Indian J. Plant Genet. Resour. 30(1): 72-76 (2017)
DOI 10.5958/0976-1926.2017.00010.9

SHORT COMMUNICATION

Saccharum edule Hassk. an Under-exploited Germplasm Resource of Sugarcane

K Chandran*[1], M Nisha[1], P Mahesh[2] and R Arunkumar[1]
[1]*Sugarcane Breeding Institute–Research Centre, Kannur-670002, Kerala, India*
[2]*Sugarcane Breeding Institute, Coimbatore-641007, TamilNadu, India*

(Received: 07 July 2015; Revised: 08 July 2016; Accepted: 25 July 2016)

The genus *Saccharum* L. has six species of which *S. edule* Hassk. is being cultivated from New Guinea to Fiji for its edible aborted inflorescence. The germplasm maintained at Sugarcane Breeding Institute- Research Centre, Kannur, Kerala houses 17 accessions of *S. edule* and these accessions were characterized for 30 qualitative and 10 quantitative morphological traits. There was considerable variability among these accessions for the characters studied. The yield evaluation of regularly flowering clones in a replicated trial showed significant variation for yield attributes of edible inflorescence and the clones, namely, IJ 76-338, IJ 76-360 and IJ 76-552 were identified with potential for commercial cultivation.

Key Words: Edible Inflorescence, Germplasm resource, *Saccharum edule*, Sugarcane

The genus *Saccharum* L. belongs to the family *Poacea* and has six species *S. officinarum, S. barberi*, *S. sinense*, *S. edule*, *S. robustum* and *S. spontaneum*. The first four of the species are domesticated and the remaining two are wild. All the species of the *Saccharum* except *S.edule* are utilized in breeding programme to develop superior commercial hybrids of sugarcane. The modern varieties of sugarcane are complex hybrids involving these species and even allied genera like *Erianthus*, *Miscanthus* etc. *S. edule* Hassk is a species with aborted inflorescence which is being cultivated from New Guinea to Fiji for its edible inflorescence (Massal and Barrau, 1956). Daniel and Roach (1987) cited that Rumphius listed *S. edule* as *Ova piscium* in his herbarium Amboinense (Vol. 5) in 1747, as to the Indonesians the inflorescence resembled a mass of fish egg. It has many common names in the place of its cultivation, Coastal pitpit, duruka, dule in Fiji and Fiji asparagus, naviso, pit-pit in Melanesia. The unopened flower heads of *S. edule* are gathered and used as a vegetable, eaten either raw or cooked. The world collection of sugarcane germplasm located at Sugarcane Breeding Institute-Research Centre, Kannur houses 17 accessions of *S. edule*. Warner and Grassl (1958) reported large number of distinct clones of *S. edule in* Melanesia. Berding and Koike (1980) noticed a large number of clones in the western highlands of Irian Java. Later Grassl (1967) suggested that *S.edule* consists of two groups, the New guinea type where *S.robustum* × *Miscanthus* introgression was most probable and the Fijian type where *S. officinarum* × *Miscanthus* introgression has operated *S. edule* has a polyploid series 2n= 60, 70, and 80 with aneuploid forms. Now it is strongly believed that *S.edule* is regarded as a product of introgression in *S. officinarum* and *S. robustum* with other genera (Daniel and Roach, 1987). This species remains unexploited in India for its edible inflorescence by want of detailed information on production potential/suitable cultural practices and in other parts of the world it is still under-utilized. The present study was done to characterize the collection for various agro-morphological traits to understand the extent of variability and to assess the potential of edible inflorescence and biomass yield in the local environment.

The world collection of sugarcane germplasm is maintained at Sugarcane Breeding Institute-Research Centre, located at Kannur, Kerala, India (11°52 N, 75°25 E, 11m MSL, mean annual rainfall 3350 mm). Each of the 17 accessions (28 NG 82, 28 NG 201, 28 NG 272, 57 NG 27, 57 NG 234, NG 77-1, IJ 76-312, IJ 76-329, IJ 76-336, IJ 76-337, IJ 76-338, IJ 76-360, IJ 76-375, IJ 76-552, IS 76-119, NG 77-10, NG 77-235) was planted in one row of 2 m length during 2013-14 and the recommended packages and practices followed for sugarcane were adopted. Total 30 qualitative and 10 quantitative traits were recorded during the crop season. The morphological characters were recorded

**Author for Correspondence: Email- Chandranksd62@gmail.com*

after 8th month of the crop and cane characters after 10th month. Non- parametric analysis was done using SAS 9.0 software package with qualitative and quantitative data after converting the later into binary data to find the relationship between the accessions. The dendrogram was constructed based on UPGMA using Squared Euclidean distance as distance measure. To assess the yield potential of edible inflorescence and total biomass yield a replicated trial was conducted with nine regularly flowering accessions during 2014-15. The plants were grown in a two meter row in three replications. The inflorescence data were collected as and when it was ready for harvest from 10 shoots/accessions. Biomass yield was calculated by harvesting the shoots growing in one meter long rows. ANOVA was calculated for yield and yield related traits. For multi-factorial comparison, Principal Component Analysis (PCA) was done using SAS, JMP version 9.0. The correlations between the various parameters among the accessions were also displayed using the same software package.

