वार्षिक प्रतिवेदन 2016 - 17

Annual Report

भा.कृ.अनु.प. - गन्ना प्रजनन संस्थान

कोयम्बत्तूर - 641 007

ICAR - Sugarcane Breeding Institute

(ISO 2001:2008 Institution)

Coimbatore - 641 007

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Preface

World sugarcane production is close to 1.9 billion tonnes per annum and is concentrated in tropical regions, particularly developing nations in Latin America, Africa and Asia. Sugarcane production in India in 2016-17 season was 306 million tonnes. About 44% total sugarcane production in India comes from Uttar Pradesh (133.70 million tonnes), 16% from Maharashtra (49.69 million tons), 11% from Karnataka (33.44 mt), 7% from Tamil Nadu (22.39 mt) and 4.37% from Bihar (13.37 mt). Subtropical states contribute 56% of total cane production and tropical states contribute 44% production. In comparison to 2015-16 season cane production (348.45 million tonnes), 2016-17 season recorded 42.42 million tonnes less production (i.e. 12%) due to drought and other causes.

Sugar recovery in India in 2015-16 crushing season was 10.62%. The highest recovery of 11.33% was reported in Maharashtra, followed by Telangana (10.85%), Karnataka (10.74%) and Gujarat (10.39%). For quite long time, sugar recovery in the subtropical states remained in single digit. However, in 2015-16, sugar recovery in Uttar Pradesh (10.61%), Haryana (10.51%), and Punjab (10.06%) surpassed more than 10%, setting a new history. The main factor responsible for this trend is adoption of Co 0238, the wonder variety of sub-tropical India, which occupied 8.97 lakh ha or 34.5% of the cane area in subtropical states. The variety was recommended in UP during 2012 and since then it has increased to over 7.29 lakh hectares (35.5%) area during 2016-17. During the last four seasons, the average cane yield and the sugar recovery in UP has increased to 72.4 t/ha and 10.61%, respectively from 61.6 t/ha and 9.18%, respectively during 2012-13. For the first time in the history of sugar industry in sub-tropical India, more than 12% average sugar recovery by three sugar mills and more than 11% average sugar recovery by 30 sugar mills in UP state was recorded. The impact analysis of Co 0238 revealed Rs. 6,887 crores (or Rs. 49,883 / ha) additional income to farmers and Rs. 815 crores to sugar industry. During the last four seasons, farmers as well as the sugar industry in UP earned Rs. 7,702 crores additionally due to increased cane yield and higher sugar recovery. As a result, the socio-economic status of farmers and the financial situation of sugar industry have improved a lot.

Ever since its inception in 1912, the foremost objective of the Institute is to develop improved sugarcane varieties for the different agroclimatic regions of the country. Co clones, developed at the Institute, have contributed a lot not only in the country but also in 28 other countries, either as commercial varieties or as parents in their hybridization programmes. At present, about 99% of cane area in the country is occupied by 'Co' and Co allied varieties developed in collaboration with the Institute. During 2016-17 season 16 Co varieties namely Co 0118, Co 0124, Co 0232, Co 0233, Co 0235, Co 0237, Co 05009, Co 0238, Co 0239, Co 05011, Co 1148, Co 7717, Co 89003, Co 98014, Co 87263 and Co 87268 in subtropical region and 21 varieties namely Co 0323, Co 1053, Co 62175, Co 6907, Co 7805, Co 8014, Co 8021, Co 8371, Co 86002, Co 86027, Co 86032, Co 86249, Co 87044, Co 92005, Co 92012, Co 94010, Co 94012, Co 97009, Co 99004, Co 99006 in tropical India were grown in over 49.7% of the cane area which is a significant achievement of single institute. Co 86032 and Co 0238 put together occupied 40.1% of the total cane area in the country.

Co 09004, an early maturing, in Peninsular Zone and Co 09022 (Karan 12), a midlate maturing clone from Institute's Regional Centre at Karnal, in North West Zone were identified for release in respective zones.

Fourteen elite clones (Co 17001 to Co 17014) from Coimbatore and six clones from ICAR-SBI, Regional Centre, Karnal (Co 17015 to Co 17020) have been designated as 'Co' canes from the Pre-Zonal Varietal Trials. Co 11015, identified as short duration clone, recorded numerically higher sucrose (20.39%) than the standards Co 8338 (19.04%) and CoC 671 (17.30%) at 8th month.

A new initiative was taken to identify location specific sugarcane varieties by having an institute-industry collaborative project between ICAR-SBI, Coimbatore and SISMA-Tamil Nadu. Twenty promising genotypes were multiplied at Coimbatore and supplied to nine sugar factories in Tamil Nadu.

National Hybridization Garden (NHG) with 629 parental clones was maintained for the breeders of 24 participating centres, wherein 502 bi-parental crosses, 12 poly crosses, 42 selfs and 94 general collections (GC) were made. Besides, 60 bi-parental crosses and 40 GCs were made at the National Distant Hybridization Facility available at ICAR-SBI RC, Agali. A total quantity of fluff weighing 19.52 kg was supplied to the participating centres.

Breeder seed multiplication was taken up both at the Institute and in farmer's fields and 816.23 tons of quality seed cane was supplied with a net profit of Rs. 4,08,115/-. A total of 50,700 virus free tissue culture plants were supplied to sugar factories, progressive farmers and for breeder seed production. Virus free mother culture flasks of the varieties Co 86032, Co 0212 and Co 0238 were supplied to tissue culture laboratories of Tamil Nadu, Karnataka, Andhra Pradesh, Gujarat and Maharashtra. At Karnal, 3,766.23 quintal breeder seed of eight sugarcane varieties of North West Zone were produced and supplied to the various stakeholders.

Germplasm exploration was conducted in the states of Punjab and Haryana and 97 *S. spontaneum* and five *E. bengalense* were collected. Under National Active Germplasm (NAG) of sugarcane, 226 clones were maintained.

Two novel stem specific genes (Dirigent and O-Methyl Transferase) were isolated from *E. arundinaceus* and Co 86032. In the studies on genetic engineering of sugarcane for water deficit stress tolerance, 128 transgenic events were evaluated.

Indo-Australia collaborative research project on genetic control and genomic selection for important traits in sugarcane was recently initiated. Four biparental cross populations (CoM 0265 x Co 775, BO 91 x Co 775, Co 86002 x BO 91, Co 1148 x Co 775) for drought, red rot and sucrose were raised.

Putative transgenic sugarcane lines resistance to Sugarcane streak mosaic virus (SCSMV) and Sugarcane yellow leaf virus (SCYLV) were developed through RNAi approach, engineered with the suppressor genes namely SCSMV- P1 and SCYLV- P0, respectively.

Based on the bioassay studies and the enzyme analysis a consortium of *Metarhizium anisopliae* isolates MTCC 6060, ITCC 5489 and SBMa has been found good for field evaluation against white grub.

DNA barcodes were developed for seven insects viz. woolly aphid *Ceratovacuna lanigera*, eriophyid mite *Aceria sacchari*, hispa *Asamangulia cuspidata*, black bug *Cavelerius sweeti,* leaf folder *Cnaphalocrocis ruralis*, cut worm *Spodoptera litura* and the braconid parasitoid *Cotesia flavipes*.

Outreach programs included two sugarcane R&D workers meetings, four national level training programs, one Interface Meet, national level 'Kisan Mela' and three one-day training programs. Three frontline demonstrations were conducted in farmers' fields. 'Cane Adviser' and 'Ganna Salahkar', mobile app on sugarcane containing information from sett planting to harvest in English and Hindi, respectively have been launched and the same is being developed in Tamil.

The Institute has provided services like virus indexing and fidelity testing of tissue culture plantlets to different tissue culture production units in the country. The Institute, in collaboration with ICAR-CIAE, Research Centre, Coimbatore, has developed Sett Treatment Device and tractor drawn Settling Transplanter. Manufacturing of both the implements have been licensed to two firms.

It is my pleasure to present the Annual Report of the ICAR-Sugarcane Breeding Institute, summarizing the salient achievements of the institute during the year 2016-17. I thank all the scientists and other staff of the institute who helped in the successful conduct of research, members of the editorial board, especially Dr. T. Rajula Shanthy, for their tremendous efforts in bringing out the Annual Report. Continuous encouragement and guidance received from Dr. T. Mohapatra, the Secretary, DARE and the DG, ICAR, Dr. J.S. Sandhu, DDG (CS) and Dr. R.K. Singh, ADG (CC), ICAR are gratefully acknowledged.

Bakshi Ram
Director

2. THE ORGANIZATION

Background

ICAR- Sugarcane Breeding Institute (SBI), Coimbatore has been conducting research on various aspects of sugarcane agriculture and varietal improvement since its inception in 1912. The Institute has developed over 2940 'Co' selections, many of them becoming popular as commercial varieties in different parts of the country. Co canes bred at SBI along with the varieties identified from the crosses made at the institute by the State Sugarcane Research Stations occupy nearly 95% of the cane area in the country. Thus, the sugarcane varieties cultivated in the country today are directly or indirectly derived from this institute. Co canes were successful as commercial varieties in over 30 countries at one time and are being extensively used as parents in breeding programmes even today. The Institute maintains one of the largest collections of sugarcane genetic resources in the world.

Location

The Institute is located 8 km from the Coimbatore railway station and 19 km from the Coimbatore airport. Geographically it is located at 77° E longitude and 11° N latitude at an altitude of 427 m above mean sea level.

Centres

The Institute has one Regional Centre at Karnal (Haryana) and two Research Centres at Kannur and Agali (Kerala).

Mandate

- To breed superior sugarcane varieties / genotypes having high sugar productivity as well as sustainability and to assist State sugarcane breeding programmes.
- To collect, maintain, evaluate, document and conserve sugarcane genetic resources.
- To conduct basic and strategic research on crop improvement, production and protection aspects of sugarcane cultivation.
- To effect technology transfer, consultancy and human resource development in the areas of sugarcane agricultural research.

Staff position

Table 1. Staff position as on 31.03.2017

Category	Sanctioned	Filled	Vacant
Director	1	1	-
Scientific	78	72	6
Technical	73	56	17
Administrative	40	29	11
Supporting	79	60	19
Total	271	218	53

Financial Statement

Table 2. Abstract of expenditure during 2016-17

Head	Amount in Lakhs (Rs.)
Non-plan	2928.87
Plan	422.96
Other plan schemes	28.02
Externally funded schemes	161.32
Total	3541.17

Organizational set up

The research activities of the Institute are being carried out in three divisions and two sections at the main Institute and its Regional / Research Centres under the administrative control of the Director.

The Prioritization, Monitoring and Evaluation Unit (PME) supports the research management functions like prioritization, coordination, planning and review of research programs to ensure that the system functions with the requisite accountability in terms of efficiency and optimal utilization of resources. An administrative wing comprising Establishment, Audit and Accounts, Cash and Bills, and Stores effectively provides the required administrative support. The Estate section, besides maintenance of buildings, takes care of the vehicle management and security arrangements (Fig. 1).

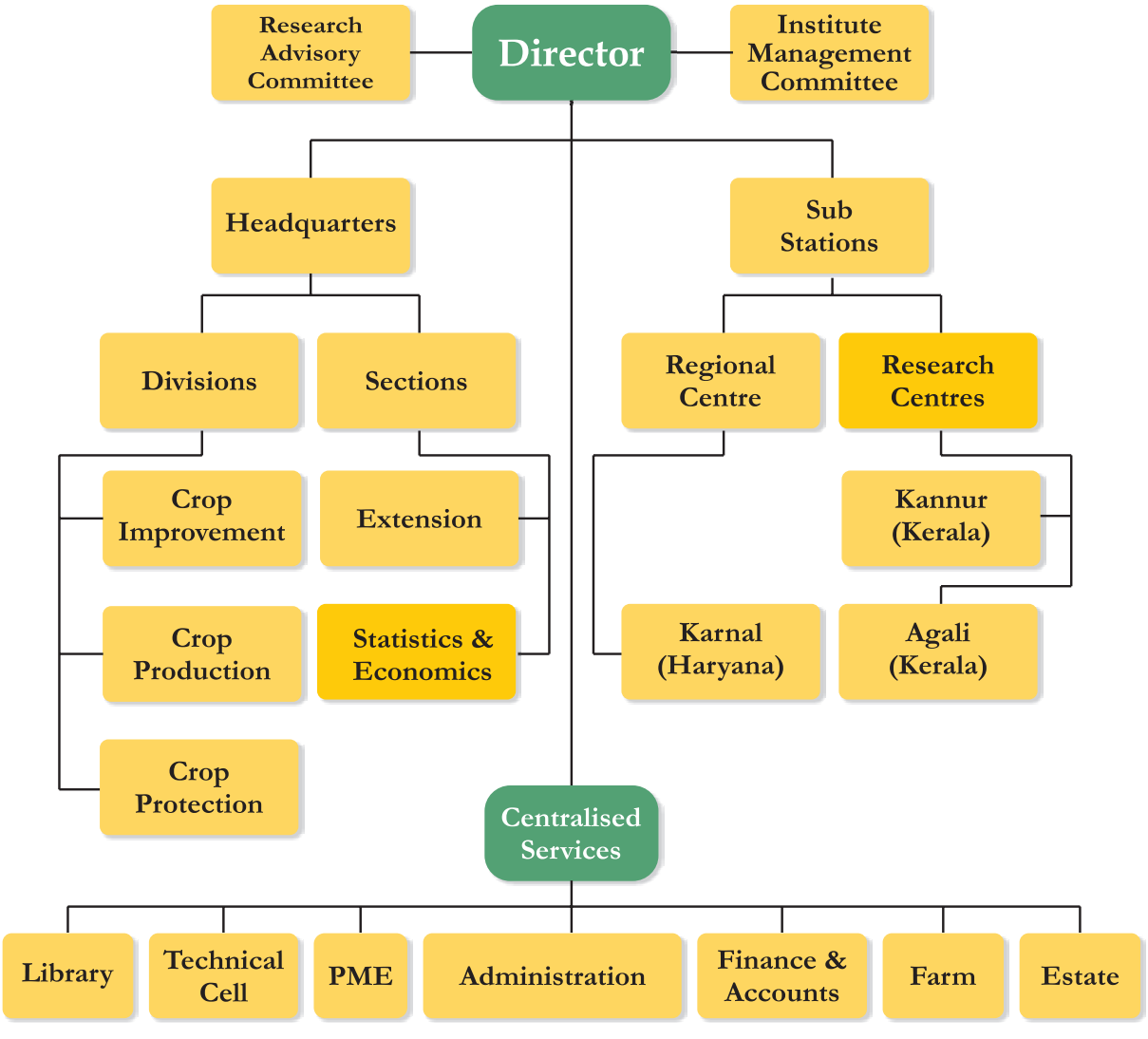


Fig.1 Organizational structure of SBI

Farm

The main Institute has a total area of 89.09 ha including farm, laboratory and office buildings. The farm area is 54.98 ha and is situated in four campuses *viz.,* Main (7.28 ha), ECC (28.50 ha), Additional land (17.20 ha) and VPT (2.00 ha). ICAR-SBI Regional Centre, Karnal has 22 ha, ICAR-SBI Research Centre, Kannur has 8.33 ha and ICAR-SBI Research Centre, Agali has 12 ha.

