACTERISTICS.—Prominent group 51 covering at base one-third of width of dewlap; groups 51a and 52 form a shallow band across midrib. The chromosome number is $2n=126$ to 130 according to Starrett. [9]

CLONE RELLAGADI

(Fig. 17)

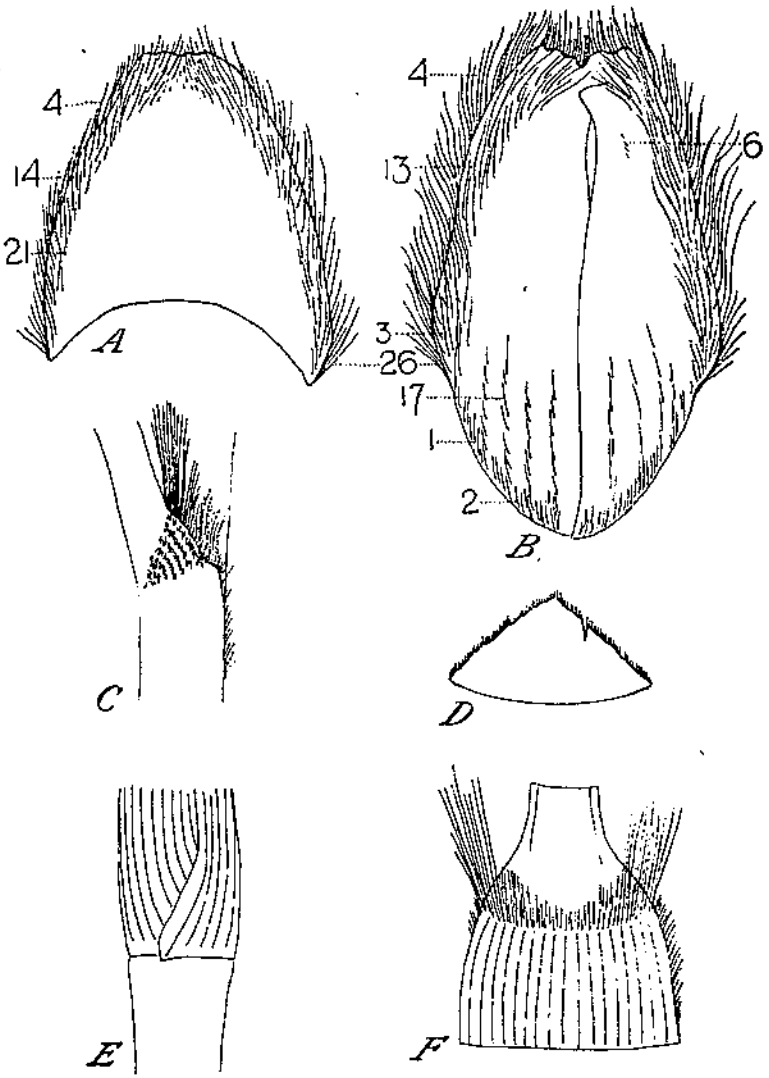


FIGURE 17.—Clone Rellagadi: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

[9] See footnote 4, p. 10.

ORIGIN.—From Godavari River in India, imported in 1930.

CULMS.—Light-green and heavily waxed; internodes short, cylindrical, 7 mm. across, hollow in center; stem-epidermis pattern 1, cork cells reniform, usually broader than long, average width of long cells 10μ, stomates abundant; growth rings narrow and swollen; root bands 7 mm. high, cylindrical but obconoidal on side opposite bud, with two rows of semicrowded or sparse root primordia; prophylls of buds small, elongate-ovate, with wing inserted below middle of prophyll and rather narrow; tip slightly truncate and notched.

LEAVES.—Leaf sheaths short (20 to 22 cm.), persistent and smooth, overlying sheath margin with short (2.5 cm.) but prominent group 56 and occasionally an inconspicuous group 56 also found on underlying sheath margin, sheath base straight; blades short (112 cm.) and narrow (1.8 cm.) becoming reduced to width of midrib above blade joint; lower epidermis with prominent stomatal grooves; dewlaps wedge-shaped with tips pointing downward; outer dewlap surface fairly hairy, hairs short (group 58) but a small marginal tuft of long hairs (group 58a) usually present on side corresponding to overlying sheath margin; inner dewlap surface with well-developed marginal tufts (group 51) and semilong surface hairs (group 51a) which, together with group 52, form a dense, wedge-shaped patch across midrib; ligules high, deltoid, with prominent marginal fringe (group 61) and well-developed dorsal pubescence (group 66).

DIFFERENTIATING CHARACTERISTICS.—Internodes and sheaths very short; short but conspicuous group 56 on overlying sheath margin; presence of hair group 58a on side of overlying sheath margin; somatic chromosome number according to Starrett is $2n=86$ [10] and 64 according to Janaki-Ammal (*8*).

CLONE S. H. 244

(Fig. 18)

ORIGIN.—Imported from India in 1937, originally found in the Province of Bihar, northern India.

CULMS.—Light-green and medium heavily waxed; internodes short, cylindrical, somewhat constricted below sheath base, 6 mm. across, hollow in center, stem-epidermis pattern 3, cork cells squarish and solitary, average width of long cells 14μ, stomates medium abundant; growth rings yellow orange, narrow and flush with internode; root bands about 5.5 mm. high, obconoidal, with one or two rows of sparse root primordia; prophylls narrow ovate with wing inserted at middle of prophyll, wing narrow at point of insertion but massive near apex, tip double-notched.

LEAVES.—Leaf sheaths fairly long (30 cm.), persistent and smooth, both sheath margins prominently ciliated (group 56); sheath base straight; blades very long (180 cm.) and very narrow, reduced practically to width of midrib throughout entire length; lower epidermis with narrow and deep stomatal grooves; dewlaps wedge-shaped and sharply sloping downward; outer surface medium or slightly hairy (group 58), inner surface with corner tufts (group 51) extending nearly to center of midrib; shorter surface hairs of group 51a and hairs of group 52 form a dense mat across entire midrib; ligules high, deltoid

[10] See footnote 4, p. 10.

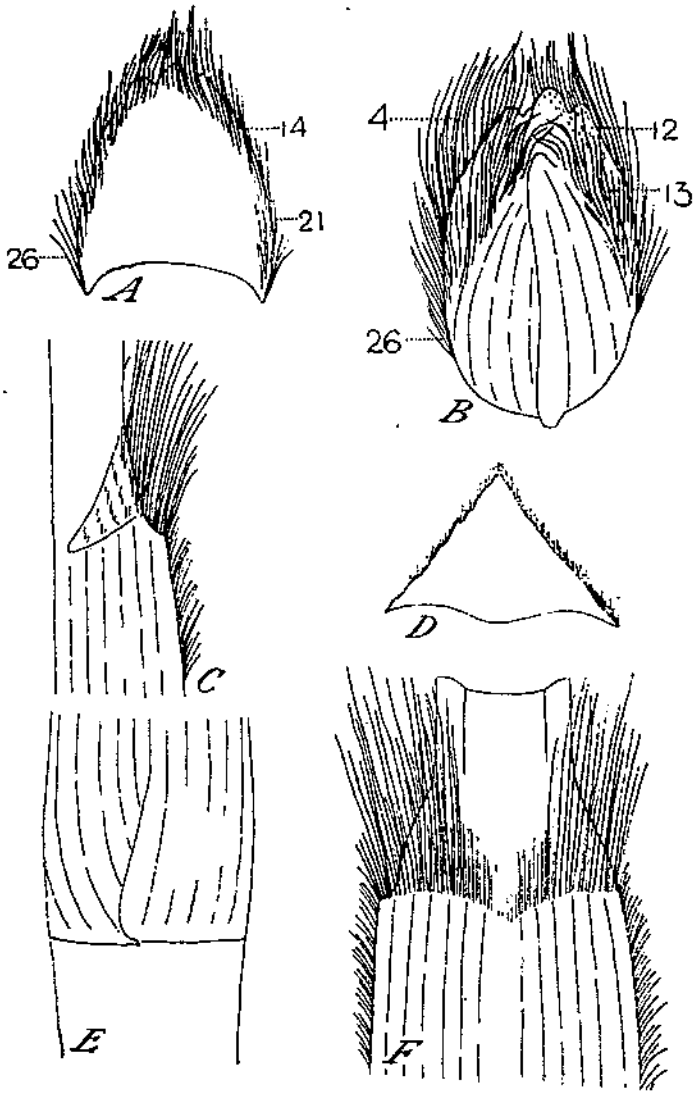


FIGURE 18.—Clone S. H. 244: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

with conspicuous marginal fringe (group 61) and exceedingly long dorsal pubescence (group 66).

DIFFERENTIATING CHARACTERISTICS.—Long grasslike leaf blades reduced practically to width of midrib throughout entire length; long hairs of group 51 extending practically across midrib. The chromosome number is $2n=80$ according to Starrett [11] and 64 according to Janaki-Ammal (*8*).

[11] See footnote 4, p. 10.