Morphological traits showed considerable variation between accessions. The rind colour and internode surface are generally used for identifying a genotype in *Saccharum species*. In the accessions studied, the exposed rind colour ranged from green to brownish green. Similarly all bud traits viz., shape of bud, bud size, bud germ pore, bud cushion and bud groove, bud hair and bud extension were also highly variable. Variation for lamina surface was categorized into three viz., hairy on either side of the lamina, only at dorsal side or in some cases totally glabrous. In seven accessions the hairs were not observed on lamina, three accessions had hairs only on dorsal side and seven accessions had hairs on either side of the lamina. Other leaf traits like leaf sheath colour, leaf sheath hairiness, leaf sheath clasping, dewlap colour, ligule shape and ligular process also showed variation between accessions. With the canopy character the plants can be easily distinguished into compact erect, open tip droopy, open semi droopy or open droopy type. Most of the accession were open droopy (12 accessions) followed by open tip droopy (3), compact erect type (1) and open semi droopy (1). The culms had HR brix which ranged from 8.9% in IJ 76-329 to 14.0% in IS 76-119. Red rot is a major disease of sugarcane and all the accessions were screened against COC 671 isolate of the red rot pathogen. The study revealed that most of the clones were either susceptible or highly susceptible to red rot disease but one clone IJ 76-336 was moderately resistant.

Only nine out of 17 clones flowered regularly at the site of evaluation and the percentage of flowering shoots and the size and fresh weight of the edible inflorescence also varied between the accessions. The edible inflorescence after removing the leaf sheath was creamy yellow in color (Fig 1) except in IJ 76-375 where it was yellowish orange. Waqaniu-Rogers (1986) reported that the red *duruka* or *minimanu* has only one variety, whereas, the white *duruka* has at least six named varieties which are distinguished by size of stem, length of edible portion when mature and period when they are ready to harvest in Viti Levu, FIJI.

The combined cluster analysis of 30 qualitative and 10 quantitative traits showed that most of the accession behaved as independent units with high dissimilarity coefficient. Between two accessions IJ 76-329 and IJ 76-312 more than 75% similarity was observed indicating that these accessions may be a minor variant collected from same locality. The accession 28 NG 82 showed very high dissimilarity with other accessions and remained as a distant node in the dendrogram (Fig. 2) and the remaining accessions were grouped into two distinct major clusters. Similar observations with respect to diversity were recorded by Saraswathi *et al*. (2013) in the *S. edule* collection from Papua, Indonesia collected from the population growing from lowland to highland (0-175 MSL). The cluster analysis done by them based on morphological traits showed two distinct clusters from

Fig 1. Edible inflorescence of IJ 76-368

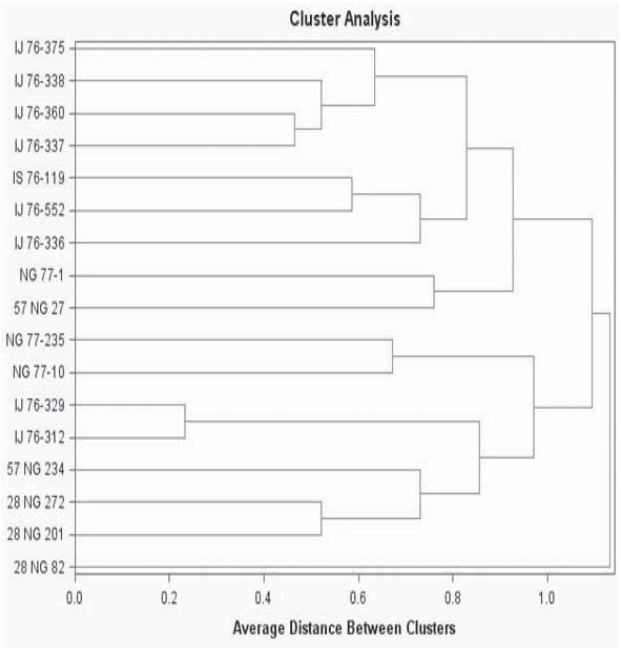

Fig. 2. Dendrogram based on 30 qualitative and 10 quantitative traits of *S.edule* collection

