Journal of Sugarcane Research (2020) **10**, 100-106
https://doi.org/10.37580/JSR.2020.1.10.100-106

SHORT COMMUNICATION

SBIEC 14006 – A high biomass energycane for power, alcohol and paper industries

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(Received 06 August 2020; accepted 14 August 2020)

Abstract
Six energycanes viz., SBIEC 14001, SBIEC 14002, SBIEC 14003, SBIEC 14004, SBIEC 14005 and SBIEC 14006 developed at ICAR-Sugarcane Breeding Institute were evaluated along with a registered genetic stock SBIEC 11002 for biomass production under suboptimal management condition with limited irrigation and fertigation during 2013-14 and 2014-15 and under normal irrigation during 2015-16 (Plant crop) and 2016-17 (Ratoon crop). Among the six clones evaluated, SBIEC 14006, a selection from open pollinated fluff of *Erianthus arundinaceus* clone IK 76-75 was identified as promising clone based on high harvestable biomass and fibre content in cane. This clone recorded the highest mean harvestable biomass of 265.28 t/ha compared to the SBIEC 11002 (219.22) across four environments and showed 21.01 % improvement. The mean harvestable biomass yield under limited irrigation condition was 241.47 t/ha while under normal irrigation condition the yield was 289.08 t/ha. For fibre % cane also SBIEC 14006 recorded the highest value of 27.54 % compared to SBIEC 11002 (20.90 %). The clone recorded an average of 8.94 % juice brix and 4.72 % juice sucrose. It also recorded 2.18 cm cane diameter and 1.24 kg of single cane weight. Tall and non-lodging nature of canes makes the clone amenable for mechanical harvesting. This clone can be ratooned for at least 7-8 years hence no need for replanting every year. This promising clone is identified as an ideal energycane due to more biomass yield per unit area and requires low input, low production cost and low nutrient requirement which are the characteristics of energycanes.

Keywords: Type I energycanes; Type II energycanes; Biomass; Fibre %; *Erianthus arundinaceus*

Economic and year round availability of biomass from exclusive energy crops opens up great opportunity as an alternate sources of fossil fuels for the generation of green energy (Lynd et al. 2008). Sugar industries are generating huge biomass as byproduct called bagasse, which is fed to the boilers for generating electricity thus play a pro-active role in reducing environmental pollution to certain extent. Molasses is another by product used in distilleries for the production of alcohol which is blended with petrol to reduce air pollution. Realizing the importance of effective utilization of these byproducts in generating green energy and realizing additional income, most of the Indian sugar industries have taken steps to setup cogenetation and distilleries in sugar mill complex and made intelligent use of this opportunity for sustainable growth. However these units are receiving raw materials for their operation during the cane crushing season of 6 – 8 months and rest of the period these units are not in operation due to want of raw materials (Govindaraj 2017). Underutilization of these units result in reduced income from huge money invested in establishing these units.

In order to achieve the dual goal of increased alcohol and power production through full capacity utilization of these subsidiary units, sugar industries require special high biomass varieties to meet their specific requirement of raw materials round the year (Kim and Day 2010). Sugarcane breeders worldwide are attempting to develop new high biomass varieties which are adapted to adverse conditions (drought, salinity, etc.) through introgression of biomass genes from related species and genera in *Saccharum* complex. These high biomass, more vigorous with multiple ratooning ability varieties are called as energycanes (Knoll et al. 2013; Matsuoka and Stolf 2012) which are specifically selected for biofuel production. In addition to generation of electricity, huge lignocellulose content of the energycanes can be also profitably exploited in converting them into ethanol hence cultivation of such energycane is gaining importance worldwide (Carvalho-Netto et al. 2014).

Breeding for energycane development was initiated at ICAR-Sugarcane Breeding Institute, Coimbatore during the year 2009 with the objectives of developing both Type I and Type II energycanes (Tew and Cobill 2008). The clones with >15% juice brix and >20% cane fibre were designated as Type I energycanes (Govindaraj et al. 2012). While the juice can be used for direct fermentation in distilleries to produce alcohol, the bagasse may be used in the cogeneration unit for generating electricity. Type II energycanes should have >25% cane fibre and <10% juice brix. This type of energycanes can be harvested as whole canes with trash and tops and directly fed into the boilers for producing electricity (Govindaraj et al. 2012). Type I energycanes are developed through hybridization and selection involving *Saccharum spontaneum* as a donor parent for high fibre content, increased tillers, wider adaptability to adverse climatic conditions and better ratoonability. *Erianthus arundinaceus*, a member of *Saccharum* complex is extensively used for developing Type II energycanes in tropical region, as this species is a huge biomass producer with multiple ratooning ability and resistance to major pests and diseases (Govindaraj and Nair 2014). Both these energycanes have increased lignin content compared to the commercial sugarcane varieties (Knoll et al. 2013). Energycanes have more efficient users of water and nutrient hence can be cultivated in marginal lands and problematic