CLONE S. H. 249

(Fig. 19)

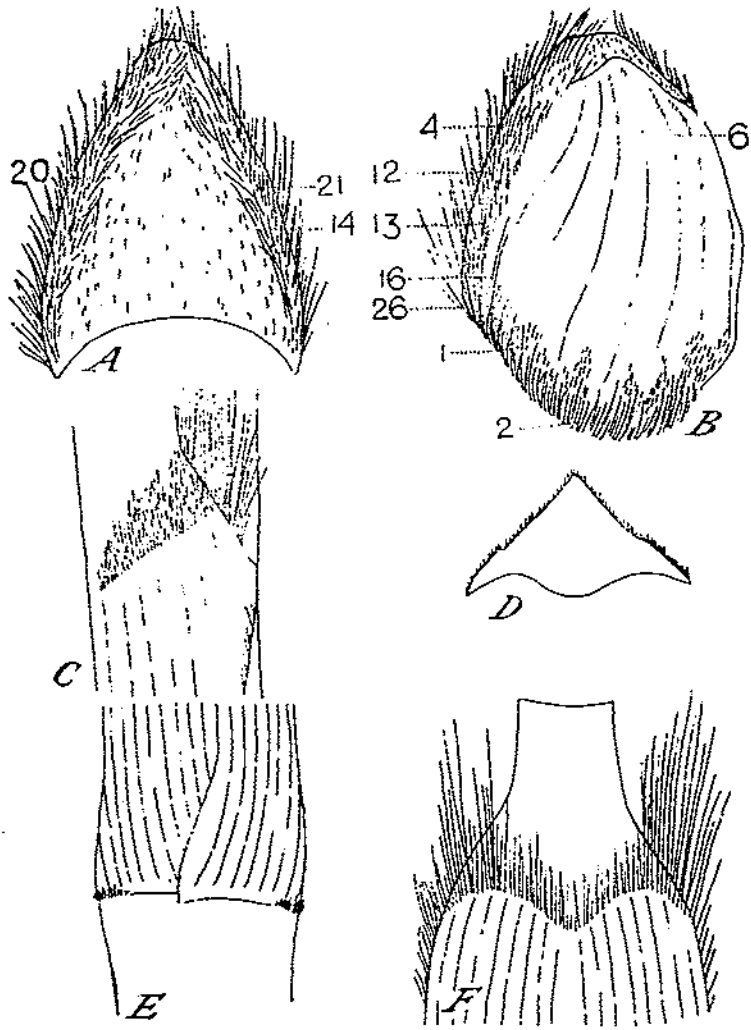


FIGURE 19.—Clone S. H. 249: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

ORIGIN.—Imported from India in 1937, originally found in the Province of Bihar, northern India.

CULMS.—Yellow-green and heavily waxed; internodes slightly bobbin-shaped, about 7 mm. across, pithy and hollow in center; stem-epidermis pattern 2, cork cells squarish and solitary, average width of long cells 11μ, stomates moderately abundant; growth rings narrow or medium wide and slightly swollen; root bands 6 mm. high

with a row of large and a partial row of small root primordia; prophylls small (6.5 mm.), elongate-ovate, with wing inserted below middle of prophyll, wing silvery and very hairy. Many buds have the overlapping side of prophyll so developed as to show little or nothing of the underlying side.

LEAVES.—Leaf sheaths fairly long (33 cm.), persistent and smooth; both sheath margins prominently ciliate (group 56); sheath base straight and occasionally ciliate (group 59) with hairs mostly in region opposite bud; blades very long (190 cm.) and practically reduced to width of narrow midrib for entire length; lower epidermis with deep stomatal grooves and upper epidermis with prominent giant spines; dewlaps wedge-shaped with tips sharply pointing downward; outer surface completely covered with long hairs (groups 58 and 58a), inner surface with prominent marginal tufts (group 51) and slightly shorter surface hairs (group 51a) which, together with group 52, form a conspicuous band across midrib; ligules high-deltoid with conspicuous marginal fringe (group 61) and less prominent dorsal pubescence (group 66). As the flanges of the ligule do not always reach the very edge of the sheath margin, a small transitional type of auricle may be considered present.

DIFFERENTIATING CHARACTERISTICS.—Long dense hairs on outer surface of dewlaps; large overlapping side of prophyll covering anterior surface of bud. The chromosome number is $2n=70$ according to Starrett.[12]

CLONE TABONGO

(Fig. 20)

ORIGIN.—Imported from northern Celebes in 1929.

CULMS.—Yellow-green and heavily waxed; internodes up to 26 cm. long, somewhat oval in cross section (15 by 13 mm.), pithy and hollow in center; stem-epidermis pattern 2, cork cells squarish and mostly solitary, cell width 12μ, stomates numerous; growth rings narrow or broad and swollen; root bands 7 mm. high, obconoidal, with two staggered rows of root primordia; prophylls 10 mm. high, ovate, with wing attached slightly below middle or at middle of prophyll, rather broad, tip truncate and notched, often with prominent apical appendage.

LEAVES.—Leaf sheaths medium long (30 cm.), persistent, when young strewn with deciduous hairs; overlying sheath margin with prominent group 56, underlying margin smooth; sheath base straight, sometimes with inconspicuous ring of cilia (group 59); blades rather long, up to 153 cm. and 2.6 cm. wide at middle; lower epidermis with medium prominent stomatal grooves; dewlaps squarish; outer surface lightly covered with short hairs (group 58), tufts on dewlap margins (group 58a); occasionally long hairs also near midrib; inner dewlap surface with prominent marginal tufts (group 51) and semilong surface hairs (group 51a) extending into center of midrib and covering the shorter hairs of group 52; ligules shallow-deltoid or asymmetrically strap-shaped (fig. 4, *M*), with medium prominent marginal fringe (group 61) and dorsal pubescence (group 66). There is a short deltoid inner auricle fringed with hairs of group 54, which extend over

[12] See footnote 4, p. 10.

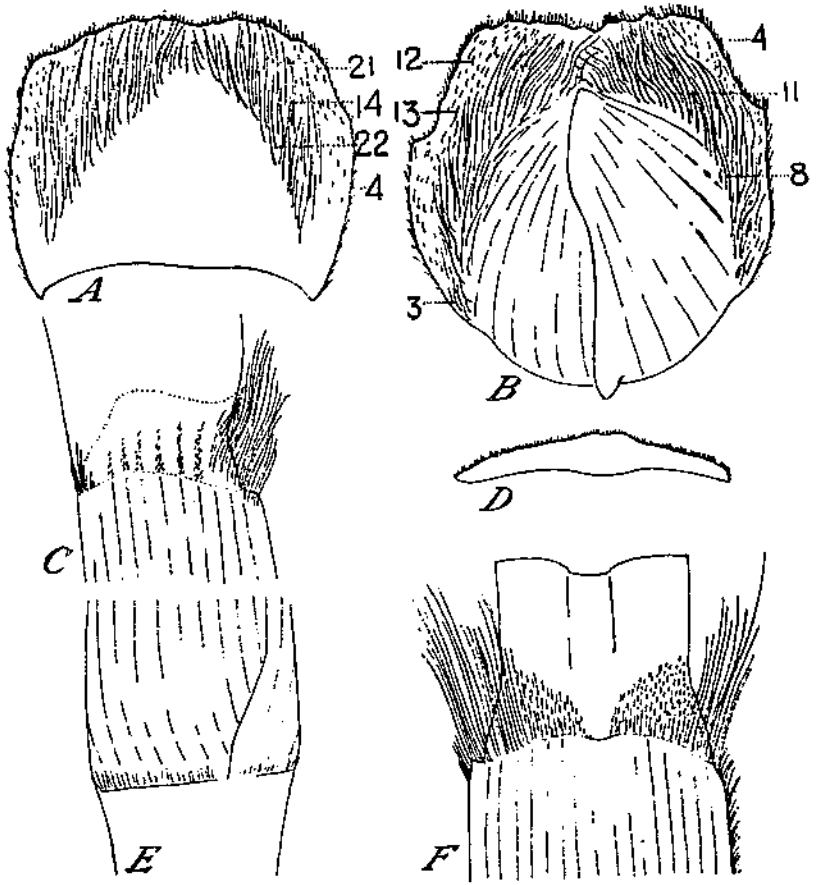


FIGURE 20.—Clone Tabongo: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

the tip, simulating an inconspicuous group 56; surface of auricle slightly pubescent (group 71).

DIFFERENTIATING CHARACTERISTICS.—Square or pentagonal buds; group 58a marginal, at times accessory tufts found near midrib; ligule asymmetrical and strap-shaped. The chromosome number is $2n=90$ according to Starrett [13] and $4n=40$ according to Bremer (*4*).

CLONE U. S. 4520

(Fig. 21)

ORIGIN.—Imported as seed from near the Amu Darya River, Turkmenistan, Union of Soviet Socialist Republics, in 1936.

[13] See footnote 4, p. 10.

CULMS.—Yellow-green and medium heavily waxed; internodes medium long or short, slightly conoidal and constricted below sheath base, up to 7 mm. across, pithy and hollow in center; stem-epidermis

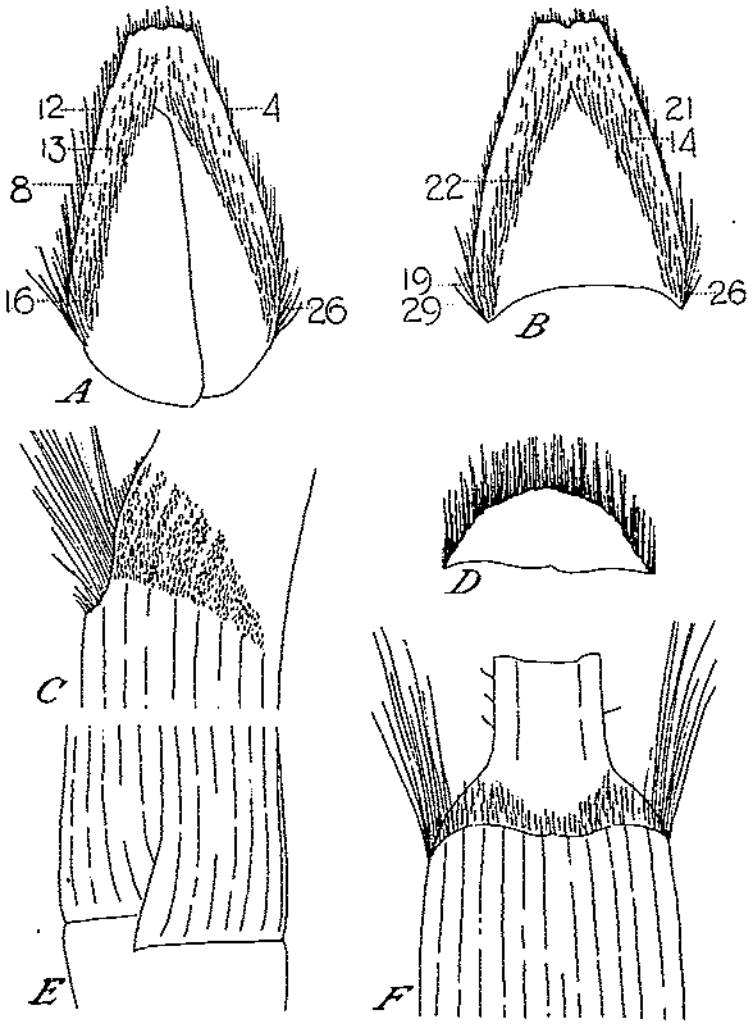


FIGURE 21.—Clone U. S. 4520: A, Anterior side of prophyll with hair groups; *B*, posterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

pattern 3, cork cells narrow reniform, broader than long, usually solitary; average width of long cells 15μ; stomates scarce or medium abundant; growth rings narrow and swollen; root bands about 5 mm.

high, obconoidal on side opposite bud with one row of sparse root primordia; prophylls long triangular with wing attached below middle of prophyll and notched, wing very hairy, sides smooth.