two geographical region and closer relatedness between populations growing in adjacent area. They also observed that each location had a unique plant characters which is explained by the geographical isolation and subsequent adaptation to the specific niche. The distinct grouping can also be explained as a result of independent origin of different groups as suggested by Grassl (1967), wherein the New Guinea type originated as a result of *S. robustum* × *Miscanthus* introgression and the Fijian type by S. *officinarum* × *Miscanthus* introgression. The populations developed by such intergeneric crosses resulted in aborted inflorescence in the progenies and further introgression was not possible. Such group continues to remain as discrete population and adapted to the specific geographical location. Premachandran (2006) suggested that the aborted inflorescence in *S. edule* may be due to *cal* and *ap1* mutants of the flowering gene as in the case of *Arabidopsis*, cauliflower, maize, rice etc., or its orthologs in *S. robustum*. He also suggested the possibility of transferring this gene to sugarcane to add one more economic product from sugarcane.

The ANOVA for nine accessions revealed that out of the 14 yield and yield related characters studied, all of the traits showed significant (1% level) variations except for tillering at 30 days after planting and cane thickness. The mean and standard error of the yield related traits are given in Table 1. The harvesting date of edible inflorescence extended from 2nd week of October to 2nd week of December indicate that it will be available only during this period as fresh vegetable and suitable preservation technique needs to be standardized for ensuring the year-around availability. Suitable preservation and packing techniques are also

Table1. Mean value of yield and yield related traits of nine *S.edule* accessions

clone	30d	90d	NMC	%F	CTK (cm)	CL (cm)	LL (cm)	LW (cm)	UOL (cm)	UOW (cm)	OL (cm)	OW (cm)	FW (g)	NC	YLD (g)	BIO (Kg)
IJ 76-312	10.0	18.3	15.7	83.8	1.7	287.8	136.0	4.7	65.4	2.0	18.6	1.7	29.0	13.0	377.3	2.1
IJ 76-329	11.7	15.0	13.3	89.8	1.6	285.6	134.7	4.6	60.6	2.0	19.2	1.8	26.8	12.0	318.3	2.0
IJ 76-337	16.7	32.7	29.0	24.3	1.3	290.0	111.8	3.9	66.1	1.3	16.1	1.2	26.1	7.0	180.4	2.5
IJ 76-338	17.3	32.7	30.3	98.1	1.2	279.4	109.3	3.1	48.4	1.4	22.2	1.3	15.0	32.3	487.0	1.7
IJ 76-360	13.7	35.0	32.3	57.5	1.3	295.6	109.6	4.1	54.1	1.9	31.4	2.0	25.3	18.3	464.5	2.2
IJ 76-375	14.0	26.3	24.3	64.3	1.2	258.3	117.3	3.8	57.0	1.6	17.6	1.6	21.1	15.7	334.3	1.9
IJ 76-552	18.7	23.7	20.7	77.0	1.5	267.8	110.4	4.1	47.9	2.1	15.8	2.0	26.9	15.7	421.1	1.8
NG 77-10	6.7	11.3	9.7	77.0	1.8	273.3	97.2	5.0	36.0	2.3	20.8	2.2	48.0	7.0	337.8	2.1
NG 77-235	15.7	27.7	23.3	77.4	1.5	272.2	129.7	4.5	89.9	1.7	22.9	1.5	23.0	17.7	406.4	2.9
SE	1.90	1.97	1.79	5.12	0.04	5.6	3.41	0.12	2.14	0.09	1.42	0.07	0.60	1.82	26.9	0.19

30d=Tillering at 30 days after planting; 90d= Tillering at 90 DAP; NMC= Number of mature canes ; %F=Percentage of flowering shoots; CTK= Cane thickness; CL= Cane length; LL= Lamina length; LW=Lamina width; UOL= Length of edible inflorescence with leaf sheath; UOW=Width of edible inflorescence with leaf sheath; OL= Length of edible inflorescence without leaf sheath ; OW= width of edible inflorescence without leaf sheath; FW= Fresh weight of edible inflorescence; NC= Number of edible inflorescence /plot; YLD= total yield of edible inflorescence/2m plot; BIO= Total biomass yield/1m plot.

needed to exploit the export market as the edible part is highly perishable owing to its high water content. The accessions IJ 76-552, NG 77-235 and IJ 76-330 flower early (2nd week of October) and the remaining started flowering from 2nd week of November. The maximum duration of flowering (two months) was recorded in IJ 76-330 which makes it suitable for prolonged availability of the fresh edible inflorescence. The highest yield of edible inflorescence/plot was recorded by IJ 76-338 followed by IJ 76-330 and IJ 76-552. The percentage of flowering stalk was highest in IJ 76-338 (98.1%).

