

On the taxonomy of the members of ‘*Saccharum* complex’

V. Alfonse Amalraj* and N. Balasundaram

Division of Crop Improvement, Sugarcane Breeding Institute (ICAR), Coimbatore 641007, S. India; *Author for correspondence (e-mail: vaamalraj@yahoo.co.in or sugaris@vsnl.com)

Received 22 October 2003; accepted in revised form 9 April 2004

Key words: *Erianthus*, *Miscanthus*, *Narenga*, Saccharinae, *Saccharum* complex, *Sclerostachya*, Taxonomy

Abstract

The difficulty and problems encountered in the study of cultivated plants, in general and sugarcane, in particular has been indicated. In order to understand these problems, a brief review on the taxonomy of *Saccharum* and closely related taxa, namely, *Erianthus*, *Sclerostachya*, *Narenga* and *Miscanthus* (generally known as ‘*Saccharum* complex’) has been given. A short account on the important morphological features that are specific to sugarcane has also been stated as classification is commonly based on such morphological characters. A note has been added on the chromosome number, origin, and distribution of the species of ‘*Saccharum* complex’ members. Taxonomic keys have been devised for identification of the genera of Saccharinae and for the species of *Saccharum* and *Erianthus* occurring in India. A new combination, *Sclerostachya fallax* (Balansa) Amalraj et Balasundaram, has also been proposed.

Introduction

Taxonomy, in a broad sense, includes not only the theory and practice of naming, classifying and identifying plants, but also deals with the scientific study of inter-relationships, origin and evolution of variation in plants. It aims at a system of classification of living organisms based on evolutionary relationships. Plant Taxonomy has developed from a merely morphological descriptive discipline to a most dynamic area of study and research. The application of supportive data from other disciplines such as anatomy, cytology, genetics, ecology, physiology, palynology, embryology, phytochemistry, molecular biology and mathematics (numerical taxonomy) has led to the resolution of taxonomic problems, refinement of taxonomic concepts, establishment of evolutionary trends and phylogenetic relationships. Taxonomy is essential –

1. For proper identity of plants.
2. For knowing their inter-relationships and evolutionary pathways.
3. To estimate potential hybridisation range and fertility.
4. To identify characters of economic importance.
5. In collection, maintenance, evaluation and utilisation of plant genetic resources.

Sugarcane taxonomy – problems:

Taxonomy of cultivated plants is more difficult due to their extensive hybridisation and high mutation rate, which lead to considerable diversity in their variation patterns. Such is the case in taxonomy of sugarcane too, due to the existence of ‘Synthetic Species’. Taxonomic identity and delimitation of species are made complicated due to the following reasons:

1. Natural hybridisation among the populations of genera/species which grow together and flower simultaneously in some areas, resulting in the existence of a range of intermediary forms.
2. Different types of chromosomal transmission in natural hybridisation and constant evolution of new variants or types.
3. Polymorphism due to a range of Euploids and Aneuploids (as in *S. spontaneum*).
4. Selection pressures due to nature and man.

Review on the taxonomy of *Saccharum* and related taxa:

Modern cultivated sugarcane is mostly a hybrid of different species of the genus *Saccharum*, which is placed in 'Saccharinae' (sub-tribe), along with nine other genera, namely: *Imperata*, *Eriochrysis*, *Eccoilopus*, *Spodiopogon*, *Miscanthidium*, *Erianthus*, *Miscanthus*, *Narenga* and *Sclerostachya*. 'Saccharinae' comes under the Tribe 'Andropogoneae' which is distinguished by the following features:

1. Presence of paired spikelets; usually one sessile and other pedicellate, borne on a fragile rachis.
2. Characteristically tropical and sub-tropical in distribution, particularly India and Indonesia with concentration of genera.