LEAVES.—Leaf sheaths short (20 cm.), persistent, and smooth; sheath base straight, occasionally fringed; blades up to 127 cm. long and very narrow, reduced to width of midrib for entire length; lower epidermis with deep stomatal grooves, upper with giant spines; dewlaps deltoid, outer surface medium or prominently hairy (group 58), inner surface with fairly prominent marginal tufts (group 51) and dense (group 52), composed of short or medium long hairs and extending across center of midrib; ligules high or somewhat shallow, deltoid with very prominent marginal fringe (group 61) and long dorsal pubescence (group 66). Descending flanges of ligule are continuous with membranaceous margins of sheath.

DISTINGUISHING CHARACTERISTICS.—Prophylls long and narrow; leaf sheath short. The chromosome number is $n=25$ according to Starrett.[14]

CLONE U. S. 4523

(Fig. 22)

ORIGIN.—Imported as seed from near the Amu Darya River, Turkmenistan, Union of Soviet Socialist Republics, in 1936.

CULMS.—Yellow-green and medium heavily waxed; internodes medium long, cylindrical and somewhat constricted below sheath base, up to 7 mm. across and hollow in center; stem-epidermis pattern 3, cork cells short squarish, rhomboid or reniform, solitary unless joined to a silica cell; average width of long cells 15.6μ. stomates medium abundant; growth rings narrow and swollen; root bands 4 mm. high and obconoidal, with one row of sparse root primordia; prophylls very small, short ovate or squarish with broad wing inserted at middle of prophyll; wing broad at point of insertion and often notched at apex, margin smooth or irregularly dentate, basal and apical appendages of membranaceous margin fairly prominent.

LEAVES.—Leaf sheaths long (34 cm.) and smooth; sheath base straight and commonly prominently ciliated (group 59), especially in older stalks; blades up to 147 cm. long and very narrow, reduced to width of midrib throughout entire length; lower epidermis with deep stomatal grooves, upper epidermis with giant spines; dewlaps small, deltoid; outer surface heavily waxed and almost smooth inner surface with small or medium marginal tufts (group 51) and prominent group 52 which extends across midrib; ligules deltoid with rounded or somewhat jagged tip, high or medium high, wider than blade and decurrently continuous with membranaceous margins of sheath; both marginal fringe (group 61) and dorsal pubescence (group 66) conspicuous.

DIFFERENTIATING CHARACTERISTICS.—This clone is distinguished from the closely related U. S. 4520 by its long sheath, short, more or less squarish prophylls, and prominently ciliated sheath base. The chromosome number is $2n=48$ to 50 and $n=25$ according to Starrett.[14]

[14] See footnote 4, p. 10.

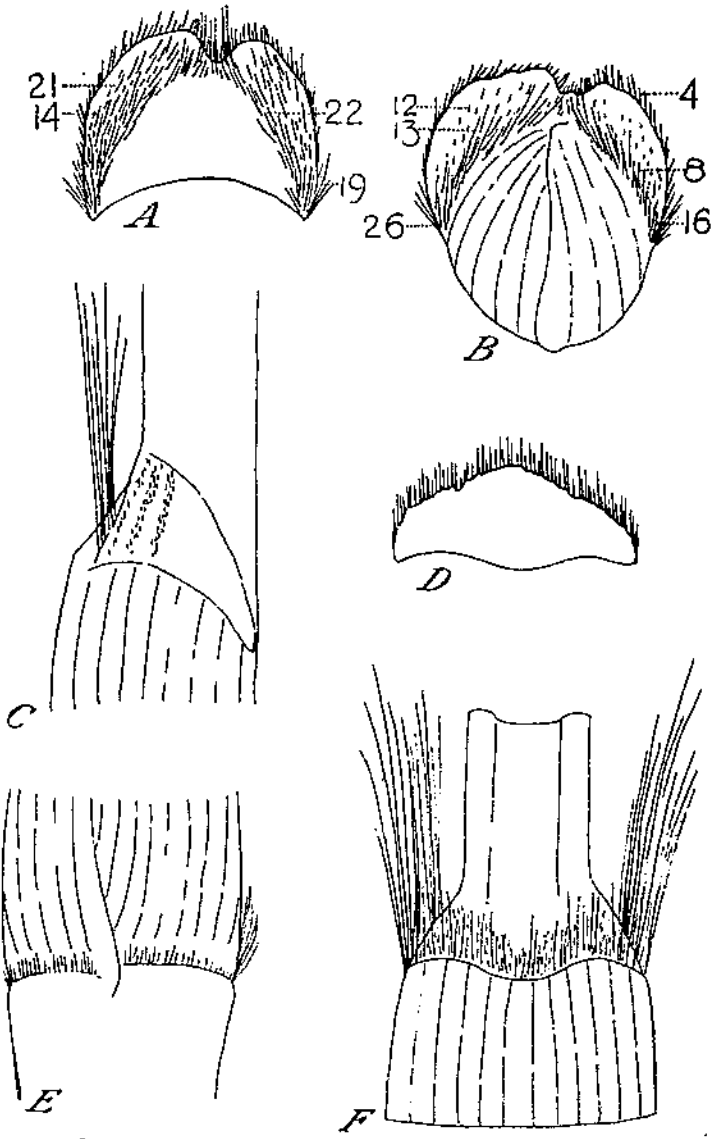


FIGURE 22.—Clone U. S. 4523: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

CLONE 28 N. G. 101

(Fig. 23)

ORIGIN.—Imported from near Kemp Welch River, Territory of Papua, in 1930.

CULMS.—Pale-green and heavily waxed; internodes relatively long, somewhat conoidal and constricted below sheath base, slightly ovate

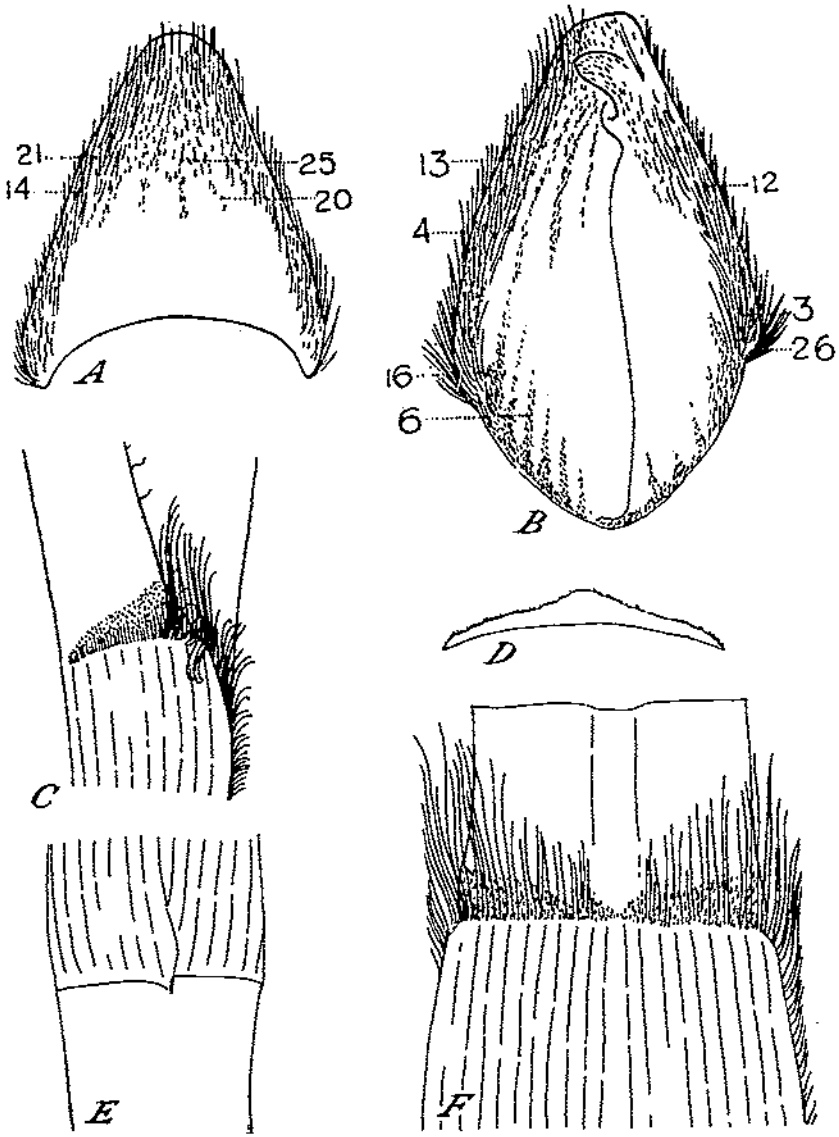


FIGURE 23.—Clone 28 N. G. 101: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

in cross section (13 by 16 mm.) and pithy in center; stem-epidermis patterns 2 and 3, cork cells squarish or rectangular, solitary or in groups of two or more, average width of long cells 9μ, stomates abundant; growth rings orange, narrow or medium wide and swollen; root bands 8 mm. high, somewhat obconoidal, with two to three rows of root

primordia, those in the lower row larger and sparser than those in the upper; prophylls 12 mm. tall, elongate-triangular or ovate with narrow, hairy wing inserted below middle of prophyll.