Library and documentation services

The library provides information support to the Research and Development activities of the Institute. It has a collection of 12115 books including bound volumes of journals, besides free publications such as annual reports, newsletters, scientific and technical publications etc. received from Indian and foreign organizations. During the period, subscription was renewed for 18 journals and purchased 71 books incurring an expenditure of Rs.6,00,000/-.

Continued to provide IP based online access to e-Journals and e-books through CeRA. Library has facilities viz. internet terminals, scanning and photocopying for the users. An online accessible bibliographic database of library holdings (OPAC) is being created using KOHA, am open-source software for integrated library system. The institute library has got ISBN and ISSN assigning facility for the publications of the institute. The priced publications (642 Nos.) of the Institute were sold, for an amount of Rs.65,990.

Weather data

Table 3. Weather data for the year 2016-17

Month	Temperature ^{0}C		RH (%)		Wind velocity (km/h)	Open pan evaporation (mm/day)	Rainfall (mm)	No. of rainy days
	Maximum	Minimum	Forenoon	Afternoon				
April 2016	38.5	25.0	81.4	38.5	1.3	5.6	8.1	1
May	35.8	24.7	85.1	49.0	1.7	4.95	66.3	7
June	33.8	24.0	81.3	55.8	4.3	4.4	79.0	7
July	32.3	22.8	80.9	56.2	4.9	4.5	17.2	3
August	33.5	23.4	77.3	49.1	4.8	6	0	0
September	33.8	21.6	82.7	51.6	3.3	5.4	0	0
October	33.9	21.3	86.5	57.7	1.7	4.5	73.8	3
November	33.4	20.9	84.6	57.5	0.5	3.5	12.2	1
December	30.9	17.4	87.5	65.0	1.1	2.85	36.6	5
January 2017	31.6	17.3	85.6	61.1	1.6	3.45	33.3	2
February	34.2	17.6	84.8	56.1	1.8	4.61	0	0
March	35.4	21.2	86.2	55.9	1.4	4.85	60.0	4
Total/ Mean	33.9	21.4	83.7	54.4	2.4	4.6	386.5	33

The total rainfall received during the year was 386.5 mm while the sixty years (1930-1990) average rainfall is 674.2 mm.

The mean maximum temperature was 33.9, which was 2.4^0 C higher than the sixty years average maximum temperature of 31.5^{0}C.

3. कार्यकारी सारांश

फसल सुधार

प्रायद्वीपीय क्षेत्र के 17 केंद्रों में आयोजित अखिल भारतीय गन्ना समन्वित परियोजना (AICRP's) के क्षेत्रीय विविधता परीक्षणों (जेडवीटी) के माध्यम से को. 09004 को एक आशाजनक जल्दी पकने वाली किस्म के रूप में पहचान की गई है। 300 दिनों में इस क्लोन ने 109.85 टन प्रति हेक्टेयर की गन्ना पैदावार, 14.56 टन प्रति हेक्टेयर की चीनी उपज और 18.94 प्रतिशत के रस सुक्रोज की मात्रा दर्ज की। इसने मानक किस्म को.सी. 671 से चीनी पैदावार व गन्ना उपज में क्रमशः 17.89 प्रतिशत व 17.84 प्रतिशत का सुधार दर्ज किया। को. 09004 के लम्बें और मध्यम मोटाई के गन्ने, शीघ्र बढ़वार, अधिक फुटाव, गैर फूल और न गिरने वाले वांछनीय गुण है। यह क्लोन पेंडी (रैटून) फसल में मानक किस्म को.सी. 671 से 18.60 प्रतिशत की रिकॉर्ड उपज सुधार के साथ एक उत्कृष्ट रैटूनर भी है। को. 09004 लाल सडन के प्रति मध्यम प्रतिरोधी, स्मट (कँडवा) प्रतिरोधी, सूखे एवं क्षारीय दशाओं के प्रति सहिष्णु है। को. 0212 एक मध्यम समय में पकने वाली किस्म है जिसे तमिलनाडु और पुडुचेरी में व्यावसायिक खेती के लिए अधिसूचित किया गया है।

वर्ष 2016–17 के दौरान आयोजित पूर्व–क्षेत्रीय विविधता परीक्षण, कोयम्बत्तूर से चौदह उत्कृष्ठ क्लोन (को. 17001 से को. 17014) और भा.कृ अनु.प.–गन्ना प्रजनन संस्थान, क्षेत्रीय केंद्र, करनाल से छः क्लोंनों (को. 17015 से 17020) को 'को' गन्ना का दर्जा दिया गया। क्लोन को.17004 लाल सड़न रोग के प्रति प्रतिरोधी होने के साथ 17.44 टन प्रति हेक्टेयर की उच्च चीनी उपज, 125.76 टन प्रति हेक्टेयर की गन्ना उपज दर्ज की। दो क्लोंनों (को. 17003 और को. 17005), 12 महीने में शर्करा के लिए होनहार थे (22.0 प्रतिशत)। करनाल केंद्र से छह को. गन्नो में से, को. 17018 ने 17 टन प्रति हेक्टेयर की उच्च चीनी उपज, 118.02 टन प्रति हेक्टेयर गन्ना उपज और 20.32 प्रतिशत सुक्रोज की मात्रा दर्ज की। वर्ष 2016–17 के दौरान एक प्रतिकृति परीक्षण में गन्ना उत्पादन और रस की गुणवत्ता के लिए लघु अवधि के कृतंको (को. 11015, को. 16001, को. 16002, पूर्व क्षेत्रीय विविधता (पीजेडवीटी) 2014–224) का मूल्यांकन किया गया था। 8वें माह में सभी पंक्ति अंतराल (90 सेंटीमीटर, 120 सेंटीमीटर एकल पंक्ति रोपण और 120 सेंटीमीटर की द्वि पंक्ति रोपण) को. 11015 (20.39 प्रतिशत) के रस में सुक्रोज प्रतिशत संख्यात्मक रूप से मानक किस्मो को. 8338 (19.04 प्रतिशत) और को.सी 671 (17.30 प्रतिशत) से उच्च स्तर पर था। को.16001 आठवें महीने में 18.65 प्रतिशत सुक्रोज के साथ दूसरा सबसे अच्छा अल्पकालिक क्लोन था।

वर्ष 2016 के पुष्पण मौसम के दौरान, 202 क्रॉस किये गए जिसमें प्रुवन (साबित) और प्रयोगात्मक क्रॉस शामिल थे और 98 द्वि–पैतृक क्रॉस और 10 पॉलीक्रॉस से 15,500 पौध कोम्बत्तूर में उगाई गई। भूतल नर्सरी में पौध मूल्यांकन से दोनों परिवारों और चयन करने योग्य संतानों के सह–वंश और एच.आर. ब्रिक्स के गुणांक सकारात्मक नहीं थे। इससे यह पता चला कि आनुवंशिक रूप से विविध क्रॉस ने आनुवंशिक रूप के समान क्रॉस की तुलना में रस शर्करा के लिए बेहतर विसंयोजक उत्पन्न किए।

अखिल भारतीय गन्ना समन्वित परियोजना के अन्तर्गत ए.वी.टी. परीक्षण में, अगेती कृतंक को. 10026 ने मानक को.सी. 671 की तुलना में व्यापारिक गन्ना उपज (सीसीएस) के लिए 25.10 प्रतिशत सुधार और गन्ना उपज के लिए 26.60 प्रतिशत सुधार मानक को. 85004 की तुलना में दर्ज किया गया जो कोयम्बत्तूर में लगे दो पौधा फसलों और एक पेड़ी (रैटून) फसल के आधार पर थे। मध्यम कृतंको में, को. 10017 ने मानक किस्म को. 86032 से व्यापारिक गन्ना उपज (सीसीएस) में 18.41 प्रतिशत का अधिकतम सुधार दर्ज किया, उसके बाद को. 10033 ने (13.53 प्रतिशत) का सुधार दर्ज किया। गन्ना उपज के लिए, मध्यम देरी के कृतंक को. 10033 ने मानक को. 86032 की तुलना में 22.08 प्रतिशत का सुधार दर्ज किया, उसके बाद को. 10017 ने (18.41 प्रतिशत) का सुधार दर्ज किया।

को. 10015 केवल एक मध्यम देरी से पकने वाली प्रविष्टि थी, जिसने व्यापारिक गन्ना उपज (सीसीएस) में (0.64 प्रतिशत) और सुक्रोज में (0.81 प्रतिशत) मानक को. 86032 की तुलना में सुधार दिखाया।

राष्ट्रीय संकरण उद्यान (एन.एच.जी.) में 629 पैतृक कृतंको को फ्लफ आपूर्ति कार्यक्रम में भाग लेने वाले 24 केंद्रों के प्रजनकों के लिए बनाए रखा गया है। 502 द्वि–पैतृक क्रॉस, 12 पाली क्रॉस, 42 सेल्फ और 94 सामान्य संग्रह (जी.सी.) किए गए। इसके अलावा, भा.कृ.अनु.प.–गन्ना प्रजनन संस्थान, क्षेत्रीय केंद्र, अगली (केरल) में उपलब्ध

राष्ट्रीय दूरवर्ती संकरण सुविधा में 60 द्वि–पैतृक क्रॉस और 40 जीसी बनाये गये। भाग लेने वाले केंद्रों को 19.52 किलोग्राम फल्फ मात्रा आपूर्ति की गई थी। हाल ही के वर्षों में राष्ट्रीय संकरण उद्यान में किए गए क्रॉस के पैतृक विविधता पर विश्लेशण से पता चला है कि माता–पिता की विविधता सूचकांक (पी.डी.आई.) 30 से 50 प्रतिशत के बीच है। 2016–17 संकरण कार्यक्रम के दौरान 15 भाग लेने वाले केंद्रों में से पी.डी.आई. 60 प्रतिशत से अधिक था।

भा.कृ.अनु.प.–गन्ना प्रजनन संस्थान, कोयम्बत्तूर और सिस्मा (एस.आई.एस.एम.ए.)–तमिलनाडु के बीच संस्थान–उद्योग सहयोगी परियोजना के द्वारा स्थान विशिष्ट गन्ना किस्मों की पहचान करने के लिए एक नई पहल की गई। बीस होनहार जीनोटाइप्स को कोयम्बत्तूर में गुणन किया गया और तमिलनाडु के नौ चीनी कारखानों को आपूर्ति की गई। कृंतक को. 11015 और को. 09004 ने एच.आर. ब्रिक्स के उच्चतम मान 23.0 प्रतिशत दर्ज किया। कृंतक को. 0238, को. 13018, को. 13020, को. 15005, को. 15007, को. 16001 और को. 16002 में 21.0 प्रतिशत से अधिक ब्रिक्स दर्ज की गई। तमिलनाडु के चीनी मिलों के क्षेत्रों में कीट और रोगों का सर्वेक्षण और निगरानी की गई थी। स्तम्भ बेधक का प्रकोप लोकप्रिय किस्म को. 86032 में सबसे अधिक था इसके बाद जड़ बेधक का प्रकोप था। उच्च तापमान और सूखा ने चूसने वाली कीटों जैसे सफेद मक्खियों, सैनिक कीट और मिलीबग्स की घटनाओं में वृद्धि की। पीला पत्ती रोग (वाई.एल.डी.) का प्रकोप को. 86032 में अधिक स्पष्ट देखा गया। सामान्यतः सूखे से प्रभावित फसल में जड़ बेधक के साथ विल्ट की सहभागिता को देखा गया है। कुछ मिल क्षेत्रों में कहीं–कहीं घसैला रोग और गन्ना सड़ांध रोग (सेट रोट) की दुर्लभ घटना भी देखी गई।

भा.कृ.अनु.प.–बीज परियोजना के अन्तर्गत, इस साल के दौरान शुरू की गई। नई गतिविधियों के परिणामस्वरूप गन्ना बीज उत्पादन और आपूर्ति में वृद्धि आनुवांशिक शुद्धता के साथ हुई। संस्थान में बीज श्रृंखला की पाँच गन्ना किस्मों (को. 86032, को. 0212, को. 06030, को. 06022 और को. 0403) के नाभिक बीज का गुणन किया गया। प्रजनक बीज का गुणन दोनों क्षेत्रो, संस्थान में और एक प्रगतिशील किसान के क्षेत्रो में लिया गया। किसान भागीदारी प्रणाली के तहत 816.23 टन गुणवत्ता वाले बीज की आपूर्ति और 4,08,115 रु का शुद्ध लाभ इस कार्यक्रम के तहत महत्वपूर्ण उपलब्धियां हैं। चीनी फैक्ट्रियों, प्रगतिशील किसानों और प्रजनक बीज उत्पादन के लिए कुल 50,700 विषाणु मुक्त टिश्यू कल्चर (उतक सवंर्धित) पौधों की आपूर्ति की गई। को. 86032, को. 0212 और को. 0238 के विषाणु मुक्त मात्र सवर्धन फ्लास्क राज्यों जैसे तमिलनाडु, कर्नाटक, आंध्र प्रदेश, गुजरात और महाराष्ट्र के टिश्यू कल्चर (उतक सवंर्धित) प्रयोगशालाओं को आपूर्ति की गई। गन्ने की व्यावसायिक खेती के लिए सत्यचिन्हित बीज (ट्रू सीड) उत्पादन के मानकीकरण पर अध्ययन शुरू किया गया। उष्णकटिबंधीय और उपोष्णकटिबंधीय प्रजातियों के स्वयं के संतानों में मिल योग्य गन्ने (एन.एम.सी.) और अपवर्तनांक मापी (एच.आर.) ब्रिक्स के लिए भिन्नता का विस्तार दर्ज किया गया।

उष्णकटिबंधीय क्लोन को. 775 में एन.एम.सी. के लिए सबसे कम भिन्नता (0.54) देखी गई जबकि उपोष्णकटिबंधीय कृन्तक एल.जी. 99183 ने गन्ना व्यास (0.09) के लिए न्यूनतम भिन्नता दर्ज की। गन्ना प्रजनन संस्थान, क्षेत्रीय केन्द्र, कन्नूर (केरल) में, 372 स्व–सतंती का मूल्यांकन गन्ना एकरूपता, गन्ना मोटाई और गन्ना ऊंचाई के संबंध में किया गया। सी.पी. 97–1100 की सतंती गन्ना मोटाई के लिए एक समान थी, जबकि एन.सी.ओ. 310 की सतंती गन्ना मोटाई के लिए तथा गन्ना ऊंचाई के लिए एक समान थी। गन्ना रंग, गन्ना ऊंचाई, गन्ना व्यास और एच.आर. ब्रिक्स उपज के लिए वियोजन प्रतिरूप अंतर–संगत जन्मजात संतानों के छह संयोजनों में अध्ययन किया गया। S2 x S4 के संयोजन में 65.0 प्रतिशत से अधिक माता के गन्ना रंग के समान थे, जबकि संकर S2 x S7 में केवल 19.20 प्रतिशत के पास माता के समान गन्ना रंग था। कुल मिलाकर, अंतर्भव आबादी लम्बी, मध्यम गन्ना मोटाई वाली मध्यम स्तर के ब्रिक्स के साथ दिखाई देती थी।