Clayton (1972) recognised two natural groups in Saccharinae Table 1 (For Key see Appendix 1):- Saccharastrae (10 genera) and Eulaliastrae (9 genera). The former with multiple racemes on an axis and the latter with solitary to digitate racemes. The tribe Andropogoneae is placed under the sub-family Panicoideae that comes under the Family Poaceae (Gramineae). *Saccharum spontaneum*, for example, is taxonomically classified as below:

Family	Poaceae (Gramineae)
Sub-family	Panicoideae
Tribe	Andropogoneae
Sub-tribe	Saccharinae
Group	Saccharastrae
Genus	<i>Saccharum</i>
Species	<i>spontaneum</i>

Based on morphological similarity, crossability/ breeding behaviour and evolutionary relationship, the genera *Saccharum*, *Erianthus*, *Narenga*, *Sclerostachya* and *Miscanthus* are of immediate concern to Sugarcane Researchers.

Roxburgh (1820) in Flora Indica included 11 species under *Saccharum*, which are now placed under 4 different genera. While Steudel (1854) included 62 species under *Saccharum* which are now distributed among eight different genera. Hooker (1896) doubtfully separated *Erianthus* from *Saccharum* on the basis of presence of awned fourth glume (IV) and referred 11 species in *Erianthus*. Later, Haines (1921), Jeswiet (1925), Grassl (1946), Dutt and Rao (1950) and Mukherjee (1958) have also treated *Erianthus* as a separate genus following Hooker. Grassl (1971) went a step further and split *Erianthus* into two genera, placing the old world species under the new genus *Ripidium* (established earlier by Trinius in 1821 and designated as Section *Ripidium* under *Erianthus* by Henrard in 1926) and retaining only the new world (American) species under *Erianthus*. But this genus *Ripidium* was found to be illegitimate (as per ICBN) as already a fern genus *Ripidium* existed. Hence, some authors recognise *Ripidium* as section of *Erianthus*, following Henrard (1926). Bor (1960) had treated the nine species of *Erianthus* under *Saccharum* as well as *Erianthus*, being not sure of the separation. Mukherjee (1958) had revised the genus *Erianthus*. Recent studies had shown that *Erianthus* is quite distinct from others, based on root tip tannin presence (Rao et al. 1957); leaf lipid (Vijayalakshmi and Rao 1963); Esterase isozyme studies by Waldron and Glasziou (1972); flavonoid F13 studies by Williams et al. (1974) and molecular marker studies.

Grassl (1971), on the basis of morphology and hybridisation, included the genus *Narenga* in *Sclerostachya*. He had justified that both (*Narenga* and *Sclerostachya*) have $2n = 30$, with similar growth habit; both are self-incompatible and behave similarly in generic crosses with *Saccharum* and *Erianthus*.

Mukherjee (1954) revised the genus *Saccharum* and reviewed its origin (Mukherjee 1957). He pointed out that the four genera *Saccharum*, *Erianthus*, *Sclerostachya* and *Narenga* constituted a closely related inter-breeding group concerned in the origin of sugarcane. He termed 'Saccharum complex' to indicate this large breeding pool and

Table 1. Significant differences (at generic level) between *Saccharum*, *Erianthus*, *Sclerostachya* and *Narenga*.

Character	<i>Saccharum</i>	<i>Erianthus</i>	<i>Sclerostachya</i>	<i>Narenga</i>
1. Root eyes	2 or more rows	Only 1 row, if present	Absent	Absent
2. Bud	Well developed and reproductive	Scaly, except in 2 species	Absent	Scaly not reproductive
3. Dewlap	Present	Absent	Present	Present
4. Spikelet pair	Sessile and pedicellate	Sessile and pedicellate	Both pedicellate	Sessile and pedicellate
5. Callus hairs	Over 2-3 times the length of spikelet	Shorter, same or little longer than spikelet	About half the length of spikelet	Shorter or as long as the spikelet
6. Glume I	Dorsally glabrous in both sessile & pedicellate flowers	Dorsally villous or glabrous in sessile and always villous in pedicellate flower	Slightly hairy on margins	Dorsally glabrous in both sessile & pedicellate flowers
7. Glume II	Dorsally glabrous	Glabrous in sessile and villous in pedicellate	Glabrous in both	Glabrous in both
8. Glume IV	Absent in 2 spp (S.o, S.r) If present, rarely awned.	Present, mucronate to awned, rarely exerted	Present, never awned	Present, never awned
9. Tannin in root tip	Absent	Present	Absent	Absent
10. Ratio of stomata in upper & lower leaf side	2:1	3:1	1:1	2:1

suggested Indo-Burma-China region as the centre of origin. Daniels et al. (1975) included *Miscanthus* section *Diandra* to 'Saccharum complex' as it was thought to be involved in the origin of *Saccharum*.