LEAVES.—Leaf sheaths up to 30 cm. long, persistent and hairy, especially when young; overlying sheath margin prominently fringed (group 56), the hairs becoming continuous with the long marginal hairs of group 58a; underlying sheath margin smooth or with a very inconspicuous group 56; sheath base straight; blades up to 135 cm. long and 3.1 cm. broad at middle, midrib broad and shallow; lower epidermis with prominent stomatal grooves and giant spines; dewlaps ligulate or narrow wedge-shaped; outer surface of dewlaps medium-hairy (group 58) but with long marginal tufts (group 58a); inner surface with long tuft hairs (group 51) extending almost to center of midrib, medium-long surface hairs (group 51a) extending into midrib, often concentrating in center of midrib to form a prominent group 55; ligules very shallow-deltoid or crescentiform, with medium prominent marginal fringe (group 61) and dorsal pubescence (group 66).

DIFFERENTIATING CHARACTERISTICS.—Group 51 extends across entire base of dewlaps; group 58a not always restricted to margin but forming a fringe along base line of dewlaps; young sheaths covered with spines that later become partially or completely deciduous; group 59, if present at all, only partially developed. The chromosome number is $2n=96$ and $n=48$ according to Starrett.[15]

CLONE 28 N. G. 291

(Fig. 24)

ORIGIN.—Imported as seed from Eriana Swamp, near Port Moresby, Territory of Papua, in 1935.

CULMS.—Yellow-green and heavily waxed; internodes somewhat bobbin-shaped and constricted below sheath base, about 12 mm. across with large pithy center; stem-epidermis pattern 2, cork cells squarish, a few short-pointed, solitary or in groups of 2 or more, average width of long cells 11μ, stomates abundant; growth rings medium and swollen; root bands 5 mm. high, somewhat obconoidal with one or one and one-half rows of root primordia; prophylls 8 mm. high, ovate or somewhat squarish, with wing attached at middle of prophyll; edge of wing smooth or notched and not extending above germ pore, surface of wing hairy but with the hairs concentrated near region of juncture. Often overlying side has a prominent apical appendage.

LEAVES.—Leaf sheaths fairly long (up to 32 cm.), persistent and very hairy; overlying and underlying sheath margins prominently ciliate (group 56), but character not outstanding because of general hairiness of entire leaf sheath; sheath base slightly decurrent and partly fringed (group 59), blades relatively short (116 cm.) and up to 2.7 cm. wide at middle; midrib rather shallow; lower epidermis with prominent stomatal grooves and giant spines; dewlaps ligulate, outer surface with medium prominent group 58 and prominent marginal tufts (group 58a); inner surface with prominent corner tufts (group 51) and medium-long surface hairs (group 51a) meeting in midrib, group 52 inconspicuous; ligules shallow-deltoid or crescentiform with in-

[15] See footnote 4, p. 10.

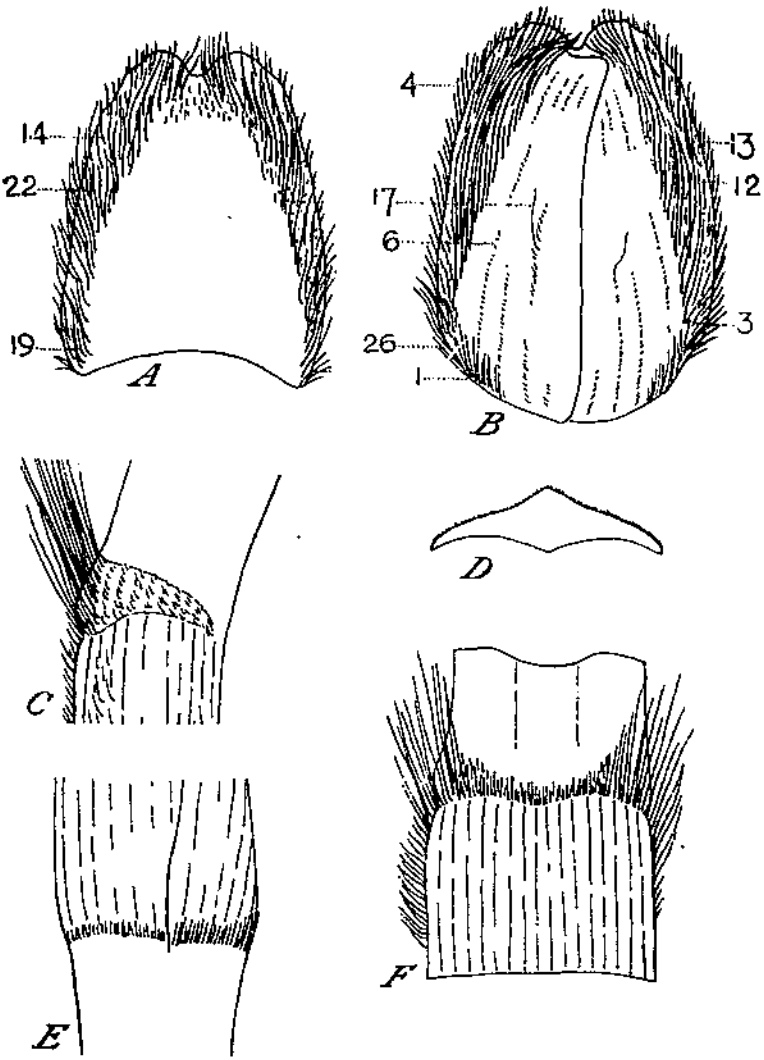


FIGURE 24.—Clone 28 N. G. 291: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

conspicuous marginal fringe (group 61) and very prominent dorsal pubescence (group 66).

DIFFERENTIATING CHARACTERISTICS.—General pubescence of leaf sheath; marginal tufts on outer surface of dewlaps (group 58a); absence of wing area over tip of prophyll. The chromosome number is $2n=114–116$ and $n=58$ according to Starrett.[16]

[16] See footnote 4, p. 10.

CLONE 28 N. G. 292

(Fig. 25)

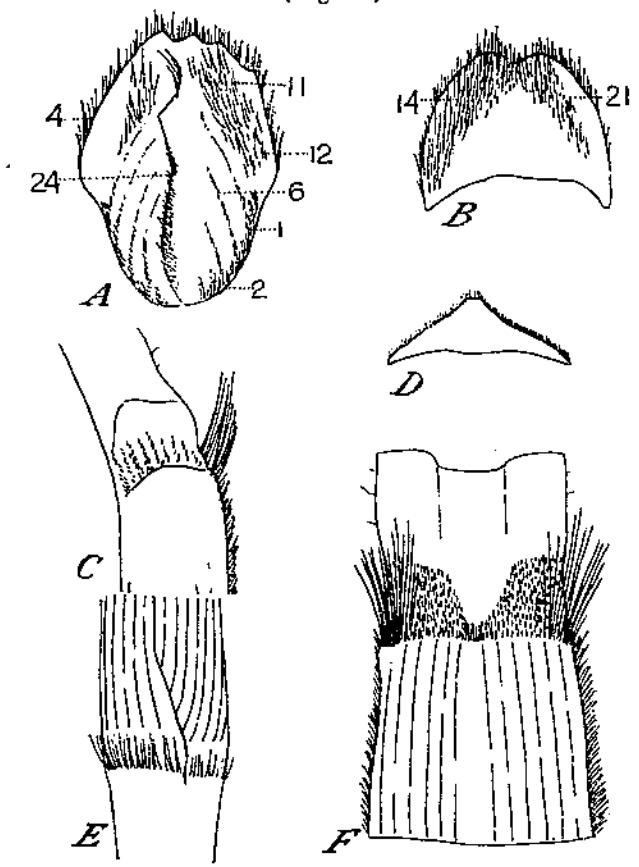


FIGURE 25.—Clone 28 N. G. 292: *A*, Anterior side of prophyll with hair groups; *B*, posterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

ORIGIN.—Imported as seed from near Port Moresby, Territory of Papua, in 1935.

CULMS.—Light-green and heavily waxed; internodes slightly oval, somewhat bobbin-shaped and constricted below sheath base, 12 mm. across, with large, pithy, and somewhat hollow center; stem-epidermis pattern 2, cork cells squarish or rhomboidal and usually solitary, average width of long cells 9μ, stomates abundant; growth rings light-olive, medium-wide or wide and swollen; root bands 7 mm. high, obconoidal on side opposite bud with one or two staggered rows of root primordia; prophylls small, ovate with wing inserted at middle of prophyll, tip truncate and cleft, overlying membranaceous margin often with prominent basal and apical appendage.

LEAVES.—Leaf sheaths medium long (28 cm.), persistent and very hairy; overlying and underlying sheath margins with prominent

group 56; sheath base straight and partially ciliate (group 59); blades short (up to 118 cm.) and 2.5 cm. wide at middle, midrib shallow; lower epidermis with prominent stomatal grooves; dewlaps high, squarish, with convex upper margin; outer surface medium hairy (group 58), inner surface with broad marginal tufts (group 51) and inconspicuous group 51a; hairs of group 52 cover entire dewlap surface and extend across midrib; ligules flat-deltoid, with fairly prominent marginal fringe (group 61) and prominent dorsal pubescence (group 66).