दो गन्ना किस्मों (को. 1148 एवं को. 775) के स्वाभाविक बीज का उपचार 0.3 प्रतिशत (वी/वी) ईएमएस के साथ उत्परिवर्ती आबादी के विकास के लिए किया गया था। गुणसूत्रबिंदु संबंधित जीन (ब्म्छभ्3) को प्रवर्धित और अनुक्रमित किया और उत्परिवर्ती आबादी में ब्म्छभ्3 जीन को वर्णित करने के लिए संदर्भ के रूप में रखा गया। को. 775 और को. 0238 के सोमाक्लोंस, उत्प्रेरण कृन्तक और 0.2 प्रतिशत और 0.05 प्रतिशत ई.एम.एस. के साथ कृन्तक को उपचार कर विकसित किया गया। को. 86032 (2एन=108). सोरग़म बाइकोलर (2एन=20) के बीच व्यापक संकर से प्राप्त हुई और 50 पौधों को चरित्रण किया गया। गन्नो की संख्या 1 से 34 के बीच, जबकि एच.आर. ब्रिक्स

मान 14.0 से 24.0 प्रतिशत तक था। एक बीजगणित संतति, जिसमे दैहिक (सोमेटिक) गुणसूत्र संख्या (2एन=65) गन्ने के पैतृक के समान व 10वें माह में 19.0 प्रतिशत एच.आर. ब्रिक्स तथा 34 गन्नो के साथ दर्ज की गयी। गन्ना सत्यचिन्हित बीज (ट्रू सीड) से जुडे रोगज़नक़ों का फल्फ से उगने वाले पौधों में इसका मूल्यांकन कर पता लगाया गया। चार सामान्य रूप से उत्पन्न होने वाली कवक संबद्ध जीनस ऑल्टरनेटिया, कर्वुलेरिया, प्युजेरियम और हेलमिन्थोस्पोरियम को अलग–थलग किया और उनका चरित्रण किया गया। इक्कीस ऊर्जा केन का मूल्यांकन कर्नाटक के समीरवाडी में किया गया।

छह क्लोनों (एसबीआईईसी 11003, आईए 1167, एसबीआईईसी 11001, एसबीआईईसी 13010, एसबीआईईसी 11008 और आईए 3135) में 30.0 प्रतिशत से ज्यादा फाइबर प्रतिशत पाया गया और 6 मीटर लंबाई की पंक्ति में 100 से अधिक गन्नो का उत्पादन दिया। एक अन्य परीक्षण में, 15 उर्जा गन्नो का दो उपोष्णकटिबंधीय मानकों (को. 0238 व कोशा 767) के साथ कटाईयुक्त बायोमास, गन्ना उपज और अन्य पादप कार्यिकी के मापदंडों के लिए मूल्यांकन करनाल में किया गया। को. 0238 औसत गन्ना उपज 99.93 टन प्रति हेक्टेयर के साथ सबसे अच्छा मानक था। कटाईयुक्त बायोमास के लिये एसबीआई–ईसी 11005 (78.59 टन प्रति हेक्टेयर), एसबीआई–ईसी 11003 (69.9 टन प्रति हेक्टेयर), एसबीआई–ईसी 13007 (67.58 टन प्रति हेक्टेयर) और एसबीआई–ईसी 11006 (65.78 टन प्रति हेक्टेयर) शीर्ष रैंकिंग क्लोन थे, इन्होने प्रायोगिक औसत (56.86 टन प्रति हेक्टेयर) के मुकाबले 15 प्रतिशत से ज्यादा सुधार दर्ज किया।

प्रथम क्लोनल मूल्यांकन में सीवाईएम 11–85 में 65 कोशिकाद्रव्यी विविध (सीडी) संकरों के मानक का को.सी. 671 की तुलना में 300 दिनों में 19.84 प्रतिशत की तुलना में 20.9 9 प्रतिशत की उच्चतम शर्करा दर्ज की गई। गन्ने की 607 बैकक्रॉस हाइब्रिड ई. अरंडिनसियस /एस. स्पोंटेनियम /एस. बारबेरी कोषिकाद्रव्य के साथ अनुरक्षित किये गए। को. 16018, जो एक से.स्पोनटेनियम और ई. बेन्गालेंसे की 5 वीं पीढ़ी बैक क्रॉस हाइब्रिड जिसने उच्च गन्ना उपज 202.8 टन प्रति हेक्टेयर दी, और जो ए.आई.सी.आर.पी. के तहत बहु–स्थान परीक्षण में प्रवेश कर गई।

ई. प्रोसेरस (आईनडी 90–776) एवं एस. ऑफसिनेरम (पीआईओ 96–435) की प्रथम पीढी संकर में जीनोमिक स्वस्थानी संकरण (जीनोमिक इन–सिटू हाइब्रिडिजेशन) अध्ययन किए गए। ई. प्रोसेरस हाइब्रिड के 40 गुणसूत्रों की पहचान की गई, जिनमे 2द + द पृथक्करण का पता चला है। इस संकर के बीसी1 में जो ई. प्रोसेरस का लेबल है वह स्वस्थानी संकरण द्वारा एरियेंथस के 20 गुणसूत्रों के साथ एन + एन पृथक्करण का पता लगाता है। ई. अरंडिनसियस के 82 कृंतको में साइटोलॉजिकल चरित्रीकरण से 2 एन= 30 साईंटोटाइप केवल छः क्लोनों, का पता चलता है। भारतीय क्लोनों में मुख्य रूप से 2द=40 और 34.1 प्रतिशत क्लोनों 2द=60 साईंटोटाइप थे। सुधारित एस. रोबस्टम से उत्पन्न 350 बीसी 2 क्लोंन के मूल्यांकन में, पीआईआर 001057 एवं कोसी 671 की संतति ने लाल सड़न रोधी कृंतको की उच्च आवृत्ति दी और 360 दिनों पर ग्यारह कृंतको में 18.20–20.26 प्रतिशत शर्करा की श्रेणी दर्ज कि गई। एस. बारबेरी से जुड़े 135 हाइब्रिड संकरो के साथ एक और परिक्षण में, 40 कृंतको में 300 दिन में शर्करा 18.25 प्रतिशत से ऊपर और 360 दिनों में 13 कृंतको में 19.0 प्रतिशत से ऊपर दर्ज की गई।

उत्तक संवर्धित पौधों में पीजीपीआर के वृद्धि कारक प्रभाव का आकलन करने के लिए विभिन्न उपचारों के माध्यम से प्राप्त अध्ययन से पता चलता है कि आईएए की मात्रा नियंत्रण के 41.55 ग्राम प्रति ग्राम के मुकाबले में ग्लूकॉनैक्टोबैक्टर + बैसिलस संयोजन (पत्ती उतक की 67.77 माइक्रोग्राम प्रति ग्राम) में सबसे अधिक, इसके बाद सीडोडोनामास + बेसिलस (64.92 माइक्रोग्राम प्रति ग्राम) में थी। जड़ ऊतकों में आईएए की मात्रा नियंत्रण (33.24 माइक्रोग्राम प्रति ग्राम) के मुकाबले, बैसिलस (43.64 माइक्रोग्राम प्रति ग्राम) और स्यूडोमोनस + बेसिलस (42.76 माइक्रोग्राम प्रति ग्राम) में अधिक थी। बैसिलस का लाभकारी प्रभाव उच्च आईएए की मात्रा द्वारा देखा जा सकता है जिसके परिणामस्वरूप उतक सवार्धित पौधों की बेहतर वृद्धि और ताकत होती है। विभिन्न फसलों से CENH3 के साथ जुड़े डीएनए अनुक्रम प्राइमर डिजाइनिंग के लिए उपयोग लिये गये। एच. वलगेयर के CENH3 अनुक्रमों से बनाया गये प्राइमर ईरिअन्थस (250 बीपी) और दो अंतवर्गीय संकर (आईजीएच–43, आईजीएच–39) में प्रवर्धित हुए। आईजीएच–39 के अनुक्रमों में सेकेरम संकर आर 570 के गुणसूत्रबिंदु बाधने वाली प्रोटीन (सीएनएपी–बी) के साथ 93 प्रतिषत समानता देखी गई।

CENH 3 जीन का स्थानीयकरण प्रतिदीप्ति स्वस्थाई संकरण (एफ.आई.एस.एच.) द्वारा साइटोकॉलिक रूप से पुष्टि

की गई। अलग–अलग गुणसूत्रबिन्दुओ में अलग–अलग सिग्नल की तीव्रताएं यह बताती हैं कि प्रत्येक गुणसूत्र बिंदु में इस जीन के लिए एक अलग कॉपी संख्या हो सकती है।

सूखा सहिष्णुता के लिए ई. प्रोक्रस के बीसी 1 संकर के स्क्रीनिंग में, जीयू 12–28 और जीयू 12–30 में संवेदी मानक को. 775 की तुलना में काफी अधिक गन्नो की समश्टि दर्ज की गई। पानी के तनाव के तहत अधिकतम औसत कटौती, गन्ना की लम्बाई (24.28 प्रतिशत) के लिए जिसके बाद पोरी की लंबाई (18.68 प्रतिशत) के लिए पाई गयी। बीसी 1 के संकर में, गन्ने की लम्बाई में कम से कम कमी जीयु 12–22, जीयु 12–26 और जीयु 12–30 में देखी गई थी।

पंजाब और हरियाणा राज्यों में जर्मप्लाज्म अन्वेषण किया गया और 97 एस. स्पोंटेनियम और पांच ई. बेंगलेन्स एकत्रित किये गए। कोयम्बत्तूर में, 1963 जंगली गन्ना जैवद्रव्य कृंतको, जिसमें एस. स्पोंटेनियम, ई. अरंडिनेसियस और 1793 संकर कृंतको ('को' कैन्स, 'को' संबद्ध क्लोन, विदेशी संकर, इंटरजेनरिक और अत्तरजातीय संकर और उसके डेरिवेटिव) शामिल है का संरक्षण किया गया। गन्ना के राष्ट्रीय सक्रिय जर्मप्लाज्म (एन.ए.जी.) के तहत 226 कृंतको का संरक्षण किया गया। महाराष्ट्र से एकत्र किए गए 41 एस. स्पॉन्टेनियम कृंतको की रूपात्मक वर्णन से गन्ना पोरी आकार और लिग्युल आकृति के लिए पर्याप्त भिन्नता का संकेत दिया।

उष्णकटिबंधिय के तहत डस (डीयुएस) परीक्षण के लिए गन्ना संदर्भ किस्मो का कोयम्बत्तूर और अगली में संरक्षित किया हुआ है। दूसरे वर्ष में तीन नई किस्मों और दो किसान किस्मों का डस (डीयुएस) परीक्षण किया गया। पौधा किस्म और कृषक अधिकार संरक्षण प्राधिकरण के डस (डीयुएस) परीक्षण दिशा निर्देशों के अनुसार, 27 आकृतिक वर्णन दर्ज किए गए। 186 संदर्भ गन्ना किस्मों के संग्रह और चार किसान किस्मों को भा.कृ.अनु.प.–गन्ना प्रजनन संस्थान, कोयम्बत्तूर में संरक्षित किये गये।

दो एरियनथस क्लोंन (आईके 76–91 और आईजे 76–389 और एक एस. स्पोंटेनियम (एसईएस 90) क्लोन में ऑक्सीडेंटिव तनाव के दौरान जीन एक्सप्रेशन पैटर्न पर जांच से कई तनाव संबंधी जीनो (एचएसपी, एपीएक्स, एनएसी, एआरएफ, जीएसटी, मायबैस और कैट) का पता चला। 500 पीपीएम पर, हाइड्रोजन पेरोक्साइड के 48 घंटे की प्रेरण के दौरान सभी तीन क्लोनों ने जीएसटी की अभिव्यक्ति में उल्लेखनीय वृद्धि दिखायी, जबकि एरिएनथस क्लोंन आईके 76– 91 ने एनएसी जीन अभिव्यक्ति में दोनों 48 और 72 घंटे के उपचार में वृद्धि का प्रदर्शन किया। ऑक्सीडेंटिव तनाव के लिए उत्तरदायी एनएसी जीन को एरियनथस से लेकर पीटीजेड 57 आर/टी वेक्टर का उपयोग करके क्लोन किया गया और फिर ई. कोली (डीएच5) होस्ट में परणित किया गया। एनएसी जीन को द्विचर वेक्टर में उप–क्लोनिंग दिशात्मक क्लोनिंग रणनीति द्वारा की गई और परिणामस्वरूप कॉलोनियों को कॉलोनी पीसीआर के माध्यम से पुष्टि की गई।

12 गन्ना क्लोनों में फूलों के जीन के लिये अभिलक्षण किया गया। प्राइमरों के 4 सेटों एलएफवाई (522 बीपी), एफडी (561 बीपी), एफटी (750 बीपी) और सीओ (568 बीपी) के उपयोग से फूलो से जुड़े जीन को प्रवर्धित किया गया। ब्लास्ट एन के परिणाम बताते हैं कि एलएफएआई जीन में ट्रांसक्रिप्शन कारक फ्लोरिकाला / लिफी और कल्पित कोशिका दीवार संबंधित रिसेप्टर कीनेज़ जैसी छद्म जीन में 98 प्रतिशत की क्वेरी कवरेज के साथ 80 प्रतिशत समानता थी।

ज्वार व मक्का से रूपांकित जीन विशिष्ट प्राइमरों का उपयोग ई. अरुडिनेसीयस, एस. ओफिसीनेरम और एस. स्पॉन्टेनियम प्रजातियों के कृतंको से छः अजैविक तनाव संबंधी जीन (एमआईपीएस, जीएलआई III) एक्सपीए 1, एपीपीबी 5, एपीपीबी 6, एपीपीबी 7) को अलग करने के लिए किया गया। एक्स्प्रेसिन जीन (ईएक्पीए1) जो ई. अरुडिनेनसीयेस (आईके 76–81) से क्लोन किया गया, दो इंट्रोन्स के साथ 1330 बीपी लंबा है और 762 बीपी आकार के सीडीएस को पीसीएएमबीआईए 1305 में क्लोन किया गया।

पोर्टयुबिआइ882 प्रमोटर द्वारा क्रमशः "–ग्लूकरोनीडेस (जीयूएस) और सीएएमवी 35एस प्रमोटर को बदलकर 1 वेक्टर संचालित किया गया। पोर्टयुबिआइ882 + ईएक्पीए1 एग्रोबैक्टीरियम परिवर्तन के माध्यम से तम्बाकू और गन्ना दोनों में परिवर्तित किया गया था। गन्ने के 18 ट्रांसजेनिक घटनाओं के कार्यिकीय मापदंडों पर स्क्रीनिंग से आरडब्लूसी, प्रकाश संश्लेशण दक्षता (एफवी/एफएम), क्लोरोफिल मात्रा तथा तेजी से प्राप्ति में वृद्धि गैर–ट्रांसजेनिक पौधों की