General morphology of sugarcane (*Saccharum* species):

The genera and species are separated and identified primarily on the basis of floral characters, because they are the most stable, while characters of vegetative reproduction could be influenced by environmental changes. At clonal level, such characters are used for classification or identification. Actually, a combination of several vegetative characters is used for identification of clones.

Saccharum species (sugarcane also) reproduces from true seed (known as 'fluff' due to soft hairs), nodal buds (in the form of stem cuttings called 'setts') and rhizomes or clumps. The lateral branches, called tillers, of the plant arise from underground nodal buds or rhizomes to form a stool of culms. The rhizomatous character is well developed in *S. spontaneum*, which may form dense interlacing mats of roots and runners, difficult to eradicate. Thus, *S. spontaneum* tillers profusely while *S. officinarum* has a low capacity for tillering. The angle at which tillers arise from a stool contributes to the overall growth habit of a clone. Tillers may grow erect, sub-erect (decumbent) or recumbent (lodging). Root system is generally spread to about 8 feet radius and 10-15 feet depth.

The sugarcane stem or culm is composed of a series of nodes and internodes, each node bearing a leaf in the axil of which a bud is present. The colour, waxiness and shape of the internodes are varietal characters. The angle of the leaf blade, its nature (position: erect or droopy) is characteristic of clones. Leaves are solitary, alternate, distichous (2 rows) and sessile. Leaf sheath encloses the internodes and younger leaves. Hairiness on sheath or leaf blade is also important. Ligule and auricle have some diagnostic value based on their presence, size and shape. The senescent leaves either abscise or remain firmly attached to the stem.

Above each node, root band or zone with growth ring and root eye rows (ranging one to many) are seen. On germination, the roots arise from these root eyes and shoot from the bud

present at the nodes. The size, shape and extension of the buds are of diagnostic value.

Origin and taxonomy of ‘*Saccharum* complex’ members:

Saccharum L. (Based on the Latin word meaning ‘sugar’): This genus was established by Carl Linnaeus in 1753. The generally accepted circumscription is that of Jeswiet (1925) modified by Brandes (1958).

1. *S. officinarum* L. ($2n = 80$): ‘Noble canes’ cultivated for thick juicy canes with high sucrose and low fiber and distributed in South East Asia, New Guinea. Centre of Diversity is New Guinea where nearly 1000 clones have been collected. But centre of origin is doubtful – there being two opinions: (a) that it originated from *S. robustum* due to natural and human selection in Wallacea/New Guinea (Grassl 1974, 1977); and (b) that it evolved from *S. spontaneum*, *Miscanthus* and *Erianthus arundinaceus* (Daniels and Roach 1987). All *S. officinarum* clones (except ‘Badilla’) have a leaf flavonoid pattern similar to that of *S. robustum* (Williams et al. 1974), supporting the former view.
2. *S. barberi* Jesw. ($2n = 111-120$): North Indian canes, thin with short cylindrical internodes, cultivated in north India. Barber (1922) classified it into five groups (*Mungo*, *Nargori*, *Saretha*, *Sunnabile*, *Pansahi*). According to Parthasarathy (1946), *S. barberi* evolved from *S. spontaneum* and *S. officinarum*. But Grassl (1977) disputes this view since the cross is highly incompatible and because *S. officinarum* came to India only after 600 BC. He suggested that *Erianthus procerus* and *Sclerostachya* contributed to *Barberi* clones. Waldron et al. 1975 suggest that some *Barberi* clones had ‘beta amylase’ isozyme bands characteristic of *Erianthus* and *Sclerostachya* indicating a diverse origin.
3. *S. sinense* Roxb. ($2n = 81-124$): Chinese canes with taller plants, broader leaves and bobbin shaped internodes and equivalent to *Pansahi* group. Cultivated in China. Isozyme studies (Hemaprabha and SreeRangasamy 2001) showed that *S. sinense* have a relatively com-

plex genetic constitution than *S. barberi* due to the presence of more isozymes. Grassl (1977) modified the view of Brandes (1958) that *S. officinarum* introgressed with *S. spontaneum* to produce *S. sinense*. He also suggested that *Miscanthus sacchariflorus* and not *S. spontaneum*, initially introgressed with *S. officinarum* and that *S. spontaneum* introgression was at a later stage. RAPD analysis by Hemaprabha and SreeRangasamy (2001) supported the *S. spontaneum* based origin of *S. sinense* and *S. barberi*.