DIFFERENTIATING CHARACTERISTICS.—Very hairy leaf sheath; tall squarish dewlaps; shallow deltoid ligule. Differs from 28 N. G. 291 by lacking hair group 58a. The chromosome number is $2n=84$ to 88 according to Starrett.[17]

CLONE 28 N. G. 293

(Fig. 26)

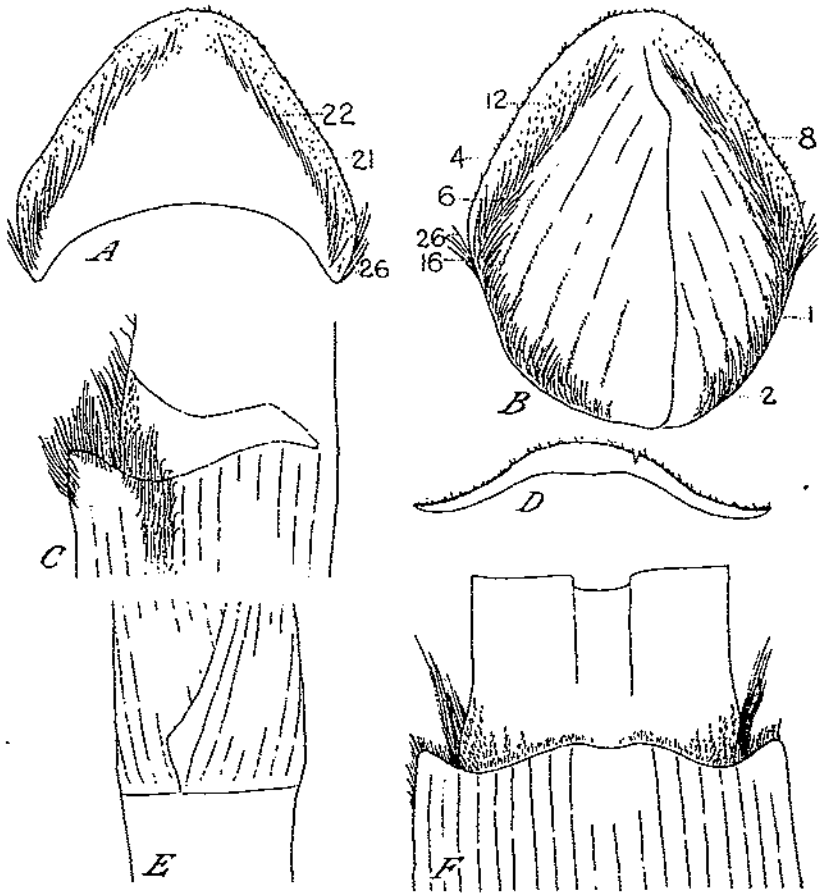


FIGURE 26.—Clone 28 N. G. 293: *A*, Posterior side of prophyll with hair groups; *B*, anterior side of prophyll with hair groups; *C*, lateral view of outer surface of dewlap with adjoining sheath and blade portions; *D*, ligule; *E*, sheath base with adjoining internode and sheath portions; and *F*, inner surface of blade joint with ligule removed to show hair groups.

[17] See footnote 4, p. 10.

ORIGIN.—Imported as seed from near Vailala River, Territory of Papua, in 1935.

CULMS.—Light-green, slightly waxed but with prominent wax band below sheath base; internodes medium long, slightly oval in cross section, cylindrical, about 18 mm. across, pithy in center; stem-epidermis pattern 3, cork cells square or rectangular, solitary or in groups of two or more, average width of long cells 9μ, stomates medium-abundant or scarce; growth rings medium wide and slightly swollen; root bands high, slightly obconoidal on side opposite bud, with four or more rows of crowded root primordia; prophylls medium large, broad ovate with wing inserted below middle of prophyll; tip round-pointed, overlying membranaceous margin often with small apical appendage.

LEAVES.—Leaf sheaths medium long (30 cm.), persistent and somewhat hairy, the hairs most prominent along sheath margins; near base of dewlaps the hairs spread laterally to form a pseudo-fringe along dewlap margin; sheath base straight; blades 125 cm. long and 4.2 cm. wide at middle, midrib rather massive; dewlaps more or less ligulate; outer surface mostly smooth except sheath hairs which extend into dewlap, forming a pseudo-group 58a; inner surface with very small marginal tufts (group 51) and medium prominent group 52 which does not extend across midrib; ligules shallow-crescentiform with short marginal fringe (group 61) and prominent dorsal pubescence (group 66); outer auricle deltoid with marginal fringe (group 54) descending slightly over the auricle tip, the surface bearing hair group 70; inner auricle more prominent than outer, also fringed (group 54) but with hairs extending only to tip of organ; surface of auricle also pubescent (group 71).

DIFFERENTIATING CHARACTERISTICS.—Four to five rows of root primordia; relatively prominent auricles; broad lamina. The chromosome number is $2n=88$ to 94 according to Starrett.[18]

DISCUSSION

The clones of *Saccharum spontaneum*, varied and widely distributed as they are, have many morphological features in common that unite them in one group and tend to distinguish them from noble canes.

The culms are not self-cleaning. The sheaths, even in the lower nodes, are persistent up to maturity. They are pale green or sea green when young and yellowish to bone white when mature. The surface is covered with a heavy bloom. A few clones, Burma, Lahore, and 28 N. G. 293, are only slightly waxed, and the latter is further distinguished by having a well-defined wax band.

The internodes are medium long or long with much variation within clonal limits. Consistently long internodes are found in Burma, and abnormally short ones in Rellagadi. Most clones have cylindrical or slightly bobbin-shaped internodes, and the cross section is terete, sometimes oval as in Tabongo. Those with very thick nodes and prominent constriction below the sheath base, like Burma, are distinctly conoidal. The surface of the internode is marked neither by growth cracks nor corky cracks.

[18] See footnote 4, p. 10.

The tissue of the culm as seen in a cross section is whitish and pithy, except for a relatively narrow, green-colored rind, and there is usually a central cavity present. The rind is always very hard, and the sheaths of the bundles of the outer ring are confluent, occasionally discrete. The number of bundles in the outer ring varies, but their density is not correlated with culm diameter since clones as distinct as U. S. 4520 and Kloet show the same bundle distribution.

The topography of the culm epidermis is less varied than that in many of the noble canes. Most clones can be put into one of two classes. The distribution of clones according to epidermal pattern is given in table 2.

TABLE 2.—*Grouping of clones of Saccharum spontaneum according to various morphological features*

Morphological feature	Aegyptiacum	Algiers	Burma	Coimbatore Local	Dacca	Djatiroto	Formosa	Formosa 4	Gehra Bon	Kepandjen	Kloet	Lahore	Pasoeroean	Rellagadi	S. H. 244	S. H. 249	Tabongo	28 N. G. 101	28 N. G. 291	28 N. G. 292	28 N. G. 293	U. S. 4520	U. S. 4523
Stem-epidermis pattern:																							
(1) Cork-silica pairs alternating with long cells												X		X									
(2) Silica cells wanting or very scarce; cork cells solitary or in groups	X	X	X		X	X	X									X	X		X	X			
(3) About 50 percent of short-cell groups lacking silica cells										X					X						X	X	X
(3a) Resembling (2) and (3) but with much variation				X				X	X		X		X					X					
Root primordia:																							
1 row	X											X										X	X
1½ staggered rows		X		X							X				X	X	X		X	X			
2 rows			X		X	X	X	X	X	X			X	X				X					
4–5 rows																					X		
Prophyll pattern:																							
(1) Pentagonal, tip broad						X											X						
(2) Squarish				X					X										X	X		X	
(3) Ovate	X							X		X			X			X					X		
(4) Obovate		X			X		X											X					
(5) Long ovate, wing insertion low			X					X			X	X	X					X					X
(6) Narrow ovate														X	X								
Pubescence on prophyll:																							
Almost glabrous		X																					
Dominant hair groups restricted to region of juncture				X		X	X	X		X		X					X						
Wings very hairy, sides smooth or slightly hairy									X		X		X	X	X	X			X	X	X	X	X
Both wing and sides very hairy	X		X		X													X					
Width of blade:																							
Reduced to almost width of midrib throughout												X			X	X						X	X
Reduced to midrib at base		X		X										X									
Narrow, ±1.5 cm	X						X	X	X														
Medium, ±2.5 cm										X							X						
Broad, ±3.5 cm			X		X								X					X	X	X			
Very broad, 4 cm						X					X										X		
Length of blade:																							
100–125 cm			X	X			X	X			X			X					X	X	X		
125–150 cm		X			X	X							X					X				X	X
150–170 cm	X								X	X		X					X						
Over 170 cm															X	X							

TABLE 2.—*Grouping of clones of Saccharum spontaneum according to various morphological features*—Continued

Morphological feature	Aegyptiacum	Algiers	Burma	Coimbatore Local	Dacca	Djatiroto	Formosa	Formosa 4	Gehra Bon	Kepandjen	Kloet	Lahore	Pasoeroean	Rellagadi	S. H. 244	S. H. 249	Tabongo	28 N. G. 101	28 N. G. 291	28 N. G. 292	28 N. G. 293	U. S. 4520	U. S. 4523
Stomatal grooves:																							
Prominent and deep	X	X		X	X		X	X	X			X		X	X	X		X	X	X		X	X
Shallow or incomplete						X				X	X		X				X						
Wanting			X																		X		
Upper blade epidermis:																							
Cork-silica bands in central zone:																							
Present	X			X	X		X	X	X			X	X			X		X	X	X		X	X
Absent		X	X			X				X	X			X	X		X				X		
Giant spines:																							
Present								X				X				X		X	X	X		X	X
Absent	X	X	X	X	X	X	X		X	X	X		X	X	X		X				X		
Length of leaf sheath:																							
Short, ±20 cm														X								X	
Medium long, ±30 cm	X			[1]X			X			[1]X	X	X	[1]X		[1]X	[1]X	[1]X	[1]X	[1]X	[1]X	[1]X		
Long, ±35 cm			X		X																		[1]X
Very long, above ±35 cm		X				X		[1]X	X														
Hairiness of leaf sheath:																							
Smooth				X	X	X	X		X		X	X		X	X	X						X	X
Slightly hairy			X							X							X						
Prominently hairy:																							
Early deciduous	X	X						X															
Persistent													X					[2]X	X	X	[2]X		
Hair group 56:																							
On overlying margin:																							
Prominent			X		X	X	X			X	X±		X	X	X	X	X	X	X	X			
Sparse								X	X														
Absent	X	X		X								X									X	X	X
On underlying margin:																							
Prominent			X		X								X		X	X			X	X			
Sparse							X							X				X					
Absent	X	X		X		X		X	X	X	X	X					X				X	X	X
Hair group 58a:																							
Wanting		X	X	X		X	X		X			X			X							X	X
Forming marginal tufts	X				X			X		X	X		X	X			[3]X		X				
Forming narrow band along base of dewlap		[4]X														X		X			[4]X		