तुलना में ट्रांसजेनिक पौधों में सूखा तनाव के बाद तेजी से रिकवरी का संकेत दिया। दो नये तना विशिष्ट जीन (डिरिजिन्ट और ओ–मिथाइल ट्रांसफरेज़) ई.अरुडिनेसीयेस और किस्म को. 86032 से अलग किये गए। अनुक्रम विश्लेशण से पता चला है कि डिरिजिन्ट जीन 837 बीपी (एरिएनथस) और 864 बीपी (को. 86032) लम्बे थे जिसमें दो इंट्रोन्स और सीडीएस 563 बीपी थे। ओएमटी जीन एक इंट्रॉन और 1073 बीपी के सीडीएस के साथ 1.2 केबी आकार का था और कारील्टर सीपी 72–1210 के अन्य रिपोर्टिंग डिरिजिन्ट और ओएमटी के साथ 96 प्रतिशत और 91 प्रतिशत समानता दिखायी थी।

गन्ने के इन्वरटेज अवरोध करने वाले जीनों की कार्यात्मक भूमिका को समझने के लिए, इनवर्टेज इनहिबिटर जीन के अंतर अभिव्यक्ति पैटर्न को देखने के लिए सूक्रोज मात्रा के दो विपरीत जीनोटाइप (को. 11015 और बीओ 91) का चयन किया गया। इनवर्से अवरोधक निर्माणों के प्लाज्मिड डीएनए बाइनरी ट्रांसफ़ॉर्मेशन वेक्टर में उप क्लोनिंग के लिए ईकोली DH5 में परिवर्तित हो गया।

गन्ने का पानी की कमी तनाव सहिष्णुता में जेनेटिक इंजीनियरिंग पर अध्ययन के लिए, 128 ट्रांसजेनिक घटनाओं का मूल्यांकन किया गया। डीआरईबी 2, एचएसपी 070, पीडीएच 45 ट्रांसफॉर्मैट्स और डीआरईबी 2 और पीडीएच 45 जीन की पिरामिडिंकरण कोशिका झिल्ली की तापीय स्थिरता, अजैविक तनाव जीनो की उच्च स्तर अभिव्यक्ति, सापेक्ष पानी की उच्च मात्रा, कोलोरोफील की मात्रा और प्रकाश संश्लेशक दक्षता में वृद्धि में सुधार करने में महत्वपूर्ण भूमिका निभाते हैं। जीन विशिष्ट प्राइमरों, ईएडीआरइबी 2, ईएएसओडी, ईएसीएटी और ईएएपीएक्स के अनुक्रमों को ई. रुंडिनसेस में प्रवर्धित किया और एनसीबीआई जीन बैंक में जीन जमा किए गए। इन चार जीनों को गन्ने की किस्म को. 86032 में एग्रोबैक्टीरियम के माध्यम से रूपांतरणीय किया गया और इन जीनो की पिरामिडीकरण के लिये बीओलस्टिक बमबारी पद्धति का पालन किया गया । ट्रांसजेन के समाकलन हेतु प्रमोटर–जीन फ्यूजन प्राइमरों का इस्तेमाल करके 28 डीआरईबी 2 और 17 कैट कल्पित ट्रांसजेनिक्स में की पुष्टि की। ट्रांसजेनिएक्स में कोशिका झिल्ली थर्मोस्टाबिलिटी अध्ययन बिना ट्रांसफॉर्मेस (को. 86032) के साथ–साथ किया और पाया की सामान्य सिंचाई की स्थिति के तहत 25 ट्रांसजेनिक घटनाओं में कोषिका झिल्ली जख्म में उल्लेखनीय कमी आई है।

गन्ना में महत्वपूर्ण गुणों के लिए आनुवंशिक नियंत्रण और जीनोमिक चयन पर भारत–ऑस्ट्रेलिया सहयोगी अनुसंधान परियोजना हाल ही में शुरू की गई। सूखा, लाल सड़न रोग और सुक्रोज़ के लिए चार द्विपैत्रक क्रॉस आबादी (सीओएम. 0265 X को. 775, बीओ. 91 X को. 775, को. 86002 X बीओ. 91, को.1148 X को. 775) उगाये गए। रोपाई के 90 दिन बाद सूखे के लिये उपचार हेतु सिंचाई रोककर सूखा की स्थिति में पैदा की गई। सूखा के लिये जैसे पत्ती रोलिंग, टिप सुखाना, हरितपन और पौधे ओज की शक्ति के लिए पादप कार्यिकी मापदंडों पर

दृश्य स्कोरिंग की गई। सूखे का सूचकांक 1(हरितपन) से 5 (पौधों के सुखाने तक) रखा।

फसल उत्पादन

पेड़ी (रैटून) की फसल में, 100 प्रतिशत उर्वरक की सिफारिश की खुराक (100 प्रतिशत आर.डी.एफ.) का प्रयोग करते हुए, गन्ने के भूसे को काट कर माइक्रोबियल कंसोर्सिया के साथ मिट्टी में दबाने से गन्ना उपज में 81.86 टन प्रति हेक्टेयर की उच्च पैदावार दर्ज की गई। पहली पेड़ी (रैटून) गन्ना फसल में, 20 टन गोबर की खाद+150 किलोग्राम एस.टी.सी.आर. आधारित उर्वरक देने से गन्ना उपज में नियंत्रण के उपर 65.49 प्रतिशत की बढ़ोतरी के साथ (137.74 टन प्रति हेक्टेयर) लाभप्रद रही।

गन्ने के साथ सोयाबीन की अन्तःफसल में गन्ने की 122.82 टन प्रति हेक्टेयर सबसे अधिक उपज दर्ज की गई। इसके बाद गन्ना के साथ सनई में (117.31 टन प्रति हेक्टेयर) और उरद में (116.38 टन प्रति हेक्टेयर) दर्ज की गई है, जबकि नियंत्रण (गन्ना की एकमात्र फसल) में गन्ना उपज 74.30 टन प्रति हेक्टेयर दर्ज की गई। रस की गुणवत्ता मापदंडों पर विभिन्न उपचार का कोई असर दर्ज नही किया गया।

प्रयोगशाला की स्थिति के तहत बायोचार ऊष्मायन के 180 दिन बाद, गन्ने के भूसे, गन्ना टॉप, ठूंठी और खोई में कार्बन की हानि पता नहीं चला। गन्ने के भूसे में से बायोचार की विद्युत प्रवाहकत्त्व 4.5 डीएस/एम तथा पीएच्. 9.4 दर्ज की गई। गन्ने के सूखे भूसे में प्योरोलिसिस के कारण पोषक तत्व नत्रजन, फोस्फोरस तथा पोटैशियम का नुकसान क्रमशः 93, 38 और ढ1 प्रतिशत था।

हाइड्रोपोनिक और रेत संवर्धन की स्थिति में गन्ने के जीनोटाइप कोलख. 8102 (1027 ग्राम) और को. 97010 (1011 ग्राम) में प्रति गमले में सबसे अधिक जड़ वजन दर्ज किया गया। इसके बाद को. 06022 (830 ग्राम), को. 95020 (743 ग्राम), को. 99004 (658 ग्राम), कोजा. 64 (632 ग्राम), को. 62175 (623 ग्राम) और को. 0238 (581 ग्राम) दर्ज किया गया। सबसे कम जड़ का निर्माण को. 8371 (27 ग्राम) में हुआ, इसके बाद को. 419 (103 ग्राम) और को. 94008 (118 ग्राम) में हुआ। किस्मों को. 06022, कोलख. 8102, को. 99004 और कोजा. 64 में उच्च जड़ आयतन (झ1000 मिलीग्राम/गमला) दर्ज किया गया और सबसे कम (ढ110 मिलीग्राम/गमला) को. 8371, को. 740 और को. 419 में दर्ज किया गया।

एक संशोधित पॉकेट मैन्युरिंग उपकरण को 10 इंच तक गहराई में 2 इंच के व्यास छेद बनाने के लिए सॉफ़्टवेयर सॉलिड वर्क्स का उपयोग करके डिज़ाइन किया गया है। उपकरण की ऊंचाई 3.5 फीट और भेदनेवाला उपकरण का ऊपरी व्यास 5 सेंटीमीटर था। एक क्वैडकोप्टर ड्रोन (डीजेआई–फैंटम 3 मॉडल 4 के. रिजोल्यूशन के साथ – एफसी 330 एक्स कैमरा) का उपयोग गन्ना फसल की पत्तियों की खेत की छवियों लेने के लिए किया गया। लोहे की कमी के लक्षण के मामले में, आरजीबी मान (आर. 150 से 230, जी. 175 से 240, बी.100 से 160), एल'ए'बी' मान (70 से 90, –25 से +1, 0 से 48), ह्यू संतृप्ति मान (एस. 0.3 से 0.45, वी. 0.7 से 0.9) और वाईसीबीसीआर मान (वाई. 150 से 210, सीबी. 90 से 120, सीआर. 120 से 130) लोहे की कमी के पत्ते की छवियों के चित्र प्रसंस्करण के माध्यम से प्राप्त किए गए।

कम पानी की परिस्थितियों के लिए सेकेरम के वाणिज्यिक संकरों की कार्यिकी क्षमता का मूल्यांकन किया गया। 31 ने टीडीएमपी में (50 प्रतिशत) सिंचाई की कमी में 22 प्रतिशत, 50 प्रतिशत सिंचाई संख्या में 32 प्रतिशत) काफी कमी दिखाई और सामान्य सिंचाई पर 28 प्रतिशत सिंचाई की मात्रा को कम करके, 50 प्रतिशत सिंचाई की कमी में पर्णहरित प्रतिदीप्ति (एफवी/एफएम) की दक्षता में महत्वपूर्ण कमी देखी गई। गंभीर सूखे के तहत 74 प्रतिशत क्लोनों ने तंग पत्ती रोलिंग दिखा, जबकि 26 प्रतिशत क्लोंस में तंग पत्ती रोलिंग सिंचाई के एक दिन बाद दिखाये। को. 95020 ने दोनों स्थतियों में पत्ती रोलिंग नहीं दिखाया है। उच्च तापमान तनाव में उपापचयी और आणविक प्रतिक्रिया से पता चलता है कि दोनों को. गन्ने और स्पोंटेनियम क्लोनों में उच्च तापमान में क्लोरोफिल रंगद्रव्य सांद्रता, SPAD मान और प्रकाश रासायनिक दक्षता (एफवी/एफएम अनुपात) एक महत्वपूर्ण कमी दिखाई गई। हालांकि किस्म को. 99004 और एसएएस–150 में तनाव परिस्थिति में भी काफी अधिक मान दर्ज किए गए। 2–डी जेल वैद्युतकणसंच पर प्रोटोमिक कार्य से पता चलता कि गर्मी तनाव के प्रति प्रतिक्रिया में एक अतिरिक्त गर्मी प्रेरित प्रोटीन स्पॉट (20 न.) दत्तक किस्म को. 99004 और को. 0315 में पाए गए और अलग–अलग व्यक्त प्रोटीन स्पॉट के माल्डी–विश्लेशण के लिए बाहरी स्त्रोत से सेवाएं ली गई।

मैसर्स बन्नारी अम्मान शुगर्स प्राइवेट लिमिटेड में क्षेत्रीय परीक्षण में अनुकूलित खुराक के 100 प्रतित अनुसंशित उर्वरक देने के परिणामस्वरूप 142.54 टन प्रति हेक्टेयर की उच्च गन्ना उपज हुई। मैसर्स पोनी शुगर्स (ई) लिमिटेड के खेत में अनुकूलित खुराक के 125 प्रतिषत पर अनुसंशित उर्वरक डालने से अन्य सभी उपचारों की तुलना में गन्ना उपज (148.13 टन प्रति हेक्टेयर) में काफी उच्च लाभ दिया। दोनों परीक्षणों में विभिन्न उपचारों के तहत रस की गुणवत्ता काफी भिन्न नहीं थी।

फसल सुरक्षा

नियंत्रित परिस्थितियों में 3147 कृंतको का मूल्यांकन लाल सड़न रोग प्रतिरोधिता के लिए किया गया और उसमें से 1131 कृंतक प्रतिरोधी के रूप में पहचाने गए। सिस्मा परीक्षणों में शामिल बारह को. किस्मों की लाल सड़न के प्रति प्रतिरोधक के रूप में पहचान की गयी। को. 86032 के अलावा, नई किस्म को. 0212 ने भी लाल सड़न के लिए क्षेत्र सहिष्णुता दर्षायी गयी। दोनों पुरानी और नई गन्ना किस्मों ने लाल सड़न के लिए एक विभेदकारी व्यवहार का प्रदर्शन किया और उष्णकटिबंधीय क्षेत्र के अधिकांश नए पेथोटाईप ने निर्दिष्ट पेथोटाईप के मुकाबले एक उच्च विषमता का प्रदर्शन किया।

दबाने वाली घटाव संकरण (एसएसएच) विश्लेषण के परिणामस्वरूप सी. फाल्केटम में रोग जनकता से संबंधित जीन की पहचान और लक्षण का वर्णन किया। फाल्केटम की प्रोटियोम परिच्छेदिका में अलग–अलग विषम पेथोटाईप

का प्रतिनिधित्व किया गया जिससे रोग जनकता से संबंधित प्रोटीन जैसे पेप्टिडाइल प्रोलिल सीआईएस/ट्रांस आइसोमेरसे, फंगल विशिष्ट प्रतिलेखन कारक, आदि की पहचान हुई ।

आरएनएआई दृष्टिकोण द्वारा एक प्रमुख जीन पीकेएस1 के कार्यात्मक विश्लशण ने सी. फल्केटम पैथोजेनेसिस में इसकी संभावित भूमिका की पुष्टि की गयी। गन्ने में सी. फल्केटम और टी. हर्जिएनम के साथ प्रोटीओम विश्लेशण में शामिल एक ट्राट्रोफ़िक परस्पर क्रिया से संकेत मिला है कि पहचान की गई प्रोटीन रक्षा संबंधी प्रोटीन जैसे डाइसल्फ़ाइड आइसोमोरेज़, प्यूरवेट डेकरबोक्सीलेज़, पेरोक्साइड आदि के साथ समरूपता साझा करता है, जो अन्य कोलेटोट्राइकम एसपीपी से सूचित किया गया। ओरीज़ा जेपोनिका, सोरग़म बाईकलर, ट्रिटिकम एस्टीवम और ज़िया मेज के संदर्भ जीनोम के अग्रगामी एमआईआरएनए की बिना संरेखित रीड के साथ सी. फल्केटम के साथ चुनौती दी गई और गन्ना में एमआईआरएनए के बारे में भविष्यवाणी कि गयी, जिससे प्रतिरोधी और अतिसंवेदनशील किस्मों में एमआईआरएनए में अंतर अभिव्यक्ति पायी गयी।