Table 1. Performance of SBIEC 14006 for harvestable biomass yield (t/ha) and fibre % in cane under four environments

Clone	HBM t/ha					Fibre %				
	2013-14	**2014-15**	**2015-16 (P)**	**2016-17 (R)**	**Mean**	**2013-14**	**2014-15**	**2015-16 (P)**	**2016-17 (R)**	**Mean**
SBIEC 14001	132.12	145.23	182.00	191.23	**162.64**	24.23	25.21	26.11	26.48	**25.51**
SBIEC 14002	186.92	200.00	234.22	206.75	**206.97**	20.41	20.48	21.32	22.20	**21.10**
SBIEC 14003	158.08	159.14	212.15	226.78	**189.04**	21.98	20.27	20.18	21.11	**20.88**
SBIEC 14004	136.15	161.34	185.21	186.27	**167.24**	25.24	22.04	25.00	23.13	**23.85**
SBIEC 14005	143.08	158.12	162.16	194.25	**164.40**	26.50	23.38	25.88	23.28	**24.76**
SBIEC 14006	233.65	249.29	282.83	295.34	**265.28**	27.24	26.99	28.22	27.70	**27.54**
INGR 12017	203.00	217.12	227.77	228.98	**219.22**	21.17	20.79	21.58	20.05	**20.90**
CD	24.04	28.16	23.08	17.37		2.86	1.83	1.09	1.22	
CV	12.23	15.86	17.95	14.66		5.97	7.26	10.03	12.52	

areas where any other agricultural crops can not be profitably cultivated (Sandhu and Gilbret 2014; Knoll et al. 2013; van Antwerpen et al. 2013). They are also suitable candidates for regeneration of degraded forest land and greening of waste lands as they are adapted to various environmental stress conditions (Mandal and Mithra 2004)

Six energycanes viz., SBIEC 14001, SBIEC 14002, SBIEC 14003, SBIEC 14004, SBIEC 14005 and SBIEC 14006 developed at ICAR-Sugarcane Breeding Institute were evaluated along with INGR 12017 (SBIEC 11002), a registered genetic stock for biomass production in replicated trials. While SBIEC 14002, SBIEC 14003, SBIEC 14004 and SBIEC 14005 were Type I energycanes, SBIEC 14001 and SBIEC 14006 were type II energycanes. The trials were conducted in suboptimal management condition with limited irrigation and fertigation during 2013-14 and 2014-15 and under normal irrigation during 2015-16 (Plant crop) and 2016-17 (Ratoon crop). Data were recorded on cane diameter, single cane weight, harvestable biomass, juice sucrose, juice brix and cane fibre at 12 months in plant crop (2013-14, 2015-16 and 2016-17 P) and 11 months in ratoon crop (2016-17 R). Fibre content in cane was estimated gravimetrically. Three fully grown healthy sugarcane stalks per clone at 11 months were cut from field. The canes were shredded using mechanical fiberizing mill and mixed thoroughly for unbiased drawing of samples. Five hundred grams of the shredded canes was weighed and pressed using a hydraulic press to release the juice. The remaining fibre with moisture and residual juice were taken in cotton bags and washed with water for removing the remaining juice. It was again pressed to release water and dried in a hot air oven at 60°C for 2 days and 90°C for 2-4 days until the weight of the dry fibre reached constant value. The final weight of the fibre was recorded and percentage of dry fibre was worked out.

Fibre % = (Final Dry weight X 100) / Initial fresh weight

Table 2. Performance of SBIEC 14006 for juice quality parameters at harvest

Clone	Juice Sucrose %					Juice brix %				
	2013-14	**2014-15**	**2015-16 (P)**	**2016-17 (R)**	**Mean**	**2013-14**	**2014-15**	**2015-16(P)**	**2016-17(R)**	**Mean**
SBIEC 14001	3.49	4.23	3.22	2.94	**3.47**	8.88	7.98	7.98	6.88	**7.93**
SBIEC 14002	13.25	12.20	14.15	14.25	**13.46**	17.38	16.65	18.20	17.38	**17.40**
SBIEC 14003	15.87	13.79	15.50	14.39	**14.89**	18.70	17.33	17.99	17.26	**17.82**
SBIEC 14004	10.79	11.40	10.99	10.41	10.90	14.36	15.26	15.20	15.63	**15.11**
SBIEC 14005	10.97	8.89	9.87	10.27	**10.00**	14.90	14.99	13.12	14.26	**14.32**
SBIEC 14006	5.87	4.65	5.12	3.23	**4.72**	9.92	8.88	8.97	8.00	**8.94**
INGR 12017	12.83	13.26	12.35	12.00	**12.61**	15.46	15.78	15.03	15.05	**15.33**
CD	1.77	1.08	1.20	1.26		1.66	1.34	1.28	1.19	
CV	9.31	5.23	4.76	3.29		6.01	6.99	6.22	5.03	

Table 3. Performance of SBIEC 14006 for cane diameter (cm) and single cane weight (Kg) under four environments