Hair group 51:																								
Small and marginal	X		X			X		X	X	X		X	X	X+	X							X−		X
Prominent and marginal	--	X		X	X		X+	X	X	--	X	X	X+	X			X							
Prominent and basal	--									--						X	--			X				
Hair group 51a:																								
Prominent over entire surface		X		X								X				X	X	X	X					
Limited to narrow wedge			X			X		X	X	X					X						X−			
Limited to narrow band	X				X+		X				--		X							X				
Extending into midrib	X	X		X	X+		X	X−		X		X	X		X	X	X							
Hair group 55:																								
Present									X					X					X					
Absent	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X			X	X	X	X	X
Ligular types:																								
Tall deltoid with acute or rounded tip (fig. 4, *C, D, E*)				X					X					X	X	X						X	X	
Inverted deltoid (fig. 4, *F*)										X		X±												
Flattened rhomboid (fig. 4, *G*)					X		X							X										
Falcate (fig. 4, *H*)								X																
Strap-shaped, crescentiform (fig. 4, *M*)																		X						
Shallow-deltoid crescentiform (fig. 4, *I*)	X	X	X																	X	X		X	
Shallow crescentiform (fig. 4, *K*)						X					X		X					X				X		
Length of marginal cilia on ligule (group 61):																								
Inconspicuous							[3]X			[3]X			X									[3]X		
Medium long					X							X						X	X	X				
Long			X	X		X					X										X			
Very long	X	X						X	X						X	X	X						X	X

[1] Measurement somewhat above average figure.
[2] Hairs often less prominent.
[3] A second tuft is often present near center of midrib.
[4] Pseudo-58a may be present.
[5] Has tendency to be longer than indicated for group.

Pattern 1 is limited to Lahore and Rellagadi. Pattern 2 includes almost one-half of all clones, although Panje (*11*) found it representative of only one of his clones. Pattern 3a and pattern 3 are closely similar, the former differing from the latter only in its greater variability and the occasional absence of nearly all silica cells.

Classification based on epidermal patterns should have significance, especially for clones of pattern 1 and pattern 2.

The width of the long epidermal cell, as given in table 3, represents a graduated series from 9 to 16μ. The figures are uniformly low for the 28 N. G. group (except for 28 N. G. 291), being only 9μ, a width less than that given for Burma, which, according to Panje (*11*), had the narrowest cells of all clones studied by him. There seems to be no correlation between width of epidermal cells and thickness of stalk or cell width and geographic distribution.

TABLE 3.—*Diameter of culm, width of epidermal cells, and relative abundance of stomates*

Variety	Diameter of culm	Width of epidermal cells	Number of stomates in microscopic field[1]
	Mm.	μ	
Aegyptiacum	11	12	Few.
Algiers	8	15	Medium.
Burma	16	10	Do.
Coimbatore Local	10	12	Abundant.
Dacca	14	11	Do.
Djatiroto	12	12	Medium.
Formosa 4	11–14	15	Do.
Formosa	10	11	Do.
Gehra Bon	9	12	Do.
Kepandjen	13	14	Abundant.
Kloet	16	16	Do.
Lahore	4	13	Few.
Pasoerocan	16	12	Medium.
Rellagadi	7	10	Abundant.
S. H. 244	8	14	Medium.
S. H. 249	7	11	Do.
Tabongo	14	12	Abundant.
28 N. G. 101	15	9	Do.
28 N. G. 291	12	11	Do.
28 N. G. 292	10	9	Medium.
28 N. G. 293	17	9	Few.
U. S. 4520	7	15	Medium.
U. S. 4523	7	15.6	Do.

[1] The number of stomates as seen in different microscopic fields shows variation. Stomates are never wanting, as in many of the noble canes, but as a character in the classification scheme they have no diagnostic value.

The region of the growth ring is always the thickest part of the culm. In most of the clones of *S. spontaneum* it is swollen, though occasionally (S. H. 244) it is flush with the internode above. There is much variation in height, and, in general, the growth ring is rather high in relation to the thickness of the culm. A constantly high growth ring is found in the clone Burma, and relatively narrow rings have been observed among members of both Indian and East Indian forms.

The characteristic thickness of the nodal region is responsible for the shape of the root bands; these, in nearly all clones of *S. spontaneum*, are distinctly obconoidal in the region opposite the bud, especially in clones with high root bands such as Burma (fig. 1, *B*). The more cylindrical form of root band is found in the robust East Indian types, such as Djatiroto, Kepandjen, and Kloet, and less prominently in some of the thicker Indian clones. The height of the root band usu-

ally fluctuates between 7 and 9 mm., but in some of the small grass-like forms, such as Lahore, it may not exceed 3 or 4 mm. The root band is usually of a lighter color than the internode, although sometimes it is concolorous with it.

As the name implies, the root band bears the root primordia. The latter are arranged in regular or staggered rows, and the number of rows is normally limited to one or two. In one clone, 28 N. G. 293 (fig. 1, *C*), four or five rows are present. With the exception of this clone, the root primordia are rather widely spaced and, if more than one row is present, those in the lower row are decidedly larger than those in the upper.

From the standpoint of classification the root band is of doubtful value except for clone 28 N. G. 293, which stands out from all other forms by the large number of root primordia. Where one or two rows are present, the character is not always clean-cut, especially if the rows are close together and staggered. Clones Pasoeroean and 28 N. G. 101 have frequently two and one-half and even three rows, a character which may aid in delimiting these varieties (table 2).

The diverse forms of prophylls, though somewhat unstable in some clones, are valuable as auxiliary characters in a key for the separation of the clones. The distribution of clones according to shape of prophylls is given in table 2. Pattern 1, to which Djatiroto and Tabongo belong, is an extreme variation of the squarish pattern, which, in turn, is separated from the ovate forms only by the possession of a broad upper-wing region. Some prophylls of clones 28 N. G. 291 and 28 N. G. 292 could be put either in pattern 2 or 3. On the other hand, patterns 4 and 5 and, to a certain extent, pattern 6 are quite distinct and show a minimum amount of variation.

The shape of the prophyll is usually influenced by the margin of the wing, which may be smooth, deeply notched at the tip, or quite jagged (Algiers). In clone S. H. 249 many prophylls are very asymmetrical in that the overlying side is often developed to such an extent as to cover the anterior surface of the bud completely. Other clones may develop conspicuous apical appendages near the germ pore, but there is some regularity in their appearance in spite of their great variability. If other suitable characters are wanting, these appendages may well be mentioned in the description of clones.

The hair groups on the anterior and posterior surfaces of the prophyll, so important in the characterization of noble canes, have only a limited use in the classification of the clones of *S. spontaneum*. The large majority have very hairy wings and more or less smooth sides, making a separation based on hair group characters a difficult task. The relative hairiness of wing and sides as found in the different clones is given in table 2.

The pubescence of the prophyll shows typical asymmetry, with the hairs on juncture and wing most prominent on the overlying side. If, as in Pasoeroean, the juncture of the underlying side shows a typical hair group 11 and an inconspicuous hair group 13, the wing of the overlying side is usually diffusely covered with long hairs, with hair group 11 becoming an integral part of hair group 13. The hairs of the marginal fringe (group 4) are conspicuously long in almost half of the clones, notably Pasoeroean, Rellagadi, Kloet, and S. H. 244. On the other hand, some of the clones, such as Algiers, Formosa 4, Tabongo, and 28 N. G. 293, have the margin almost smooth or fringed, with

very short hairs. The basal hair groups 1 and 2 are prominent or medium-well developed in only a few clones, including those that are hairy all over. In all other forms, these hair groups are absent or the region in question exhibits an inconspicuous short pubescence that is best included in hair group 6.

The parenchymatous margin of the overlapping side of the prophyll is smooth and only inconspicuously fringed (hair group 24) in Dacca and in Burma.

By far the most valuable organ in the classification of the clones of *S. spontaneum* is the leaf with its specialized regions—ligule and dewlaps. The blades are long, linear, and tapering toward the apex, which ends in a fine point. There is considerable difference in width of blade, as shown in table 2.

In some East Indian clones the blades are rather wide, resembling those of the narrow-leaved noble canes. In others, the blade is narrow or quite narrow, becoming reduced to the width of the midrib above the blade joint or retaining a narrow portion of the blade. In the last group, the blade is practically reduced to the width of the midrib throughout its length.

There is also considerable difference in length of blade, as shown in table 2.

The length of the blade, which fluctuates between 100 and 170 cm., is independent of geographic distribution, since both short- and long-leaved clones are found among the Indian and East Indian forms.

By dividing the length of the blade by its width, there is obtained what Panje (*11*) designates as the leaf module and for which he claims greater constancy and dependability than for either length of blade or its width. Panje found that in the forms investigated by him the leaf module of the East Indian forms was less than 1 : 60 and in the Indian forms more than 1 : 100, calling special attention to the fact that Rellagadi, which has a short leaf, falls in with the Indian clones if the leaf module is taken into consideration. Clones grouped according to leaf module:

Clone:	Leaf module	Clone:	Leaf module
Kloet	1 : 24.	Formosa 4	1 : 71.
28 N. G. 293	1 : 30.	Algiers	1 : 92.
Djatiroto	1 : 35.	Formosa, Imp. 928.	1 : 100.
Burma	1 : 37.	Local 238	1 : 103.
28 N. G. 101	1 : 40.	Gehra Bon	1 : 137.
Pasoerocan	1 : 42.	Aegyptiacum	1 : 165.
28 N. G. 291	1 : 43.	Lahore, S. H. 244, S. H. 249, U. S. 4523, U. S. 4520	1 : 300 or more.
28 N. G. 292	1 : 47.		
Dacca	1 : 57.		
Tabongo	1 : 59.		
Rellagadi	1 : 62.		
Kepandjen	1 : 66.		