समलक्षण किए गए कँडुआ रोग जनन (भिन्न विषाणु पैटर्न में) के अलग–अलग मेंटिग प्रकार की संवर्धन (+और –) स्थापित की गईं और विपरीत मेंटिग के प्रकार (+ और –) के बीच विशिष्ट मेंटिग प्रकार के जीनों को लक्षित करने के लिए प्राइमर डिज़ाइन किया गया। एक कँडुआ रोग जनन उत्तरदायी गन्ना को. 96007 की प्रोटीओम प्रोफाइलिंग ने 53 अलग–अलग प्रोटीन अभिव्यक्ति की स्थापना की गई। इन प्रोटीनों की प्रतिलेख की रूपरेखा ने संकेत दिया कि संक्रमित गन्ना विभज्योतक कोशिकाओं में फेनिल प्रोपोनॉयड मार्ग, ऑक्सीडेंटिव तनाव प्रतिक्रिया और विभिन्न अन्य चयापचय और कोशिकीय प्रक्रियाओं के प्रोटीन के बीच सूक्ष्म मॉड्यूल और जटिल परस्पर क्रियाएं हैं। स्पोरिसोरियम स्किटामिनयम ऑर्थोलोगस प्रभावोत्पादक ने एस. रीलियमम, यू. मेडीस और अन्य करीबी से संबंधित कँडुआ कवक के साथ उच्च अनुक्रम पहचान को साझा किया। ट्रांसक्रिप्ट प्रोफाइलिंग से पता चला कि कृत्रिम परिवेश की स्थितियों की तुलना में वास्तविक काल के मेजबान रोगज़नक़ की परस्पर क्रिया के दौरान प्रभावकारकों उच्च तीव्रता से व्यक्त हुए।

भूरा रतुआ के रोग ज़नक़ों की मेजबान प्रतिरोध और गतिशीलता के लक्षण बताते हैं कि जो कृंतक रतुआ से बच गए और रतुआ प्रतिरोधों को उनकी वास्तविक प्रकृति कृत्रिम स्थिति अनुकूलतम स्थितियों के तहत जांच की जानी चाहिए। कृत्रिम परिवेश में पत्ती के परिक्षण से परिगलित घावों के विकास के आधार पर फुजेरियम सैकराई आइसोलेट्स को उग्र, मध्यम उग्र और कम उग्र प्रकार के रूप में वर्गीकृत किया गया। गन्ने की किस्मो का एफ.सेकेराई के साथ जब क्षेत्रीय परिस्थितियों में मूल्यांकन किया गया तब विभेदित उखेड़ा रोग के विकास देखने को मिला। उखेड़ा के लिए मेजबान प्रतिरोधकता में क्षेत्र अवलोकन से संकेत मिला कि उपोष्णकटिबंधीय क्षेत्र से उत्पन्न कृंतकों ने पैत्रको के रूप में उखेड़ा प्रतिरोध के लिए अधिक योगदान दिया। इसके अलावा, यह पहली बार प्रमाणित किया गया कि वही रोगजन्य कवक व्यवस्थित ढंग से गन्ने के पौधों को संक्रमित कर उखेड़ा तथा पोक्हा बोईंग दोनों रोगों को प्रदर्शित करता है।

कृत्रिम ट्रांसजेनिक गन्ना लाइनें गन्ना स्ट्रीक मोज़ेक वायरस (एससीएसएमवी) और गन्ने की पीली पत्ती विषाणु (एससीवायएलवी) के प्रतिरोध को आरएनएआई के माध्यम से विकसित किया, जो क्रमशः एससीएसएमवी–पी1 और एससीवायएलवी–पी0 के शमन वाले जीन के साथ व्यवस्थित थे। गन्ना स्ट्रीक मोज़ेक वायरस के पांच नए आइसोलेट्स के तुलनात्मक जीनोम विश्लेशण से पता चला कि भारतीय आइसोलेट ऑस्ट्रेलिया के गन्ना संक्रमण आइसोलेट से नजदीकी से, इसके बाद चीन और अर्जेंटीना से संबंधित और मैक्सिको, चीन, स्पेन, जर्मनी, ईरान और इथियोपिया से रिपोर्ट किए गए मक्का संक्रमण पृथक से अलग थे।

काइटोजन लेपित प्रेरक नैनो कणों का कण आकार, जीटा क्षमता और सम्पुटन दक्षता जैसे मानकों के अनुपालन के साथ संश्लेशित किया गया। काइटोजन कृत्रिम स्थितियों में 50 प्रतिशत से अधिक माईसेलियल वृद्धि और प्रमुख कवक रोग जनकों के 100 प्रतिशत बीजाणु अँकुरण को रोकता है।

चयनित ई. अरंडिनसियस जीनोटाइप जो क्षेत्र जाँच में शूट बोरर के लिए प्रतिरोधक थे उनमे डिंभक और कोशस्थ कीट का टिकाऊपन 44 से 82 प्रतिशत और 28 से 56 प्रतिशत तक था। ट्रिप्सिन एंजाइम को उनकी निरोधात्मक गतिविधि के लिए मूल्यांकन जब छह ई. अरंडिनसियस जीनोटाइप और छह विदेशी कृंतकों के पत्ती खोल, शिखर विभज्योतक और डंठल ऊतकों से निकाले जाने वाले प्रोटीनेस अवरोधकों से पता चला कि निषेध की मात्रा ई.

अरंडिनसियस के शिखर विभज्योतक में अधिक थी, इसके बाद पत्ती खोल और डंठल ऊतकों में, जबकि विदेशी क्लोनों में, ट्रिप्सिन निषेध पत्ती खोल में सबसे अधिक था, इसके बाद शिखर विभज्योतक और डंठल ऊतक थे।

जैवसैस (बायोऐसी) अध्ययन और एंजाइम विश्लेशण के आधार पर मेटारिज़ियम अनिसोप्लीय के एक संघ एमटीसीसी 6060, आईटीसीसी 5489 और एसबीएमए को सफेद लट के खिलाफ फील्ड मूल्यांकन के लिए अच्छा पाया गया है। बफर मिट्टी में गन्ने की जड़ों के साथ और बिना जड़ों के साथ फंगल जीवित रहने के अध्ययन में सीएफयू रिकवरी दर्शाती है की 30 पृथकों में से, 12 में बीजाणुओं (झ70 प्रतिषत मृत्यु दर) का अच्छा अस्तित्व दिखा और सीएफयू वसूली में सभी अन्य पृथकों से आईटीसीसी 5489, आईटीसीसी 5460, एमटीसीसी 6060, एनएएमसीसी–एफ –1296 काफी काफी बेहतर थे।

हरियाणा, पंजाब, उत्तर प्रदेश एवं तमिलनाडु से एकत्र बीटी 26 अलगाव में से चार ने द्विपक्षीय क्रिस्टल आकृति को दिखाया और इसलिए इसे क्राई 1 जीन के लिए सकारात्मक माना गया। सकारात्मक 41 बीटी पृथक से क्राई 8 जीन एम्प्लिकॉन के पूर्ण कोडन क्षेत्र की अनुक्रमण से एक नये क्राई 8 जीन होलोटाइप की उपस्थिति का पता चला जो क्राई 8एबी1 के साथ 67 प्रतिशत प्रोटीन समरूपता साझा करता है। क्रिस्टल विष का आकार लगभग 130 के.डी. प्रोटीन पाया गया। बीटी पृथक 8 और 84 में क्राई 9 डीए और क्राई1एनए जीन पाया गया।

बीटी पृथकों में उपस्थित जीन क्राई 1 और क्राई 9 डी के कारण 1 इन्स्टार तना भेदक लार्वा की 80 प्रतिशत मृत्यु दर मिली। होलोट्राईका सिरेटा पर बीटी 41 वाली होलोटाइप क्राई 8 जीन ने कोई भी मृत्यु नहीं की, हालांकि, ओरिक्टस रहिनोसिरोस लार्वा को अतिसंवेदनशील पाया गया।

कार्बोफ्यूरान और इसके चयापचयों, 3–केटो कार्बोफ्यूरान और जीसी–एमएस में 3–हाइड्रोक्सी कार्बोफ्यूरान के निर्धारण के लिए एक सरल और संवेदनशील विधि विकसित की गई है। इलेक्ट्रान कैप्चर संसूचक (जीसी–ईसीडी) से सज्जित गैस क्रोमैटोग्राफी में बिफेंथ्रीन के निर्धारण के लिए एक संवेदनशील विधि विकसित कर पुष्टि की गई है।

सात कीड़ों जैसे वुली एफिड (सेराटोवकुना लेगिंफैरा), इरियोफाइड माईट (एकेरिया सेकेराई), हिस्पा (असमानगुलिया क्यूपिडाटा), काली कीड़ी (कैवेलेरियस स्वीटी), पत्ती लपेट (सिनाफलोक्रोकिस रुरलिस), काटने वाली सुंडी (स्पोडोप्टेरा लिटयूरा) और बराकोनिड पैरासिटॉयड (कोटेसिया फ्लेविप्स) के लिए डीएनए बारकोड विकसित किए गए थे। पोरी बेधक के अंडा पेरासीटोईड्स के मौसमी गतिशीलता से पता चला कि कोयम्बत्तूर स्थितियों में अप्रैल के पहले पखवाड़े को छोड़कर पूरे वर्ष पूरे परिलक्षित टेलेनॉमस डिग्नस सक्रिय था। टेलेनॉमस जाती के व्यस्कों को नए–लैब–पोषित पोरी बेधक के अंडो के सामने अनावरित किया गया। अनुपात में भिन्नता के बावजूद, सभी दलों में व्यक्तिगत अंडा जनों में परजीवीकरण 100 प्रतिषत था।

हालांकि, पैरासिटॉइड उद्भव 14.3–100 प्रतिषत की सीमा में था। टेलेनॉमस को पोरी बेधक के अंडों पर 144 घंटे तक परीजीवी पाया गया और वयस्कों की उत्पत्ति परजीवीय आयु से प्रभावित नहीं थी। पेरासिटोइड वयस्कों को कपास रुई में 50 प्रतिशत शहद के समाधान के साथ 5–39 दिनों तक जीवित रहे जबकि 1–2 दिन शहद के बिना बचे।

कीटनाशक गतिविधि कोशिका और कोशिका मुक्त संवर्धन के चार एक्स. स्टॉकिया उपभेदों और दो फोटोरब्डस उपभेदों की कीटनाशक गतिविधि और जी. मेल्लोनेला लार्वा के खिलाफ दो फोटोरब्डस उपभेदों से पता चला है कि पी. ल्यूमिन्सेन्स उपजाती लोमोंडी (एसबीआईपीएलएलएसएम 12) जो कोशिका मुक्त संवर्धन के रूप में था जिसके कारण 73.3 प्रतिशत की अधिकतम मृत्यु दर पाई गई इसके बाद एक्स. स्टॉकिया (एसबीआईएक्सएसआरएस 1) और एक्स. स्टॉकिया (एसबीआईएक्सएसआरएस 1) जिसके कारण लार्वा की 66.6 प्रतिशत मृत्यु दर थी। पहला इंस्टार्ट सफेद लट लार्वा के खिलाफ 12 जीवाणु पृथक के कोशिका और कोशिका मुक्त संवर्धन की कीटनाशक गतिविधि पी. ल्यूमिन्सेन्स उपजाती अखार्स्टी (एसबीआईपीएलएसीएम) ने अधिकतम मृत्यु दर 80–100 प्रतिशत तक दर्ज की इसके बाद पी. ल्यूमिन्सेन्स एसएसपी अखार्स्टी (एसबीआईपीएलआरएस 7) में जिसमें 80 प्रतिशत मृत्यु दर पाई गई।

लगभग 27 ईपीएन को उपोष्णकटिबंधीय क्षेत्रों से 304 मिट्टी के नमूनों से पृथक किया गया था और उनमें से 16 हेटोरोहब्डीटीस और 11 स्टीनर्नमा नमेटोड जाति के थे। जी. मेल्लोनेला के खिलाफ परीक्षण किए गए पृथकों में, एसबीआईएच 1764 ने 5 आईजे/लार्वा में 80 प्रतिशत तक मृत्यु दर पहुँची। एसबीआईएच 1764,

एसबीआईयूपीटीएसएल 8 और एसबीआईयूपीडीएसएम 81 ने 100 प्रतिशत मृत्यु दर दर्ज की।

प्रसार

आउटरीच कार्यक्रमों में दो गन्ना अनुसंधान एवं विकास कार्यकर्ता सभा, चार राष्ट्रीय स्तर के प्रशिक्षण कार्यक्रम, एक अंतराफलक समागम , राष्ट्रीय स्तर 'किसान मेला' और तीन एक दिवसीय प्रशिक्षण कार्यक्रम हुए। किसानों के खेतों में तीन अग्रिम पंक्ति प्रदर्शनों का आयोजन किया गया। संस्थान ने चार प्रदर्शनियोंः कृषि–इंटेक्स 2016, कोडीसा व्यापार मेला परिसर, कोयम्बत्तूर; किसान दिवस, राष्ट्रीय केला अनुसन्धान केंद्र, त्रिरूचिरापल्ली; अंतर्राष्ट्रीय सम्मेलन, वीएसआई, पुणे और सुगरमैक 2017, बन्नारी अम्मन प्रौद्योगिकी संस्थान, इरोड में हिस्सा लिया।

"गन्ना सलाहकार", गन्ना रोपण से कटाई तक की जानकारी वाला एक मोबाइल ऐप तीन भाषाओं में विकसित किया गया है। तमिलनाडु राज्य के दो जिलों में आईसीटी प्रसार स्वरूप और गन्ना प्रौद्योगिकियों को अपनाने के स्वरूप का विश्लेशण करने के लिए सर्वेक्षण किया गया।

4. EXECUTIVE SUMMARY

Crop Improvement

Co 09004, an early maturing, in Peninsular Zone and Co 09022 (Karan 12), a midlate maturing clone from Institute's Regional Centre at Karnal, in North West Zone were identified for release in respective zones. Co 0212, a midlate maturing variety has been notified for commercial cultivation in Tamil Nadu and Puducherry.

Fourteen elite clones (Co 17001 to Co 17014) from Coimbatore and six clones from ICAR-SBI, Regional Centre, Karnal (Co 17015 to Co 17020) have been designated as 'Co' canes from the Pre-Zonal Varietal Trials conducted during 2016-17. The clone Co 17004 recorded the highest sugar yield of 17.44 t/ha and cane yield of 125.76 t/ha, while two clones (Co 17003 and Co 17005) recorded above 22.0% sucrose at 12th month (>22.0%). Among the six Co canes from Karnal centre, Co 17018 recorded high sugar yield of 17.00 t/ha, cane yield of 118.02 t/ha and 20.32% juice sucrose.

Evaluation of short duration clones (Co 11015, Co 16001, Co 16002, PZVT 2014-224) revealed that sucrose % in juice at 8th month was higher in Co 11015 (20.39%) than the standards Co 8338 (19.04%) and CoC 671 (17.30%) at spacing of 90cm, 120 cm single row planting and 120 cm paired row planting. Co 16001 ranked as the second best short duration clone with 18.65% sucrose at 8th month.

During 2016 flowering season, 202 crosses crosses were made and 15,500 seedlings have been raised at Coimbatore from 98 bi-parental crosses and 10 polycrosses. Seedling evaluation in ground nursery revealed a negative association between coefficient of coancestry and HR Brix in both families and selectable progenies. This explained that genetically diverse crosses yielded superior segregants for juice sucrose as compared to genetically similar crosses.