4. *S. edule* Hassk. ($2n = 60-80$): Cultivated for edible inflorescence in New Guinea to Fiji. Lennox (1938) and Brandes et al. (1938) suggested it to be a mutant form of *S. robustum*. But Grassl (1967) thought that *S. edule* of New Guinea evolved from *S. robustum* and *Miscanthus* and Fiji form from *S. officinarum* and *Miscanthus*. Leaf flavonoid studies of Williams et al. (1974) indicate that *S. edule* most probably arose from *S. robustum* or *S. officinarum*.
5. *S. robustum* Brandes et Jesw. ex Grassl ($2n = 60, 80$): wild in Indonesia, New Guinea. It is distinguished by lack of rhizomes, thick stem, tall habit, large inflorescence and small spikelets. Grassl (1974) separated red flesh ($2n = 60$) forms of *S. robustum* to a new species named *S. sanguineum* (Grassl) Grassl. Daniels and Roach (1987) view that *S. robustum* is in active state of evolution introgressing with other taxa. They thought that it evolved from introgression of *S. spontaneum* with *Erianthus*, *Sclerostachya* and *Miscanthus*.
6. *S. spontaneum* L. ($2n = 40-128$): wild and highly polymorphic with wide geographic distribution from New Guinea to Africa and Mediterranean. India is the centre of origin and diversity (Mukherjee 1957, Roach and Daniels 1987). Daniels et al. (1975) suggested that it might be a product of introgression between *Sclerostachya* and *Erianthus* (section *Ripidium*) based on flavonoid studies. African forms of *S. spontaneum* are protogynous with large bidentate glumes, possibly due to *Sorghum* introgression (Grassl 1964).

Recently, Irvine (1999) recognised only two species in *Saccharum*, namely, *S. spontaneum* and *S. officinarum* which include the wild *S. robustum* and the land races *S. barberi*, *S. sinense* and *S. edule*, based on studies in cytoplasmic DNA.

A key for identification of *Saccharum* species is given below:

Taxonomic key to *Saccharum* species:

- 1A. Inflorescence sterile, aborted and edible – *S. edule*
- 1B. Inflorescence fertile, normal and non-edible – 2
- 2A. Glumes always 4, main axis of inflorescence and cluster axes with long hairs – 3
- 2B. Glumes generally 3 or rarely 4, main axis of inflorescence often glabrate – 4
- 3A. Lodicules ciliate, peduncle hairy below and wild – *S. spontaneum*
- 3B. Lodicules not ciliate, peduncle glabrous and cultivated – 5
- 5A. Short with thin, cylindrical, grey green/white or ivory canes and narrow leaves – *S. barberi*
- 5B. Tall with thick, bobbin like, green-bronze canes and broad leaves – *S. sinense*
- 4A. Cultivated, stem soft fleshed, less fibrous, high sucrose, rachis glabrous – *S. officinarum*
- 4B. Wild, stem hard, highly fibrous, with robust habit, rachis short hairy – *S. robustum*

Erianthus. Established by Michaux in 1803, based on the Greek word 'Erion' meaning wool and 'anthos' meaning flower, referring to its woolly glumes. It is considered a primitive genus of 'Saccharum complex' (Mukherjee 1957). It is wide in distribution occurring in America (New World species), Mediterranean, India, China, South East Asia, New Guinea (Old World species). The Old World species generally placed under section *Ripidium*, are only important in the evolution and improvement of sugarcane. The Old World species contain a distinctive flavonoid di-C-glycoside that is absent in New World species (Williams et al. 1974).