This classification holds true except that the leaf of Rellagadi, as grown at Canal Point, has a leaf module of 1 : 62 that would still put it in the East Indian group.

Both lower- and upper-leaf epidermis contain much structural detail that could be incorporated in the description of the clones. Most characters are of degree rather than kind and show wide variation which renders them useless in classification. However, one character of the lower epidermis, type of stomatal groove, is distinct and reliable, except that it fails to separate most clones of *S. spontaneum*. Table 2

gives a survey of distribution and relative development of stomatal grooves.

Although two clones lack stomatal grooves completely, the East Indian forms, with the exception of three 28 N. G. clones, have only shallow or incompletely developed grooves.

The bulliform cells are easily the most outstanding structural characteristic of the upper epidermis. The bands are from one to four cells wide, and the cells composing them may be squarish, somewhat elongate, or broader than long. As a varietal character they are of unproved value, mostly because of great fluctuation in the width of the bands.

On the other hand, the presence of one or more solid rows of cork-silica pairs, often interspersed with giant spines situated at or near the middle of the broad central zone (fig. 3) in the lower epidermis, is a useful characteristic and is often, though not always, correlated with prominence of stomatal groove development (table 2).

The leaf sheaths are persistent. The sheath base is usually straight and the overlying membranaceous margin rarely decurrent or appendaged (fig. 1, *D*, *E*, *F*). The latter may terminate attached to the internode or remain free (fig. 1, *F*). A complete or partially developed ring of cilia (hair group 59) surrounding the sheath base is characteristic of Dacca, Tabongo, U. S. 4523, 28 N. G. 291, and 28 N. G. 292. The hair group is not always present even in these clones, and there is much variation in degree of development.

In length of leaf sheath a certain constancy prevails within varietal limits. An approximate grouping of clones according to sheath length is given in table 2.

According to table 2 most clones agree in length of leaf sheath. When conspicuous differences are found this character may be helpful in separating certain clones that otherwise may look identical. A striking illustration is offered by U. S. 4520 and U. S. 4523, which, except for a different degree of robustness, are so much alike that they may be separated only by the length of their leaf sheaths, which is 20 and 30 cm., respectively. Rellagadi also has a very short leaf sheath associated, in this case, with a very short internode.

The surface of the leaf sheath may be smooth or hairy. According to Panje (*11*) the Indian and East Indian forms may be divided into two groups on the basis of this character. Although all Indian forms are undoubtedly smooth, the East Indian clones may be either smooth or hairy (table 2).

Hairs may be scattered over the leaf sheath, or they are regionally distributed into dorsal (group 57) and lateral fields (group 60). The hairs of the latter may reach to the blade joint and form a pseudo-58a along the base of the dewlaps (28 N. G. 293). The sheath hairs are usually appressed and pointing upward, although they may become declinous in the upper central region of the sheath. Frequently group 57 starts a short distance below the dewlaps and terminates usually a considerable distance above the sheath base. Because of the deciduous nature of the hairs in certain clones, their occasional occurrence in young plants and absence from later-formed leaves makes this character rather unsatisfactory if applied to borderline forms. Fortunately, these clones can usually be separated on the basis of other characters.

The membranaceous sheath margins below the blade joint may be ciliate (group 56) or smooth. The cilia may be completely marginal or occasionally inserted along the entire width of the parenchymatous margin (Kepandjen). In the ciliate forms the hairs may be present on both sheath margins or restricted to the overlying one. Quantitatively the group may be prominent—either short or long—or relatively inconspicuous. Its presence or absence and its degree of development is of great importance in the classification of the clones of *S. spontaneum*. This character is subject to a minimum amount of variation and, although it often necessitates the examination of very young organs in clones in which the group is inconspicuous, it affords a convenient means of dividing the clones into groups that may subsequently be separated into smaller units on the basis of more restricted characters. In Kloet, where the presence of this group is doubtful, conspicuous varietal characters make the identification of this clone an easy task. Distribution and relative development of hair group 56 in the different clones of *S. spontaneum* are given in table 2.

The dewlaps or joint triangles form the flanges of the blade joint. They are essentially triangular or wedge-shaped with the base horizontal but more often steeply sloping. In a few clones they are squarish, notably Burma and Tabongo, although in some of the broad-leaved East Indian types, such as Kloet and 28 N. G. 293, they are ligulate like those of many of the noble canes. In the Indian canes, where the blade is reduced to the width of the midrib in the region of the blade joint, the term "dewlap" does not appear applicable and the expression "transverse mark" or "ligular bands," as used by the Indian scientists, would seem more appropriate. For the sake of convenience, however, the term "dewlap" will be retained.

The significance of the dewlaps in the classification scheme lies in the nature of the pubescence of their abaxial and adaxial surfaces. In most of the clones the outer surface of the dewlaps is practically smooth or only moderately hairy. It is densely pubescent in clones Dacca, S. H. 249, and 28 N. G. 101. In addition to the short surface pubescence (group 58), some of the clones have small tufts or narrow bands of long hairs that, because of their taxonomic value, are listed as a separate group 58a. This group is usually marginal and may often be recognized only in young, fresh material. In Tabongo a second group is often present in addition to the marginal 58a and is usually located near the midrib, whereas in H. S. 249 and 28 N. G. 101, the marginal group spreads laterally to cover the entire base of the dewlap. Clones 28 N. G. 293 and Algiers are peculiar in that the rather long hairs of the lateral fields (group 60) reach up to the base of the dewlaps and from here spread laterally toward the midrib, producing a very prominent pseudo–58a.

A grouping of the clones in relation to occurrence and relative development of 58a is given in table 2.

The inner surface of the dewlap is always hairy, though quantitatively there may be much variation among the various clones. Most prominent and conspicuous are the marginal tufts composed of long or very long hairs (group 51). These hairs arise behind the flanges of the ligule, usually from a narrow base. Occasionally they have a broader base line, occupying up to one-third of the width of the dewlap, as in Formosa and Pasoeroean, or even the entire width up to the central

part of the midrib (S. H. 244 and 28 N. G. 101). In one clone, 28 N. G. 293, the group is very inconspicuous and may be overlooked unless the material is examined closely. In addition to the marginal tufts the surface is covered with semilong (group 51a) and short hairs (group 52). The hairs of either group may be evenly scattered, matted, or somewhat localized in vertical bands. Often it is difficult to make a distinction between groups 51a and 52. If the former is very dense, the latter loses its identity.

The hairs of both groups 51a and 52 often advance to the center of the midrib where they may sometimes form a separate group, 55. Since the delimitation of group 55 is based on quantitative differences in the regional development of group 51a, and since these differences are not always pronounced, the justification of a separate group 55 could well be argued. Nevertheless, if sufficient representative material is examined, no difficulty is experienced, and the utilization of the group in a taxonomic key separating Gehra Bon from Coimbatore Local is justifiable.

There is always the tendency with the advent of flowering for the pubescence on the inner dewlap surface to increase in density, and for characters, such as a separate group 55, although prominent in young plants, to become obliterated later.

In table 2 an attempt is made to plot out for ready analysis the degree of hair-group development on the inner dewlap surface. In almost two-thirds of the clones the center of the midrib is hairy and in at least three clones a separate group 55 is distinguishable. Not all East Indian clones have a smooth midrib, since Kepandjen and Pasoeroean are decidedly hairy in this region; conversely, some of the Indian canes have a smooth midrib, also all of the 28 N. G. clones with the exception of 28 N. G. 101. There is apparently no consistent correlation between size of the marginal tufts (group 51) and extension of group 51a into the midrib, although there is a tendency for the clones with small marginal tufts to have the center of the midrib smooth.

Panje (*11*) distinguishes between two types of ligules, deltoid and crescentiform, and considers the latter intermediate between the deltoid of the Indian clones and the large, narrow, or strap-shaped ligule of the clones of the noble canes. Ligular types encountered in the clones included in this study are illustrated in figure 4, *C* to *K*. The distribution of clones according to ligular patterns is given in table 2.

All Indian clones are of the deltoid type. Some are very tall and pointed (Gehra Bon and S. H. 244); others have a rounded-truncate or jagged tip. The base line may be straight, slightly depressed in the middle, or sometimes horseshoe-shaped, as in Lahore; the most characteristic is probably the inverted-deltoid ligule of Kepandjen. The flattened rhomboid and the falcate types somewhat resemble each other and approach the shallow deltoid type. They show some variation, yet are typical enough to aid in the characterization of certain clones. Among the crescent-shaped forms the strap-shaped ligule of Tabongo does not always have high flanges, as illustrated in figure 4, *M*, but rather approaches the true crescent-shaped type.

Although the ligule is a conservative organ, with not too great a tendency toward variation, it has limited usefulness in a taxonomic key

except in the case of Kepandjen, whose inverted-deltoid ligule suffices to characterize the clone.

The pubescence of the ligule also shows important differences. The marginal cilia (group 61) may be short, medium long, or exceedingly high; likewise, the hairs on the dorsal surface (group 66) may be inconspicuous or very long, adnate or mostly free. There is usually a uniformity in degree of development of groups 61 and 66, but occasionally, as in clone 28 N. G. 291, an inconspicuous group 61 is associated with a very prominent dorsal pubescence. A grouping of clones according to relative development of group 61 is given in table 2.