In the Advanced Varietal Trial of AICRP, the early clone Co 10026 recorded 25.10% improvement for CCS yield over the best standard CoC 671 for cane yield based on the two plant and one ratoon crops at Coimbatore. Among the midlate clones, Co 10017 registered the maximum improvement of 18.41% for CCS yield over the standard Co 86032 followed by Co 10033 (13.53%). Co 10015 was the only midlate entry that showed improvement over the standard Co 86032 for CCS% (0.64%) and sucrose % (0.81%).

National Hybridisation Garden (NHG) with 629 parental clones was maintained for the breeders of 24 participating centres of fluff supply programme. 502 bi-parental crosses, 12 poly crosses, 42 selfs and 94 general collections (GC) were made. Besides, 60 bi-parental crosses and 40 GCs were made at the National Distant Hybridization Facility available at ICAR-SBI RC, Agali. A total quantity of fluff weighing 19.52 kg was supplied. Analysis on the parental diversity of the crosses made in NHG in the recent years indicated that Parental Diversity Index (PDI) ranged between 30 to 50%. PDI of 15 participating centres was more than 60% during 2016.

A new initiative was taken to identify location specific sugarcane varieties by having an institute-industry collaborative project between ICAR-SBI, Coimbatore and SISMA-Tamil Nadu. Twenty promising genotypes were multiplied at Coimbatore and supplied to nine sugar factories in Tamil Nadu. The clones Co 11015 and Co 09004 recorded the highest HR brix value of 23.0%. The clones Co 0238, Co 13018, Co 13020, Co 15005, Co 15007, Co 16001 and Co 16002 recorded brix more than 21.0%. Survey and surveillance of pests and diseases was undertaken in the factory areas of Tamil Nadu. Shoot borer incidence was high in the popular variety Co 86032 followed by root borer. High temperature and drought increased the incidence of sucking pests like white flies, scale and mealy bugs. Yellow leaf disease (YLD) was more pronounced in the variety Co 86032. A combination of wilt with root borer was commonly observed in the drought affected crop. Rare incidence of Grassy shoot and sett rot was also observed in few factory areas.

Under the ICAR- Seed project, new activities initiated during this year resulted in upscaling the production and supply of quality seed. Nucleus seed of five sugarcane varieties (Co 86032, Co 0212, Co 06030, Co 06022 and Co 0403) in seed chain were multiplied at the institute and breeder seed multiplication was taken up both at the Institute and in a progressive farmer's field. Supply of 816.23 tons of quality seed cane on a farmer participatory mode realized a net profit of Rs. 4,08,115, which is a significant achievement. A total of 50,700 virus free tissue culture plants were supplied to the sugar factories and for breeder seed production. Virus free mother culture flasks of the varieties Co 86032, Co 0212 and Co 0238 were supplied to the tissue culture laboratories of Tamil Nadu, Karnataka, Andhra Pradesh, Gujarat and Maharashtra.

Studies on standardisation of true seed production for commercial cultivation of sugarcane were initiated. Assessing the extent of variation for NMC and HR brix in the selfed progenies of tropical and sub-tropical genotypes was continued. Pattern of segregation for cane color, stalk height, stalk diameter and HR brix yield studied in six combinations of intermated inbred progenies revealed that the combination S2xS4 had more than 65.0% individuals resembling the stalk color of female parent, while the cross S2xS7 had only 19.20% of such individuals. The results showed the existence of parental heterozyogity even after a few cycles of selfing. At SBIRC, Kannur, progenies of CP 97-1100 were more uniform for cane thickness, while those NCo 310 were uniform for cane thickness and shoot height.

Selfed seeds of two sugarcane varieties (Co 1148 and Co 775) were treated with 0.3% (v/v) EMS to develop mutant population. Centromeric related gene (CENH3) has been amplified and sequenced and kept as a reference sequence for characterizing CENH3 gene in mutant population. Mutants of Co 775 and Co 0238 were developed by treating callus with 0.2% and 0.05% EMS.

Fifty seedlings derived from wide crosses between Co 86032 (2n=108) x *Sorghum bicolor* (2n=20) were characterized, which showed wide range in number of stalks (from 1 to 34) and HR Brix from 14.0 to 24.0%. One progeny with a somatic chromosome number 2n=65 resembled sugarcane parent and recorded 34 stalks with 19.0% HR Brix at 10th month.

The pathogens associated with sugarcane true seeds were assessed in the seedlings raised from fluff. Four commonly occurring fungi belonging to the genus *Alternaria, Curvularia, Fusarium* and *Helmintosporium* were isolated and characterized.

Twenty one energy canes were evaluated at Sameerwadi, Karnataka. Six clones (SBIEC 11003, IA 1167, SBIEC 11001, SBIEC 13010, SBIEC 11008 and IA 3135) recorded high fibre percent of more than 30.0% and produced more than 100 canes per row of 6m length. At Karnal, among the 15 energy canes evaluated, the top ranking clones for high harvestable biomass yield were SBI-EC 11005 (78.59 t/ha), SBI-EC 11003 (69.9 t/ha), SBI-EC 13007 (67.58 t/ha) and SBI-EC 11006 (65.78 t/ha) registering more than 15% improvement over the experimental mean (56.86 t/ha).

In the clonal evaluation of 65 cytoplasmically diverse (CD) hybrids, CYM 11-85 recorded the highest sucrose of 20.99% as compared to the standard CoC 671 with 19.84% at 300 days. 607 backcross hybrids of sugarcane with *E. arundinaceus / S. spontaneum /S. barberi* cytoplasm are maintained. Co 16018, a 5th generation back cross hybrid of S. *spontaneum x E. bengalense* with a high cane yield of 202.8 t/ha entered multi-location testing under AICRP(S).

Genomic in-situ hybridization studies were undertaken in the F1 hybrid of *E. procerus* (IND 90-776) x *S. officinarum* (PIO 96-435). Forty chromosomes of *E. procerus* have been identified in the hybrid which revealed 2n+n segregation. In situ hybridization in the BC1 of this hybrid with labeled *E. procerus* revealed n+n segregation with 20 chromosomes of *Erianthus*. Cytological characterisation in 82 clones of *E. arundinaceus* revealed that Indian clones were predominantly of 2n=40 and 34.1% of clones of 2n=60 cytotype.

Among 350 BC2 clones derived from improved *S. robustum*, the progenies of PIR 001057 x CoC 671 gave high frequency of red rot resistant and high juice sucrose in the range of 18.20-20.26% at 360 days. In another trial with 135 hybrid clones involving *S. barberi*, 40 clones recorded sucrose above 18.25% at 300 days.

Studies to assess the growth promoting effect of PGPR in the tissue culture plants derived through direct regeneration through different treatments revealed that IAA content was the highest in the *Gluconactobacter* + *Bacillus* combination (67.77 µg/g of leaf tissue) followed by *Pseudomonas* + *Bacillus* (64.92 µg/g) as compared to 41.55 µg/g in control. In the root tissues, IAA content was high in Bacillus (43.64 µg/g) and *Pseudomonas* + *Bacillus* (42.76 µg/g) against the control (33.24 µg/g). The results revealed beneficial effect of *Bacillus* as higher IAA content resulting in better growth and vigour of tissue culture plants.

The primers from CENH3 sequences of *H. vulgare* amplified in *Erianthus* (250 bp) and in two intergeneric hybrids (IGH-43, IGH-39). The sequences from IGH-39 showed 93% similarity to centromere binding protein (CENP-B) of a *Saccharum* hybrid R 570. Localisation of CENH 3 genes has been cytologically confirmed by FISH assay. Signal intensities varied in different centromeres suggesting that each centromere might have a different copy number for this gene.

Among the BC1 hybrids of *E. procerus* screened for drought tolerance, GU 12-28 and GU 12-30 were superior for stalk population over the susceptible check (Co 775). Highest mean reduction was observed for stalk height (24.28%) followed by internode length (18.68%) under water stress. Least reduction in height was observed in GU 12-22, GU 12-26 and GU 12-30.

Germplasm exploration was conducted in the states of Punjab and Haryana and 97 *S. spontaneum* and five *E. bengalense* were collected. At Coimbatore, 1963 wild germplasm clones comprising *S. spontaneum, E. arundinaceus* and 1793 hybrid clones ('Co' canes, 'Co' allied clones, exotic hybrids, intergeneric and interspecific hybrids and its derivatives) were maintained. Under National Active Germplasm (NAG) of sugarcane, 226 clones were maintained. Morphological characterisation of 41 *S. spontaneum* clones collected from Maharashtra indicated substantial variation for internode shape and ligule shape.

Sugarcane reference varieties for DUS testing under tropics were maintained at Coimbatore and Agali. The second year of DUS testing was done for three new varieties and two farmer's varieties. 186 reference collections of sugarcane varieties and four farmer's varieties were maintained at ICAR-SBI, Coimbatore.

Investigations on the gene expression pattern during oxidative stress in two *Erianthus* clones (IK 76-91 and IJ 76-389 and a *S. spontanuem* (SES 90) clone revealed multiple stress responsive genes (HSP, APX, NAC, ERF, GST, MYBAS and CAT). At 500 ppm, all three clones showed a remarkable increase in expression of GST during 48h induction of H2O2 while the *Erianthus* clone IK 76-91 exhibited an increase in NAC gene expression under both 48 and 72h of treatment.

Gene specific primers designed from *Sorghum bicolor* and *Zea mays* were used to isolate six abiotic stress responsive genes *(MIPS, GLY III, EXPA1, EXPB5, EXPB6, EXPB7)* from *E. arundinaceus, S.officinarum* and *S. spontaneum* species clones. Expansin genes (EXPA1) cloned from *E. arundinaceus* (IK 76-81) is 1330 bp long with two introns and CDS of 762 bp size, was cloned in pCAMBIA1305.1 vector driven by Port ubi882 promoter by replacing ß-glucuronidase (GUS) and CaMV 35S promoter respectively. Port ubi882+EXPA1 were transformed both in tobacco and sugarcane through *Agrobacterium* mediated transformation. Screening on physiological parameters of 18 sugarcane transgenic events indicated an increase in RWC, photosynthetic efficiency (Fv/Fm), chlorophyll content and faster recovery after the imposed drought stress in the transformed plants when compared to non-transgenic plants.

Two novel stem specific genes (Dirigent and O-Methyl Transferase) were isolated from *E. arundinaceus* and Co 86032. Sequence analysis revealed that dirigent gene was 837 bp *(Erianthus)* and 864 bp (Co

86032) long with two introns and a CDS of 563 bp. OMT gene was 1.2 Kb size with one intron and CDS of 1073 bp and showed 96% and 91% similarity with other reported dirigent and OMT of the cultivar CP 72-1210.

To understand the functional role of sugarcane invertase inhibitor genes, two contrasting genotypes for sucrose content (Co 11015 and BO 91) were chosen for observing the differential expression pattern of invertase inhibitor genes. The plasmid DNA of the invertase inhibitor constructs was transformed into *E.coli* DH5α for sub cloning into binary transformation vector.

In the studies on genetic engineering of sugarcane for water deficit stress tolerance, 128 transgenic events were evaluated. DREB2, HSP70, PDH45 transformants and pyramided DREB2 and PDH45 transformants showed improved cell membrane thermostability, higher level of abiotic stress genes expression, higher relative water content, increased chlorophyll content and photosynthetic efficiency. Using gene specific primers, *EADREB2, EaSOD, EaCAT* and *EaAPX* sequences were amplified in *E. arundinaceus* and the genes were deposited in NCBI gene bank. Co 86032 was transformed with the four genes and transgene integration was confirmed in 28 DREB2 and 17CAT putative transgenics using promoter-gene fusion primers. Cell membrane thermostability revealed a significant decrease in the cell membrane injury in the 25 transgenic events under normal irrigated conditions.

Indo-Australia collaborative research project on genetic control and genomic selection for important traits in sugarcane was recently initiated. Four biparental cross populations (CoM 0265 x Co 775, BO91 x Co 775, Co 86002 x BO 91, Co 1148 x Co 775) for drought, red rot and sucrose were raised. Drought condition was imposed and drought index ranged from 1(greenness) – 5 (drying of the plant) in the progeny.

Crop Production

In ratoon crop, shredding plus soil incorporation of sugarcane trash along with microbial consortia at 100 % recommended dose of fertilizer (100 % RDF) recorded the highest cane yield of 81.86 t/ha

In first ratoon sugarcane crop, 20 t FYM + 150 STCR based fertilizer application was found beneficial in improving cane yield by 65.49% over control (no fertilizer application) with cane yield of cane yield (137.74 t/ha)..

Sugarcane intercropped with soybean has recorded significantly higher yield of 122.82 t/ha, followed by sugarcane intercropped with sunn hemp (117.31 t/ha) and black gram (116.38 t/ha) while the control (sole crop of sugarcane) has recorded 74.30 t/ha. The juice quality parameters did not vary among the treatments.

The carbon loss after 180 days of incubation of biochar produced from sugarcane trash, tops, stubbles and bagasse under laboratory condition was undetectable. The EC of the biochar from trash was 4.5 dS/m and pH was 9.4. The nutrient loss due to pyrolysis of sugarcane dry trash was 93, 38 and <1% N, P and K, respectively.

In hydroponic and sand culture conditions of sugarcane genotypes the highest root weight per pot was recorded by CoLk 8102 (1027 g) and Co 97010 (1011 g). This was followed by Co 06022 (830 g), Co 95020 (743 g), Co 99004 (658 g), CoJ 64 (632 g), Co 62175 (623 g) and Co 0238 (581 g). Lowest root was produced by Co 8371 (27 g) followed by Co 419 (103 g) and Co 94008 (118 g). Varieties Co 06022, CoLk 8102 Co 99004 and CoJ 64 recorded higher root volume (>1000 ml/ pot), and lowest (<110 ml/ pot) was recorded by Co 8371, Co 740 and Co 419.

A modified pocket manuring tool has been designed using the software SOLID WORKS for making 2 inch diameter hole at a depth up to 10 cm. The height of the tool was 3.5 feet and the upper diameter of the penetrating tool was 5 cm.

A Quadcopter Drone (DJI-Phantom 3 model with 4K resolution – FC 330X camera) was used to capture the field images of the sugarcane crop leaves. In case of iron deficiency symptom, the RGB values (R 150 to 230, G 175 to 240, B 100 to 160), L*a*b* values (70 to 90, -25 to +1, 0 to 48), Hue Saturation Value (S 0.3 to 0.45, V 0.7 to 0.9) and YCbCr values (Y 150 to 210, Cb 90 to 120, Cr 120 to 130) were obtained through image processing of iron deficiency leaf images.

Evaluation of physiological efficiency of commercial hybrids of S*accharum* for water limited conditions, 31 revealed that a significant reduction in TDMP (22% in 50% reduction in irrigation water quantity and 32% in 50% irrigation by reducing number of irrigations over normal irrigation and chlorophyll fluorescence (fv/fm) efficiency showed greater reduction in the treatment 50% irrigation by reducing number of irrigations 28.0% over normal irrigation. Under severe drought 74% of the clones showed tight leaf rolling, while 26% of alone showed tight rolling one day after irrigation. Co 95020 has not shown leaf rolling under both conditions.