1. *E. arundinaceus* (Retz) Jesw. ($2n = 30, 40, 60$): Distributed in India, China, Indonesia and N.Guinea and characterised by the presence of vegetative cane and broad leaves (like sugarcane).
2. *E. kanashiroi* Ohwi ($2n = 60$): China to South East Asia. Similar and closely related to *E. arundinaceus* and *E. procerus*. It has been suggested to be hybrid of *Miscanthus sinensis* and *E. arundinaceus* (Adati and Shiotoni 1962). Grassl (1971) disagrees and Daniels et al. (1980) reported that it had a distinctive *Erianthus* flavonoid marker F13.

3. *E. procerus* (Roxb.) Raizada ($2n = 40$): India, Burma, Indo china, China. It resembles the above two species but lacks vegetative cane and has large droopy silky panicles.
4. *E. ravennae* (L.) P. Beauv. ($2n = 20$): Mediterranean to India. It is distinguished by erect dark green leaves, spiny leaf sheath, brownish panicle and a distinct awn (on fourth glume), which is exerted.
5. *E. elephantinus* Hook. f. ($2n = 20$): It differs from *E. ravennae* in light green broader leaves and glabrous leaf sheath. Some consider (Bor 1960) it as a race of *E. ravennae*, but flavonoid studies by Daniel et al. (1980) indicate it as a distinct species.
6. *E. bengalense* (Retz.) Bharadw. ($2n = 20, 30, 40, 60$): India to China. Commonly called as 'Munja grass' in North India.
7. *E. hostii* Griseb. ($2n = 20$): Mediterranean to Iraq. Characterised by creeping rhizomes and very short callus hairs.

The other Old World species namely *E. longisetosus* Anderss. and *E. hookeri* Hack. have been transferred to genus *Eccoilopus* by Grassl (1971) and he also shifted *E. rufipilus* to genus *Miscanthus*.

A key for identification of *Erianthus* species commonly occurring in India is given below:

Taxonomic key for determination of *Erianthus* species:

- 1A. Awn prominent, 2–3 mm long on fourth glume, well exerted out of the spikelets; Inflorescence brownish or purple-brown; Callus hair shorter than glume; upper and lower glumes of sessile spikelet dorsally glabrous ... 2
- 1B. Awn not prominent, less than 2 mm and not exerted; Inflorescence offwhite or pale green or pale purple; Callus hair longer than glume; lower glume dorsally villous, upper glume glabrous or with sparse hairs ... 3
- 2A. Leaf sheath pink tinged with stiff deciduous hairs and persistent bulbous base; lamina narrow and ashy green *E. ravennae*
- 2B. Leaf sheath glabrous; lamina broader and yellowish green ... *E. elephantinus*
- 3A. Rachilla joints longer than spikelets; Panicle silky and loose; awn mucronate... 4

- 3B. Rachilla joints equal or shorter than spikelets; Panicle not silky and loose; awn variable in length ...*E. bengalense*
- 4A. Vegetative culms present; stem with healthy buds (capable of germination) and prominent growth ring and root eyes; Panicle less droopy ...*E. arundinaceus*
- 4B. Vegetative culms absent; stem with scaly buds (not capable of germination), growth ring and root eyes not prominent; Panicle very droopy, dense and much silky ...*E. procerus*

Sclerostachya ($2n = 30$). Established by A. Camus in 1922; based on the Greek word 'Skleros' meaning hard and 'Stachys' meaning ear of corn or spike, referring to the rigid inflorescence and hard spikelets. It is distributed in India, Burma, China and Malaysia. It is characterised by both spikelets of the pair being pedicellate, hollow stalks, absence of root eyes, poorly developed buds, glabrous sheath and leaves and copper-brown panicle. Two species, namely, *S. fusca* and *S. ridleyi* have been recognised.

Narenga ($2n = 30$). Established by N.L. Bor in 1940. India and South East Asia. It is similar and closely related to *Sclerostachya* but differentiated by presence of nearly sessile spikelet in the pair, bearded nodes, pubescent sheath and leaf. Two species have been described:

Key to the two species: Spikelet 4–5 mm. – *N. fallax* Spikelet 2.5–3 mm. – *N. porphyrocoma*.