Except for clone 28 N. G. 293, auricles are wanting or very inconspicuous. If present at all they are small, deltoid, or of the transitional type. An auricle effect in the Indian clones is often produced by an abrupt ending of the parenchymatous sheath margin, though usually this margin becomes decurrently continuous with the ligule (fig. 4, *A* and *B*).

Genetic evidence in support of subdivisions based on vegetative characters is already partly available. Chromosome counts made here and abroad are given in table 4. Not all clones have been studied and, among those for which figures are available, disagreement is frequent. Thus, Dutt and Subba Rao (*6*) assign to Coimbatore Local $n=32$, whereas counts made by Starrett[19] are appreciably higher. However, it is not certain that chromosome counts reported in the literature were made from the same clones as those in the collection of the Division of Sugar Plant Investigations.

Depending on genetic make-up, character evaluation, and existence of border-line forms, the clones of *S. spontaneum* considered in this study could be variously classified.

TABLE 4.—*Grouping of clones according to chromosome number*

Clone	Counts made by Starrett [1]		Other sources	
	Diploid	Haploid	Diploid	Haploid
Aegyptiacum	90–92	45		
Burma	80–84		96 (9)	
Coimbatore Local	92	40	64 (6)	
Dacca		42	72 (5); 80 (8)	
Djatiroto			112 (4)	
Kepandjen	118–122	54	112 (4)	
Kloet		60		
Lahore	80		48 (8)	
Pasoeroean	120–130			
Rellagadi	84–88		64 (8)	
S. H. 244	80		64 (8)	
S. H. 249	70			
Tabongo	90			40 (4)
28 N. G. 101	96	48		
28 N. G. 291	114–116	58		
28 N. G. 292	84–88			
28 N. G. 293	88–94			
U. S. 4520		25		
U. S. 4523	48–50	25		

[1] See footnote 4, p. 10.

[19] See footnote 4, p. 10.

Since emphasis should be put on clearness and constancy rather than on number of distinguishing characters, Panje (*11*), who bases his classification solely on vegetative characters, eliminates as impracticable all but those given in his characterization of the two subspecies: *indicum*; plants tufted or prostrate (except in Glagah), culms slender, leaves narrow with midrib at base less than one-half the width of the blade at the insertion of the sheath, leaf module over 1:100, stomatal grooves present, sheath glabrous, throat slightly bearded (rarely glabrous), ligule deltoid; *aegyptiacum*, plants erect, culms robust, leaves broad and not so narrow at their insertion on the sheath, leaf module less than 60, stomatal grooves absent (except in Glagah), sheath hairy, throat always glabrous, ligule crescentiform.

These characters are, on the whole, fairly constant, well-defined, easily seen, and easily describable, and subject to a minimum amount of variation; they suffice for the characterization of the main groups but are inadequate for the separation of smaller units and clones. Bases for the differentiation of the latter and usefulness as aids to classification should include: Presence and degree of development of hair groups on the upper sheath margins (group 56), outer surface of dewlaps (groups 58 and 58a), inner surface of dewlaps, especially in regard to extension of group 51a into the midrib, shape of prophyll and its pubescence, number of rows of root primordia (diagnostic of clone 28 N. G. 293), pattern of stem epidermis, development of bloom including occasional differentiation of a wax band, differences in length of sheath in closely related forms (U. S. 4520 and U. S. 4523). Many of these characters are surprisingly constant, well-defined, and, with some practice, readily discernible, often without the aid of a microscope; they are indispensable in the construction of a taxonomic key.

SUMMARY

In devising a system of identification for the various clones of *Saccharum spontaneum* imported from Asia and the East Indies and grown at the United States Sugar Plant Field Station at Canal Point, Fla., different gross and minute morphological characters as well as certain microscopic features of the epidermis were employed. The presence of certain hair groups on leaf sheath, sheath base, and blade joint were found to be very useful in the major subdivisions, while qualitative differences had to be relied on in separating individual clones. The key given below is intended to cover only the 23 clones described in this bulletin.

KEY

A. Leaf blade reduced almost to width of midrib throughout.
  B. Sheath margins prominently ciliate (group 56).
    C. Outer dewlap surface densely covered with long hairs.. S. H. 249.
    CC. Outer dewlap surface slightly hairy; group 51 prominent..... S. H. 244.
  B. Sheath margins smooth.
    C. Base of ligule depressed, more or less horseshoe-shaped Lahore.
    C. Base line of ligule not horseshoe-shaped.
      D. Leaf sheath short (20 cm.)..... U. S. 4520.
      D. Leaf sheath long (34 cm.)..... U. S. 4523.

A. Leaf blade varying in width, often reduced to width of midrib above blade joint.
  B. Root band with 4 or 5 rows of root primordia ..... 28 N. G. 293.
  B. Root band with 1 or 2, rarely 3, rows of root primordia.
    C. Sheath margins prominently ciliate (group 56).
      D. Group 56 prominent on both sheath margins.
        E. Leaf sheath hairy.
          F. Blade broad (3.5 cm.), stomatal grooves shallow ..... Pasoeroean.
          F. Blade medium wide (2.5 cm.), stomatal grooves deep.
            G. Group 58a present ..... 28 N. G. 291.
            GG. Group 58a wanting ..... 28 N. G. 292.
        E. Leaf sheath smooth or inconspicuously strewn with short deciduous hairs.
          F. Blade broad (3.1 cm.), stomatal grooves wanting ..... Burma.
          FF. Blade medium (2 to 2.5 cm.), stomatal grooves prominent ..... Dacca.
      D. Group 56 prominent only on overlying sheath margin.
        E. Ligule inverted-deltoid ..... Kepandjen.
        E. Ligule not inverted-deltoid.
          F. Group 51 extends over entire width of dewlap ..... 28 N. G. 101.
          F. Group 51 limited to marginal tufts.
            G. Blade broad (3.9 cm.) ..... Djatiroto.
            G. Blade narrow or medium, up to 2.5 cm.
              H. Group 58a present; blade 2.5 cm. wide ..... Tabongo.
              HH. Group 58a wanting; blade 1.5 cm. wide ..... Formosa.
    C. Sheath margins smooth, or group 56 inconspicuous.
      D. Group 56 entirely wanting.
        E. Prophylls obovate and smooth; wing irregularly emarginate ..... Algiers.
        E. Prophylls hairy and not obovate.
          F. Blade long (160 cm.), group 51a forms shallow band across midrib ..... Aegyptiacum.
          F. Blade short (115 cm.), group 51a not restricted to narrow band ..... Formosa 4.
      D. Group 56 inconspicuous or wanting from underlying margin.
        E. Blade very broad (4.7 cm.), group 56 at times prominent ..... Kloet.
        E. Blade narrow.
          F. Leaf sheath short (20 cm.) ..... Rellagadi.
          F. Leaf sheath long (30 cm.).
            G. Group 55 present, blade long (150 cm.) ..... Gehra Bon.
            G. Group 55 wanting; blade short ..... Coimbatore Local.

LITERATURE CITED

(1) ARTSCHWAGER, ERNST.
1939. ILLUSTRATED OUTLINE FOR USE IN TAXONOMIC DESCRIPTION OF SUGARCANE VARIETIES. Internatl. Soc. Sugar Cane Technol. Sixth Cong. Proc. (1938): 116–128, illus.

(2) ———
1940. MORPHOLOGY OF THE VEGETATIVE ORGANS OF SUGARCANE. Jour. Agr. Res. 60: 503–549, illus.

(3) BRANDES, E. W., SARTORIS, G. B., and GRASSL, C. O.
1939. ASSEMBLING AND EVALUATING WILD FORMS OF SUGARCANE AND CLOSELY RELATED PLANTS. Internatl. Soc. Sugar Cane Technol. Sixth Cong. Proc. (1938): 128–153, illus.

(4) BREMER, G.
1925. THE CYTOLOGY OF THE SUGARCANE. THE CHROMOSOMES OF PRIMITIVE FORMS OF THE GENUS SACCHARUM. Genetica 7: 293–322, illus.

(5) BREMER, G.
1934. DE CYTOLOGIE VAN HET SUIKERRIET. 7DE BIJDRAGE. EEN CYTOLOGISCH ONDERZOEK VAN EEN VIJFTIGTAL IN 1929–1930 OP JAVA GEÏMPORTEERDE RIETSOORTEN. Arch. v. Suikerindus. Nederland. Indië, Meded. Proefsta. v. Java-Suikerindus. (1934): 141–166, illus.
(6) DUTT, N. L., and SUBBA RAO, K. S.
1933. OBSERVATIONS ON THE CYTOLOGY OF THE SUGARCANE. Indian Jour. Agr. Sci. 3: 37–56, illus.
(7) GREY, ROBERT M.
1927. REPORT OF THE HARVARD BOTANICAL GARDENS, SOLEDAD ESTATE, CIENFUEGOS, CUBA, 1900–1926: 1–113. Cambridge.
(8) JANAKI-AMMAL, E. K.
1936. CYTO-GENETIC ANALYSIS OF SACCHARUM SPONTANEUM L. 1. CHROMOSOME STUDIES IN SOME INDIAN FORMS. Indian Jour. Agr. Sci. 6: 1–8, illus.
(9) ——— and SINGH, T. S. N.
1936. CYTO-GENETIC ANALYSIS OF SACCHARUM SPONTANEUM L. 2. A TYPE FROM BURMA. Indian Jour. Agr. Sci. 6: 9–10, illus.
(10) JESWIET, J.
1916. BESCHRIJVINGDERSOORTEN VAN HET SUIKERRIET. EERSTE BIJDRAGE. MORPHOLOGIE VAN HET SUIKERRIET. Arch. v. Suikerindus. Nederland. Indië Meded. 24: (67)–137, illus.
(11) PANJE, RAMA RAO.
1933. SACCHARUM SPONTANEUM L. A COMPARATIVE STUDY OF THE FORMS GROWN AT THE IMPERIAL SUGARCANE BREEDING STATION, COIMBATORE. Indian Jour. Agr. Sci. 3: 1013–1044, illus.

○

END