PCA is a valuable statistical technique which has found application in reduction of original variables to a smaller number of underlying variables (Principal Components) in order to reveal the interrelationships between the different variables and to determine the optimum number of extracted principal components. The first principal component (PC1) had the highest eigen value of 6.8 and accounted for 43 per cent of the total variation in the data set, while the second principal component (PC2) with eigen value of 3.2 explained 19.8 per cent of the variation. The percentage of flowering shoots (%F), width of inflorescence with leaf sheath (UOW) and without leaf sheath (OW) were observed on the right upper side of the biplot with high positive loading for both PC1 and PC2, while fresh weight (FW), cane thickness (CTK), leaf width (LW) and leaf length (LL) were grouped together on the right lower side of the biplot with positive loadings for PC1 and negative loadings for PC2. Significant positive correlation was observed between Number of mature canes (NMC), tillers at 30 days after planting (30DAP) and tiller at 90 days after planting (90DAP) and they were found in a group at left side of biplot. Number of edible inflorescence (NEI) had a significant positive correlation (r=0.784*) with total yield of edible inflorescence (YLD). Also the cane thickness showed significant positive correlation (r=0.909**) with leaf width and this explains that higher the leaf area plausibly more photosynthesis and dry matter production by partitioning more towards shoot growth occurs.

The present study revealed that the *S.edule* can be directly exploited for edible inflorescence by commercial cultivation and the biomass for complimenting in energy production to sugar factories. Though the sugar content is varying from 8 to 14% (Ramana Rao *et al*., 1985) the extractable juice is very less and hence sugar recovery from the culms may not be economically viable. Premachandran (2006) referred the edible inflorescence as "cane flower' owing to its similar origin to cauliflower by mutation in the floral gene. However, in gross morphology it looks more similar to a maize cob and can be named as 'Cane Cob'. The study revealed that the accessions IJ 76-368, IJ 76-360 and IJ 76-552 are better yielder for edible inflorescence on account of fresh weight of edible inflorescence, good tillering, good flowering percentage of stalks and also for biomass yield. It has been reported that *S. edule* is suitable for intercropping with soybean and rotation with early flowering red duruka with late flowering white types for better commercial exploitation (Saraswati *et al.,* 2013). They also observed that wider spacing (200x200cm) improved the growth and yield, as shown by greater plant height, number of suckers, flower number and flower weight, compared to the traditional planting of 150×150 and 100×150 cm distances. The purple duruka variety which flowers twice a year introduced to Viti Levu, Fiji become popular and it is proposed to have a canning unit in Fiji to sell this as "Fijian asparagus" (Waqaniu-Rogers, 1986).

The adaptation of *S. edule* to marginal land and its ability to check soil erosion (Waqaniu-Rogers, 1986) makes it suitable for the area where sugarcane is not commercially viable. Since it has a short flowering period of nine weeks (from October 2nd week to December 2nd week) there is a need to identify suitable genotypes which are early flowering, late flowering and that flower twice in a year to make the availability of fresh vegetable for longer duration in the market. There is also a need to develop suitable packing/canning of this vegetable on account of quick perishable nature and to extend its availability in the export market.

References

Berding N and H Koike (1980) Germplasm conservation of the *Saccharum* complex: A collection from the Indonesian Archipelago, *Hawaiian Planters Record* **59**:87-176.

Daniels J and BT Roach (1987) Taxonomy and evolution. In: DJ Heinz (ed.) *Sugarcane Improvement through Breeding,* Amsterdam, Elsevier, pp 7-84.

Grassl CO (1967) Introgression between *Saccharum* and *Miscanthus* in New Guinea and Pacific Area. *Proc.Int.Soc. Sugar Cane Technol*.**12**: 995-1003.

Massal E and J Barrau (1956) Food plants of the South Sea Islands. *South Pac. Comm. Tech. Paper*, 1956 (94): 51p.

Premachandran MN (2006) Cauliflower gene in sugarcane? *Current Science* **91**: 750-751.

Roach BT (1972) Chromosome Numbers in *Saccharum edule*. *Cytologia* **37**: 155-161.

Ramana RO TC, Srenivasan TV and Palanichami K (1985) *Catalogue on sugarcane genetic resources-II*. Sugarcane Breeding Institute (ICAR), Coimbatore, India. Pp 81.

Saraswati P, NL Mawikere, IAF Djuuna and F Pakiding (2013) The diversity and cultivation system of *Saccharum edule* L. and its role as an edible plant source in Papua, Indonesia. *Acta Hort. (ISHS)* **979***:373-380.*

Waqaniu-Rogers (1986) Some observations on duruka, *Saccharum edule*, in Viti Levu, Fiji, *The Journal of the Polynesian Society* **95**: 475-478.

Warner JN and CO Grassl (1958) The 1957 sugarcane expedition to Melanesia. *Hawaiian Planters Record* **55**: 209-236.