Due to close resemblance of *Narenga* and *Sclerostachya*, Grassl (1971) published for *Narenga porphyrocoma* (Hance ex Trin.) Bor under *Sclerostachya* the correct combination *Sclerostachya narenga* (Nees ex Steud.) Grassl. Likewise we transfer *Narenga fallax* (Balansa) Bor, Kew Bull. 1948: 162 (1948), to the genus *Sclerostachya* (Hack.) A. Camus (1922):

Sclerostachya fallax (Balansa) Amalraj et Bala-sundaram, comb. nov. Basionym: *Saccharum fallax* Balansa in Morot. Journ. Bot. 4:80 (1890).

Miscanthus: Established by Andersson in 1856. Distributed from Tahiti in Pacific through East Indonesia, to north China, Japan, Siberia. Section *Diandra* is endemic to north India, Nepal and S.W. China. It is considered as most primitive among 'Saccharum complex' as revised by Daniels et al. (1975). It is distinguished from *Saccharum* and *Erianthus* by the tenacious nature of rachis and by paired pedicellate spikelets. It differs from *Sclerostachya* in having awned fourth glume and longer callus hairs. The genus has four Sections, grouped on basis of number of stamens as follows:

Three stamens ($2n = 38-114$): *Triarrhena* (1); *Miscanthus* (4); *Hariyusua* (3 spp.) 2 stamens ($2n = 40$): *Diandra* (4 spp.)

Appendix 1. Key to genera of 'Saccharinae' (modified after Clayton 1972).

1A. Spikelets pedicellate, axis of rachis continuous or disarticulating tardily:	
2A. Racemes verticillate, lemma deeply lobed	ECCOILOPUS
2B. Racemes not verticillate, lemma scarcely or not lobed:	
3A. Spikelets awnless:	
4A. Stamens 1 or 2, lower glume nearly delicate	IMPERATA
4B. Stamens 3, lower glume hard	SCLEROSTACHYA
3B. Spikelets usually awned:	
5A. Glumes membranous, panicle broad-fern shaped, leaf midrib normal	MISCANTHUS
5B. Glumes tough, panicle branched thyriform, midrib much thickened	MISCANTHIDIUM
1B. Spikelets in pairs, one sessile other pedicellate, axis of rachis disarticulating:	
6A. Glumes I and II of pedicellate flower glabrous dorsally, spikelets awnless:	
7A. Callus hair twice or more the length of spikelet, nodes and leaf-joint glabrous	SACCHARUM
7B. Callus hair shorter or as long as spikelet, nodes and leaf-joint bearded	NARENGA
6B. Glumes I and II of pedicellate flower villous dorsally, spikelets awned:	
8A. Flowers unisexual, sessile male and pedicellate female	ERIOCHRYSIS
8B. Flowers bisexual, both sessile and pedicellate	
9A. Lemma deeply cleft, spikelets in few pairs and two flowered	SPODIOPOGON
9B. Lemma not cleft, spikelets in several pairs and one flowered	ERIANTHUS