Clone	Cane diameter (cm)					Single cane weight (Kg)				
	2013-14	2014-15	2015-16 (P)	2016-17(R)	Mean	2013-14	2014-15	2015-16 (P)	2016-17(R)	Mean
SBIEC 14001	2.02	1.77	2.30	2.20	**2.07**	0.70	0.78	0.90	1.01	0.85
SBIEC 14002	2.10	1.98	2.32	2.02	**2.11**	1.30	1.46	1.35	1.10	**1.30**
SBIEC 14003	2.17	1.97	2.33	2.26	**2.18**	0.97	1.24	1.25	1.15	**1.15**
SBIEC 14004	2.21	1.86	2.10	2.18	**2.09**	0.73	0.99	0.92	0.84	**0.87**
SBIEC 14005	1.69	1.88	1.77	1.58	**1.73**	0.80	0.92	0.88	0.87	**0.87**
SBIEC 14006	2.25	2.09	2.30	2.10	**2.18**	1.20	1.18	1.32	1.25	1.24
INGR 12017	2.10	2.00	2.14	2.02	**2.07**	1.22	1.31	1.25	1.40	**1.30**
CD	0.48	0.38	0.33	0.25		0.27	0.18	0.19	0.19	
CV	11.73	15.13	9.54	8.38		13.65	12.34	14.32	16.27	

Erianthus arundinaceus, an important species in *Saccharum* complex is the only cane producing species in the *Erianthus* genera. This is tall growing high biomass generating species and sustain biomass yields in subsequent multiple ratoons (Govindaraj 2014). Among the six clones evaluated, SBIEC 14006 was identified as promising clone based on high harvestable biomass and fibre content in cane. This was a selection from open pollinated fluff of *E. arundinaceus* clone IK 76-75 and mainly selected for tall and erect canes, free from pests and diseases, high fibre and high harvestable biomass production. This clone recorded the highest mean harvestable biomass of 265.28 t/ha compared to the INGR 12017 (219.22) across four environments and showed 21.01 % improvement (Table 1).

Percent improvement was more in ratoon crop (28.98 %) compared to plant crop (24.17 %) under normal irrigation conditions. Under limited irrigation condition also it recorded 14.96 % improvement over INGR 12017. The mean harvestable biomass yield under limited irrigation condition was 241.47 t/ha while under normal irrigation condition the yield was 289.08 t/ha. For fibre % cane also SBIEC 14006 recorded the highest value of 27.54 % compared to INGR 12017 (20.90 %) and the next best clone SBIEC 14001 recorded 25.51 % (Table 1). This showed an improvement of 31.77 % compared to the INGR 12017. Across the four environments the clone showed variation for fibre content which ranged between 28.22 % and 26.99.

SBIEC 14006 is a type II energycane wherein total biomass yield and fibre % are the important economic traits and the byproduct juice is not intended for any use. The clone recorded an average of 8.94 % juice brix and 4.72 % of juice sucrose (Table 2). Sucrose and other carbohydrates presents in the juice can be used for the production of biogas after the economic feasibility studies. It also recorded 2.18 cm cane diameter and 1.24 kg of single cane weight (Table 3).

Figure 1. Nonlodging, erect and tall canes of SBIEC 14006 in plant crop

The cane grows upto 4 -5 m tall in 12 months (Fig 1). The leaf sheath is tightly attached to the cane hence available upto harvest without wasting the biomass. Tall and non-lodging nature of canes makes the clone amenable for mechanical harvesting. This clone can be ratooned for at least 7-8 years hence no need for replanting every year which brings down the cost of cultivation of biomass in ratoon crop. This promising clone is identified as an ideal energycanes due to more biomass yield per unit area and requires low input, low production cost and low nutrient requirement which are the typical characteristics of energycanes (McKendry 2002).

SBIEC 14006 has large potential to ensure uninterrupted supply of feedstock for biofuel industries throughout the year. Establishment of 10MW/hr power industry normally requires around 700 tonnes

Figure 2. High biomass production ability of ratoon crop of SBIEC 14006

of bagasse with 50% moisture per day. This power plant requires about 2,500 ha of captive plantation with average harvestable biomass potential of 200 t/ha for uninterrupted supply of raw materials throughout the year. Sugar mills can also encourage cultivation of this energycane to run the cogeneration units in the offseason crushing. It is estimated that 20MW/hr cogeneration unit also require same area of energycane plantation to produce biomass for running the power plant during the crushing offseason to the extent of six months. It is imperative that SBIEC 14006 with high harvestable biomass yield (265.28 t/ha) increased fibre content in cane (27.54 %) and amenable for multiple ratooning (Fig. 2) will be a great source of economical feedstock to the cogeneration units for operating during the non-crushing season. Preliminary studies in pulping parameters indicated that the energycane bagasse is comparable to the sugarcane bagasse hence can be an alternate and cheap raw materials for the paper mills.

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