Results of metabolic and molecular response to high temperature stress under reveals that the elevated temperature showed a significant reduction in chlorophyll pigment concentration, SPAD value and photochemical efficiency (fv/fm ratio) in both the co canes and *spontaneum* clones, however the variety Co 99004 and SES -150 are recorded significantly higher values under stress condition. Proteomic work on 2-D gel electrophoresis reveals that an additional heat induced protein spots (20 nos) were found in adopted variety of Co 99004 and Co 0315 in response to heat stress and the differentially expressed protein spots were outsourced for MALDI- analysis.

Application of customized fertilizer @ 100% of the recommended dose resulted in the highest cane yield of 142.54 t/ha in the field trial at M/s. Bannari Amman Sugars Pvt. Ltd. farm. Application of customized fertilizer @ 125% of the recommended dose gave significantly higher cane yield (148.13 t/ha) than that of all other treatments in the field trial at M/s. Ponni Sugars (E) Ltd. farm. Juice quality under different treatments did not vary significantly in both the trials.

Crop Protection

Totally 3147 clones were evaluated for red rot resistance under controlled conditions and out of that 1131 clones were identified as resistant. Twelve Co varieties included in SISMA trials were identified as red rot resistant clones. Apart from Co 86032, the new variety Co 0212 also exhibited field tolerance to red rot.

Both old and new sugarcane varieties exhibited a differential behavior to red rot pathotypes and most of the new pathotypes from the tropical region exhibited a higher virulence than the designated pathotype.

Suppressive subtraction hybridization (SSH) analysis resulted in identification and characterization of genes related to pathogenicity in *C. falcatum*. Proteome profiling of *C. falcatum* representing distinct virulence pathotypes led to identification of proteins related to pathogenicity *viz.* peptidyl prolyl cis/ trans isomerase, fungal specific transcription factor, etc.

Functional analysis of a major gene PKS1 by RNAi approach confirmed its possible role in *C. falcatum* pathogenesis.

Proteome analysis involving a tritrophic interaction with *C. falcatum* and *T. harzianum* in sugarcane indicated that the identified proteins shared homology with that of defense related proteins *viz*., disulfide isomerase, pyruvate decarboxylase, peroxidase, etc, which were reported from other *Colletotrichum* spp.

miRNA prediction was carried out in sugarcane challenged with *C. falcatum*, with unaligned reads of precursor miRNAs to the reference genomes of *Oryza japonica, Sorghum bicolor, Triticum aestivum and Zea mays*, which resulted in differential expression of miRNA among the resistant and susceptible cultivars.

Distinct mating type cultures (+ and -) of phenotyped smut pathogen isolates (varying in virulence pattern) were established and primers were designed targeting mating type specific genes, to discriminate between opposite mating types (+ and -).

Proteome profiling of a smut pathogen responsive sugarcane Co 96007 established 53 differentially expressed proteins. Transcript profiling of these proteins indicated that there are subtle modulations and complex interplay between proteins representing phenylpropanoid pathway, oxidative stress response, and various other metabolic and cellular processes in infected sugarcane meristem cells.

Sporisorium scitamineum orthologous effectors shared higher sequence identity with *S. reilianum, U. maydis* and other closely - related smut fungi. Transcript profiling demonstrated that effectors are expressed at a higher magnitude during the real-time host-pathogen interaction than under *in vitro* growing conditions.

Characterization of host resistance and dynamics of the brown rust pathogen indicated that the clones escaped from rust and their true nature of rust resistance need to be tested under artificial conditions facilitated with optimum conditions.

Fusarium sacchari isolates were classified as virulent, moderately virulent and less virulent types based on the development of necrotic lesions in *in vitro* leaf assays. Sugarcane varieties displayed a differential wilt disease development to *F. sacchari* isolates when evaluated under field conditions.

In host resistance to wilt, field observations indicated that clones originated from the subtropical region contributed more for wilt resistance among the parents. Also, it was established for the first time that the same fungal pathogen systematically infects sugarcane plants and exhibits both wilt and PB diseases.

Putative transgenic sugarcane lines resistance to *Sugarcane streak mosaic virus* (SCSMV) and *Sugarcane yellow leaf virus* (SCYLV) were developed through RNAi approach, engineered with the suppressor genes namely SCSMV- P1 and SCYLV- P0, respectively.

Comparative genome analyses of five new isolates of SCMV indicated that Indian isolates are closely related to sugarcane infecting isolates from Australia, followed by China and Argentina and they are diverged as a separate lineage from other reported maize infecting isolates from Mexico, China, Spain, Germany, Iran and Ethiopia.

Chitosan coated inducer nanoparticles were synthesized with compliance of standards like particle size, zeta potential and encapsulation efficiency. Chitosan inhibited more than 50% mycelial growth and 100% spore germination of major fungal pathogens under *in vitro* conditions.

Larval and pupal survivability ranged from 44 to 82% and 28 to 56% among the selected *Erianthus arundinaceous* genotypes resistant to shoot borer under field screening. Proteinase inhibitors extracted from leaf sheath, apical meristem and stalk tissues of six *E. arundinaceous* genotypes and six exotic clones when evaluated for their inhibitory activity against trypsin enzyme showed that the amount of inhibition was higher in apical meristem followed by leaf sheath and stalk tissues in *E. arundinaceous* genotypes, whereas among the exotic clones, trypsin inhibition was highest in leaf sheath followed by apical meristem and stalk tissues.

Based on the bioassay studies and the enzyme analysis a consortium of *Metarhizium anisopliae* isolates MTCC 6060, ITCC 5489 and SBMa has been found good for field evaluation against white grub. Fungal survival studies in bulk soil with or without sugarcane roots and cfu recovery indicated that of the 30 isolates, 12 showed good survival of spores (> 70% mortality) and the isolates ITCC 5489, MTCC 6060, NAIMCC-F-1296 were significantly superior to all other isolates in CFU recovery.

Out of the Bt 26 isolates collected from Haryana, Punjab, Uttar Pradesh, Tamil Nadu, four showed bipyramidal crystal morphology and hence was considered positive for *cry1* gene. Sequencing of the

complete coding region of *cry8* gene amplicon from the positive 41 Bt isolates revealed the presence of a novel *cry8* gene holotype which shares a protein homology of 67% with *cry8Ab1*. The size of the crystal toxin was found to be approximately 130 kDa protein. Bt isolates 8 and 84 were found to harbour *cry9Da* and *Cry1Na* genes. Bt isolates containing cry genes viz., *cry1* and *cry9D* caused 80 %mortality against 1st instar shoot borer larvae. The holotype *cry8* gene containing Bt 41 did not cause any mortality on *Holotrichia serrata*, however, *Oryctes rhinoceros* larvae were found susceptible.

A simple and sensitive method has been developed and validated for determination of carbofuran and its metabolites *viz.,* 3-keto carbofuran and 3-hydroxy carbofuran in GC-MS. A sensitive method has been developed and validated for determination of bifenthrin in gas chromatography equipped with electron capture detector (GC-ECD).

DNA barcodes were developed for seven insects viz. woolly aphid *Ceratovacuna lanigera*, eriophyid mite *Aceria sacchari*, hispa *Asamangulia cuspidata*, black bug *Cavelerius sweeti*, leaf folder *Cnaphalocrocis ruralis*, cut worm *Spodoptera litura* and the braconid parasitoid *Cotesia flavipes*.

Seasonal dynamics of egg parasitoids of internode borer revealed that the parasitoid *Telenomus dignus* was active throughout the year, except in the first fortnight of April under Coimbatore conditions. Adults of *Telenomus* sp. were exposed to variable number of freshly laid lab-reared egg masses of internode borer. Regardless of the variation in the ratio, parasitization within individual egg masses was 100% in all batches. However, parasitoid emergence was in the range of 14.3-100%. *Telenomus* was found to parasitize internode borer eggs up to 144 h of age and the adult emergence was not influenced by parasitoid age. Parasitoid adults provided with 50% honey solution in cotton swab survived for 5- 39 days as against 1-2 days without honey.

Insecticidal activity of cell and cell free culture of four *X. stockiae* strains and two *Photorhabdus* strains against *G. mellonella* larvae revealed that *P. luminescens* ssp *laumondii* (SBIPLLKSM12) as cell free culture cause maximum mortality of 73.3 % followed by *X. stockiae* (SBIXSRS1) and *X. stockiae* (SBIXSRS1) which caused 66.6 % mortality of the larvae.

Insecticidal activity of cell and cell free culture of 12 bacterial isolates against 1st instar white grub larvae revealed *P. luminescens* ssp *akhurstii* (SBIPLAACM) recorded maximum mortality of 80-100% followed by *P. luminescens* ssp *akhurstii* (SBIPLARS7) which caused 80% mortality of the grubs.

About 27 EPN were isolated from 304 soil samples from subtropical regions and among them, 16 were found to be *Heterorhabditis* and 11 were *Steinernema* spp. Among the isolates tested against *G. mellonella*, SBIH1764 caused 80% mortality at 5IJ/larva. SBIH1764, SBIUPTSL8 and SBIUPDSM81 recorded 100% mortality.

Extension

The outreach programs included two sugarcane R&D workers meetings, four national level training programs, one Interface Meet, national level 'Kisan Mela' and three one-day training programs. Three frontline demonstrations were conducted in farmers' fields.

The institute participated in four exhibitions: Agri-Intex 2016 at CODISSIA Trade Fair Complex, Coimbatore; Farmers Day at NRC for Banana, Tiruchirapalli, International Conference at VSI, Pune and SugarMech 2017 at Bannari Amman Institute of Technology, Erode.

'Cane Adviser', a mobile app on sugarcane containing information from sett planting to harvest is being developed in trilingual.

Surveys were conducted in two districts of Tamil Nadu state to analyze the ICT diffusion pattern and adoption pattern of sugarcane technologies.

5. RESEARCH ACHIEVEMENTS

5.1 CROP IMPROVEMENT

5.1.1 BREEDING

New Varieties

Co 09004 has been identified as a promising early maturing variety

Salient features : Co 09004 (CoC 671 x CoT 8201) is a high yielding, high quality and early maturing sugarcane clone suitable for cultivation in Peninsular zone comprising parts of Tamil Nadu, Telangana, Karnataka, Maharashtra, Gujarat, Madhya Pradesh, Chhattisgarh and Kerala (Fig. 2). In the Zonal Varietal Trials of AICRP(S), the clone was tested between 2012-13 and 2015-16 across 17 centres of Peninsular Zone. This clone recorded cane yield of 109.85 t/ha, sugar yield of 14.56 t/ha, Pol % cane of 14.50% and 18.94% juice sucrose at 300 days across the zone. It showed 17.89% and 17.84% improvement over the best standard CoC 671 for sugar and cane yields respectively. This clone was numerically superior to the best standard for sucrose percentage. (Fig.2.) Co 09004 has the ideal plant characters of tall canes (250 cm), early fast growing, high tillering, medium thick canes, non-flowering and non-lodging. This clone is an excellent ratooner and recorded 18.60% improvement for cane yield in ratoon crop over the best standard CoC 671. Co 09004 is moderately resistant to red rot and resistant to smut. The clone is Less Susceptible (LS) to top borer in all the locations tested. The clone is tolerant to drought and salinity conditions, the major yield limiting abiotic stresses in Peninsular Zone. Co 09004 possesses A_1 quality jaggery of golden yellow colour. Co 09004 is expected to improve sugarcane and sugar productivity under normal production condition and also in red rot and smut prone regions of Peninsular zone.

Co 0212, a midlate maturing variety has been notified for commercial cultivation in Tamil Nadu and Puducherry.

'Co' canes identified

Fourteen 'Co' canes (Co 17001 to Co 17014) from Coimbatore and six Co canes from ICAR-SBI Regional Centre, Karnal have been identified during 2017. Performance of these selections is presented in Tables 4-6.

Fig. 2. Co 09004 – A new early maturing sugarcane variety for Peninsular Zone

Table 4. Performance of 'Co' canes (2016-17) at Coimbatore

Co Numbers	Parentage	CCS (t/ha)	Cane Yield (t/ha)	Sucrose (%)		CCS (%)		Red rot	
				300 days	360 days	300 days	360 days	Plug	Nodal
Co 17001	Co 0327 x Co 0218	16.64*	109.62	19.79*	21.38*	13.94*	15.18*	MR	R
Co 17002	Co 99004 x Co 0403	15.25*	114.18*	18.08	19.05	12.57	13.36	MR	R
Co 17003	Co 11015 x Co 8347	17.43*	109.95*	17.49	22.30*	12.14	15.84*	MS	R
Co 17004	Co 8371 x CoV 92102	17.44*	125.76*	16.05	19.73*	10.88	13.86*	MS	R
Co 17005	Co 0303 x Co 0218	17.11*	107.43	18.05	22.49*	12.55	15.94*	MS	R
Co 17006	Co 08002 x Co 97015	14.14	105.31	17.90	19.06	12.47	13.42	MR	R
Co 17007	Co 8371 x Co 86011	14.70	100.97	16.02	20.55*	11.10	14.56*	S	R
Co 17008	Co 0240 x Co 0214	16.49*	106.60	16.19	21.86*	11.11	15.47*	MR	R
Co 17009	Co 99008 x CoT 8201	14.57	109.83*	16.62	19.43	11.48	13.74	MS	R
Co 17010	Co 0240 x Co 0218	14.38	101.04	15.33	20.16*	10.41	14.23*	MR	R
Co 17011	CoOr 03151 x Co 0310	15.64*	115.71*	15.46	19.16	10.55	13.51	S	R
Co 17012	Co 99006 x Co 0209	15.36*	110.45*	17.07	19.84*	11.93	13.92*	MS	R
Co 17013	C2-138 x C3-123	13.90	102.99	17.05	19.34	11.84	13.50	MS	R
Co 17014	Co 0240 x Co 0218	13.98	99.47	17.62	19.83*	12.31	14.06*	MS	R
Standards									
Co 85004		11.27	84.22	16.80	19.09	11.59	13.37		
Co 86032		13.40	100.42	18.11	19.01	12.69	13.36		
Co 94008		10.61	80.26	16.69	18.80	11.48	13.22		
Co 99004		13.29	97.47	16.29	19.47	11.18	13.65		
CoC 671		14.91	97.33	19.94	21.48	14.06	15.28		
CD		1.41	9.26	1.40	0.64	1.09	0.50		
CV		15.21	14.24	12.55	4.97	14.20	5.52		

Table 5. Performance of early maturing 'Co' canes (2016-17) at SBI Regional Centre, Karnal

Clone Number	Parentage	CCS (t/ha)	CCS (t/ha)	CCS (%)		Sucrose (%)		Pol % cane	Fibre (%)	RR rating
				240 days	300 days	240 days	300 days			
Co 17015 (K11-176)	Co 89003 GC	15.67	111.74	13.04	14.03	18.83*	19.74	15.31	12.4	MR
Co 17016 (K11-328)	Co 86032 GC	15.37	109.79	12.86	14.00	18.18	19.68	15.11	13.2	MR
Co 17017 (K11-270)	Co 06032 GC	12.23	85.0	12.95	14.36	18.52	20.44	15.86	12.4	R
Standards										
Co 0238		14.83	108.23	12.25	13.70	17.63	19.40	15.09	12.2	
CoJ 64		12.21	90.08	12.32	13.55	17.70	19.18	15.07	11.4	
CD		2.37	19.1	0.82	0.76	1.01	0.88			
CV		11.54	11.3	3.94	3.81	4.1	3.13			

Table 6. Performance of mid - late maturing 'Co' canes (2016-17) at SBI Regional Centre, Karnal

Clone Number	Parentage	CCS (t/ha)	Cane yield (t/ha)	CCS (%)		Sucrose (%)		Pol % cane	Fibre (%)	RR rating
				300 days	360 days	300 days	360 days			
Co 17018 (K11-201)	Co 0327 GC	17.00*	118.02*	13.11*	14.4	18.56	20.32*	15.44	12.0	MR
Co 17019 (K11-228)	Co 94008 GC	13.39	93.35	13.38*	14.35	18.93	20.25*	15.26	12.6	MR
Co 17020 (K11-444)	CoLk 8102 x Co 99006	13.79	97.58	12.97*	14.15	18.33	20.20*	15.47	13.4	MR
Standards										
CoS 767		10.87	82.31	10.58	13.20	18.11	18.69	14.3	13.5	
CoS 8436		11.30	82.80	10.67	13.65	18.41	19.43	15.03	12.6	
CD		2.63	19.1	0.76	1.02	0.88	0.77			
CV		11.71	11.3	3.81	4.71	3.13	2.5			

Breeding superior sugarcane varieties of different maturity with improved cane yield, quality and resistance to biotic and abiotic stresses

(i) Breeding sugarcane varieties for tropical region

(G. Hemaprabha, R.M. Shanthi, S. Alarmelu, P. Govindaraj, A. Anna Durai, K. Mohanraj, C. Appunu, Adhini S. Pazhany, S. Karthigeyan, R. Karuppaiyan, A.J. Prabakaran, C. Mahadevaiah, S. Sheelamary, T. Lakshmi Pathy, H.K. Mahadevaswamy and *V. Vinu)*

Arrowing plot

(K. Mohanraj, C. Mahadevaiah, S. Alarmelu, Adhini S. Pazhany and *H.K. Mahadevaswamy)*

During 2016-17, flowering was moderate with 40% flowering intensity in 233 parental clones. During 2017, 246 parental clones comprising Co canes (141), Co allied (35), breeding materials (12), inbreds (5), CD clones (15), interspecific hybrids (8), genetic stocks (10) and exotic clones (20) have been planted for utilization in crossing programme.