References

- Adati S. and Shiotani I. 1962. The Cytotaxonomy of the genus *Miscanthus* and its phylogenetic status. *Mic. Univ. Fac. Agric. Bull.* 25: 1–24.
- Barber C.A. 1922. The classification of Indian canes. *Intern. Sugar J.* 24: 18–21.
- Bor N.L. 1960. The Grasses of Burma, Ceylon, India and Pakistan. Pergamon, London.
- Brandes E.W., Sartoris G.B. and Grassl C.O. 1938. Assembling and evaluating wild forms of sugarcane and closely related plants. *Proc. ISSCT* 6: 128–151.
- Brandes E.W. 1958. Origin, classification and characterisation of sugarcane. In: Artschwager E. and Brandes E.W. (eds.), *Sugarcane*. USDA. Handbook, Vol. 122. pp. 1–35, 260–262.
- Clayton W.D. 1972. The awned genera of andropogonae: studies in gramineae: XXXI. *Kew. Bull.* 27: 457–74.
- Daniels J., Smith P., Paton N. and Williams C.A. 1975. The origin of the genus *Saccharum*. *Sugarcane Breeding News.* 36: 24–39.
- Daniels J., Paton N., Smith P. and Williams C.A. 1980. Further studies on leaf flavonoids as evolutionary indicators in *S. officinarum*. *L. Proc. ISSCT.* 17: 1317–1335.
- Daniels J. and Roach B.T. 1987. Taxonomy and evolution. In: Heinz D.J. (ed.), *Sugarcane Improvement through Breeding*. Elsevier, Amsterdam.
- Dutt N.L. and Rao J.T. 1950. The present taxonomic position of *Saccharum* and its congeners. *Proc ISSCT* 7: 287–293.
- Grassl C.O. 1946. *Saccharum robustum* and other wild relatives of noble sugarcanes. *J. Arnold Arb.* 27: 234–252.
- Grassl C.O. 1964. Problems relating to the origin of wild and cultivated *Saccharum*. *Indian J. sugarcane Res. Dev.* 8: 106–116.
- Grassl C.O. 1967. Introgression between *Saccharum* and *Miscanthus* in N. Guinea & Pacific. *Proc. ISSCT* 12: 995–1003.
- Grassl C.O. 1971. Taxonomy of *Saccharum* relatives: *Sclerostachya*, *Narenga* & *Erianthus*. *Proc. ISSCT* 14: 240–248.
- Grassl C.O. 1974. The origin of sugarcane. *Sugarcane Breeding Newsl.* 34: 10–18.
- Grassl C.O. 1977. The origin of sugar producing cultivars of *Saccharum*. *Sugarcane Breeding Newsl.* 39: 8–33.
- Haines H.H. 1921. *The Botany of Bihar and Orissa*. London.
- Hemaprabha G. and Sree Rangasamy S.R. 2001. Genetic similarity among five species of *Saccharum* based on isozyme and RAPD markers. *Indian J. Genet.* 61(4): 341–347.
- Henrard J.F. 1926. *Erianthus* section *Ripidium* Henr. Feddes Repertorium (Berlin) 22: 350.
- Hooker J.D. 1896. *Gramineae in Flora of British India*. Vol VII.
- Irvine J.E. 1999. *Saccharum* species as horticultural classes. *Theor. Appl. Genet.* 98: 186–194.
- Jeswiet J. 1925. Systematics of the genus *Saccharum* Reports of the Expt. Station for Java sugar industry No. 12.
- Lennox O.G. 1938. Sugarcane collection in New Guinea during 1937. *Proc. ISSCT* 6: 171–182.
- Mukherjee S.K. 1954. Revision of the genus *Saccharum*. *Bull. Bot. Soc. Bengal* 8: 143–148.
- Mukherjee S.K. 1957. Origin and distribution of *Saccharum*. *Bot. Gaz.* 119: 55–61.
- Mukherjee S.K. 1958. Revision of the genus *Erianthus*. *Lloydia* 21: 157–188.
- Parthasarathy N. 1946. The probable origin of north Indian sugarcanes. *J. Indian Bot. Soc.* (MOPI comm. Vol.) 133–150.
- Rao J.T., Kandasamy P.A. and Kumari R.K. 1957. Tannin in root tip as a probable genic character of *Erianthus*. *Curr. Sci.* 26: 219–220.
- Roach B.T. and Daniels J. 1987. A review of the origin and improvement of sugarcane. *Proc. Copersugar Intern. Sugarcane Workshop, Brazil.* 1–32.
- Roxburgh W. 1820. *Flora Indica.* 239–251.
- Steudel E.G. 1854. *Synopsis Plantarum Glumacearum.* 1: 405–409.
- Vijayalakshmi U. and Rao J.T. 1963. Phytosterols in the leaves of *Saccharum* and allied genera. *Proc. ISSCT.* 11: 578–582.
- Waldron J.C. and Glasziou K.T. 1972. Isozymes as a method of varietal identification in sugarcane. *Proc. ISSCT* 14: 249–256.
- Waldron J.C., Glasziou K.T. and Daniels J. 1975. B-Amylase isozymes as genetic markers in *Saccharum* and related genera. *Proc. ISSCT* 15: 145–152.
- Williams C.A., Harborne J.B. and Smith P. 1974. The taxonomic significance of leaf flavonoids in *Saccharum* and related genera. *Phytochemistry* 13: 1141–1149.