Hybridization (2016 season)

(G. Hemaprabha, R.M. Shanthi, K. Mohanraj, S. Karthigeyan, S. Sheelamary , C. Mahadevaiah, T. Lakshmi Pathy and *V. Vinu)*

During 2016 flowering season, 202 crosses were effected. Following table gives the split up of crosses effected under different categories.

Categories	No. of crosses
Tropical x subtropical	60
With genetic stocks/ prebreeding material	9
Proven crosses	20
Short duration clones	7
Experimental combinations (high yield/red rot resistance/ high quality/ drought tolerance)	83
Inbreds	7
IGH/ISH	16
Total	202

Ground nursery

(C. Mahadevaiah, G.Hemaprabha, A.Anna Durai and *Adhini S. Pazhany)*

During 2016, 15,500 seedlings from 98 biparental Crosses, 10 PCs and 12 GCs were transplanted. During 2015 season, 18000 seedlings were screened for Brix and cane yield traits and final selection will be made from the ratoon crop trial.

Correlation between coefficient of coancestry and cross performance

A part of the seedlings from 13 crosses effected based on Coefficient of Co-ancestry have been evaluated. Relationship between Coefficient of Coancestry on family and selection index (selectable progeny performances) for NMC, cane thickness and HR Brix in ground nursery seedlings were studied. Negative association was observed between Coefficient of Coancestry and Brix content in both families (-0.4582) and selectable progenies (-0.3282). This implies that genetically diverse crosses yield superior segregants with improved sucrose content in selectable progenies as compared to genetically similar crosses. Coefficient of Coancestry explains 21% and 10.77% of total phenotypic variability of Brix content in families and selectable progenies respectively. Similarly, negative association was also observed for cane thickness and Coefficient of Coancestry (-0.5662) in selectable progenies explaining 32.05% of total phenotypic variability (Fig 3). However, no significant association was observed between Coefficient of Coancestry and number of millable canes. Further analysis will be carried out in a larger seedling population with more number of crosses in the ratooned seedlings.

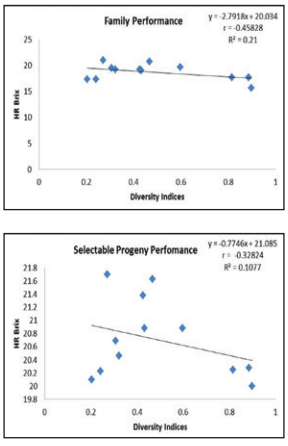


Fig. 3. Relationship between Coefficient of Coancestry and selection Index

Ground nursery ratoon (2014-16)

(C. Appunu, A. Anna Durai, S. Alarmelu and *Adhini S. Pazhany)*

A total of 18,800 seedlings from 67 biparental crosses and 9 GCs raised in ground nursery were ratooned during 2015. In all, 425 and 625 genotypes recorded good field stand with HR Brix more than 22 % and 20 % at 300 and 330 days respectively. Ninety percentage of selections recorded cane thickness >2.8 cm. Progenies from crosses involving Co 11015, CoC 671 and Co 0118 as one of the parents had high early sucrose accumulation. Co 13010 GC recorded a mean Brix of 18.19% followed by Co 0240 x Co 11012 with 17.99 % Brix % at 300 days. Thick canes were observed in the progenies of CoM 11087 x Co 09010. Co 13010 GC had the maximum Brix

of 20.4% at 360 days followed by Co 0240 x Co11012 (19.8%) and Co 11001 x Co 99006 (18.94%). Selection percentage ranged from 4.8 % to 16.72 % among the families, Table 7 shows the best crosses with maximum number of recombinants. Based on number of millable canes, cane thickness, field stand and HR Brix, 3194 clones were selected for further evaluation in first clonal trial.

Table 7. Crosses with high percent selection in the ground nursery ratoon 2014-2016

Crosses with more selections	Selection %
Co 11015 PC	12.70
Co 13010 GC	14.53
Co 7201 x CoC 671	16.72
Co 0403 x Co 11015	12.50
Co 0403 x Co 99006	11.46
Co 86002 x HR 83-65	11.26

I Clonal trial (ratoon)

(G. Hemaprabha, K. Mohanraj, R.M. Shanthi and *S. Karthigeyan)*

Over 6000 progenies from 85 crosses/GCs were evaluated for their ratoon performance in I Clonal trial and selections were made. Co 94005 x Co 86011, Co 8371 x Co 2000-10, Co 0240 x Co 0209, Co 0403 x Co 0214, Co 8371 PC, Co 99006 x Co 06015 and Co 99006 x Co 0403 resulted in more than 25% selection.

II Clonal Trial

(S. Alarmelu, P. Govindaraj, A. Anna Durai, C. Appunu, Adhini S. Pazhany and *R. Karuppaiyan)*

A total of 683 entries were evaluated with three standards *viz*. CoC 671, Co 86032 and CoM 0265 in Augmented RCBD. At 240 days, 29 clones recorded juice sucrose above18.0%, the best being 12-174 (Brix- : 22.67%; sucrose: 20.54%). At 300 days, the clones 2016-168 (Co 86002 x Co 0218), 2016-94 (Q 63 x CoT 8201), 2016-207 (Co 86002 x Co 0209), 2016-256 (Co 0209 x Co 8341), 2016-278 (Co 0209 x Co 8341), 2016-318 (CoSnk 03754 x Co 89003), 2016-355 (Co 0212 x Co 0314), 13-74,13-76 combined yield, quality and resistance to red rot. Forty five clones recorded >18.0 % sucrose and were promising at 360 days. The clones, 2016-112 (Co 11015 x Co 8353), 2016-106 (Co 08016 GC), 2016-019 (Co 87011 x CoC 671), 2016-014 (Co 86032 x CoM 0265), 2016-003 (CoM 0265 x Co 11015), 2012- 217 (Co 06002 x CoN 10072), 13-74 (CoC 671 x Co 06002), 13-120 (Co 10033 x CoN 10072), 13-76 (Co 06022 x Co 94008), 13-47 (Co 06002 x CoN 10072), 13-28 (Co 11019 x Co 06002), 13-107 (Co 86032 x CoN 10072), EB 1230041 and EB 1247063 combined high yield and recorded sucrose above 18 %. Among the clones 58 R, 159 MR and 145 MS types to red rot were identified. One hundred and thirty five clones were promoted to PZVT. Evaluation of new genotypes at different stages led to the identification of exceptionally elite clones for different characters as listed in Table 8.

Table 8. Salient findings from different trials

Traits	No.	Clones
Brix >24% at 360 days	2	2016-044,12-258
Sucrose >22% at 360 days	10	12-10,12-258, 2016-044, 2016-017, 2016-158, 2016-034, 2016-105, 2016-31, 2015-92, 2016-163
Sucrose 20% at 360 days + red rot resistance	18	13-102, 13-120, 13-62, 13-117, 2016-168, 2016-371, 2016-384, 2016-783, 2016-046, 2016-086, 2016-005, 2016-023, 2016-069, 2016-039, 2016-058, 2016-03, 2016-016, 2016-017
SCWt >3.0 kg	1	13-100 (Co 86032 x CoN 10072)
Short duration types >18% sucrose at 240days	14	2016-001, 2016-112, 2016-015, 13-47, 13-74, 13-28, 13-120, 13-76, 13-126, 13-107, 12-174, 13-107, 2016-168, 2016-370
Superior cane yield (>200 t/ha)	3	2016-158 (Co 85002 GC) 2016-112 (Co 11015 x Co 8353) 2015-32 (Co 0240 x Co 0209)
High yield (>200 t/ha) + high sucrose (>22%)	1	2015-32 (Co 0240 x Co 0209). Cane yield: 204.6 t/ha, Sucrose: 22.34%.

Pre Zonal varietal Trial

(P. Govindaraj)

Among 41 clones evaluated along with five standards *viz*., Co 86032, Co 99004, CoC 671, Co 94008, Co 85004 in RBD with two replications, 14 elite clones were selected and assigned Co numbers from Co 17001 to Co 17014. Co 17005 recorded the highest CCS of 15.94% compared to the standard Co 86032 (13.36%). The highest cane yield was recorded by Co 17004 (125.76 t/ha) compared to Co 86032 (100.42 t/ha). Four clones *viz*., Co 17005 (22.49%), Co 17003 (22.30%), Co 17008 (21.86) and Co 17001 (21.38%) recorded more than 21% of juice sucrose and were significantly superior to the standard Co 86032 (19.01%). Percentage improvement of the 14 Co canes over the best standard Co 86032 as given in Fig 4, indicated the advantage of Co 17001, Co 17003, Co 17004, Co 17005, Co 17008, Co 17009, Co 17012, Co 17013 and Co 17014 for CCS, cane yield and sucrose % at 360 days.

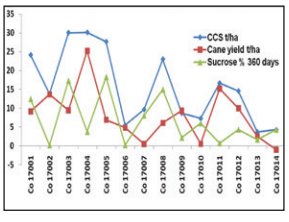


Fig 4. Percentage improvement of selected Co canes compared to the best standard Co 86032

PZVT multiplication

(R.M. Shanthi and *S. Karthigeyan)*

Selections from 2017 was laid out with 82 clones selected form 166 clones multiplied and selected based on cane yield parameters, Brix and resistance to red rot. The new series of 2017 had 208 elite selections pooled from different projects.

Screening for diseases

Red rot

(P. Malathi)

In 2016, 79 clones comprising of 51 PZVT clones of 2015 series and 28 clones of 2014 PZVT series for retesting were planted along with 2 standards *viz*.,

CoC 671 and Co 94012 in the field and screened by plug and nodal methods of inoculation with Cf671 and Cf94012 isolates. Results showed that out of 51 clones of 2015 series, 18 and 9 were identified as R/MR by plug method for Cf671 and Cf94012 isolates, while out of 28 clones of 2014 series 9 and 6 were identified as R/MR by plug method for Cf671 and Cf94012 respectively.

Smut

(A. Ramesh Sundar)

For the crop period totally 51 PZVT entries (2015 series) were evaluated for smut resistance. The profile of the ratings are HS (26 clones), S (8 clones), MS (9 clones), MR (6 clones) and R (2 clones). For the current season (2017-18), 82 clones (2016 series) were planted after challenge inoculation with smut teliospores and are being evaluated for smut reaction along with respective Susceptible and Resistant standards.

Botanical characterisation and DNA Finger printing of elite selections and varieties

(G. Hemaprabha and *H.K. Mahadevaswamy)*

Botanical description of Co 2016 series (Co 16001 to Co 16025) was completed for 33 morphological characters. DNA profiling of 15 clones with 20 STMS primers were completed. DNA Fingerprints of three release proposals from Anakapalle and one from VSI, Pune were generated with 10-12 STMS primers on payment basis.

Identification and testing of short duration sugarcane clones

(R. Karuppaiyan and *G. Hemaprabha)*

Four perspective short duration (SD) clones *viz,* Co 11015, Co 16001, Co 16002, PZVT 2014-224 were evaluated in RBD during 2016-17 along with 4 standards (CoC 671, Co 8338, Co 86032 and Co 99004) in two different trials for cane yield and juice quality at 8th month. In trial 1, sucrose% in juice at 8th month was numerically higher in Co 11015 (20.39%) than the standards Co 8338 (19.04%) and CoC 671 (17.30%) at all row spacing (90 cm, 120 cm single row planting and 120 cm paired row planting). Juice purity percentage of Co 11015 at 8th month was 90.47% which is a good sign of cane maturation. Co 16001 ranked as the second best short duration clone with 18.65% sucrose percentage at 8th month with 87.34% juice purity.

In trial 2, the clone Co 11015 and Co 16001 recorded higher sucrose percentage at 8th month (20.74% and 19.60%, respectively) than the standards CoC 671 (18.87%) and Co 8338 (19.61%). The purity% in juice were above 85% (90.47% in Co 11015 and 87.71% in Co 16001). However, cane yield was lower in the short duration clones; Co 16001 and Co 11015 recorded 73.70 t/ha and 66.56 t/ha, respectively which were 16.16 t/ha and 23.31 t/ha lower than that of the standard CoC 671. CCS yield of Co 16001 at 8th month (9.96 t/ha) was 1.97 t/ha lower than that of CoC 671 (11.93 t/ha). At 11th month after planting, highest sucrose% was recorded in Co 11015 (21.19%) and Co 16001 (20.32%) which were higher than that of CoC 671 (20.27%). In Co 16001 decline in sucrose content was noticed after 10th month due to flowering, unlike in Co 11015. At 12th month cane yield of Co 16001 was 97.36 t/ha and of Co 11015 was 85.49 t/ha which was 23.66 t/ha and 18.93 t/ha higher than the cane yield recorded at 8th month from these SD clones (Table 9).

Table 9. Performance of short duration clones at 240 days

Sl.No	Name of the clone	Brix %	Sucrose (%)	Purity (%)	CCS (%)	Cane yield (t/ ha)	CCS yield (t/ha)	Cane yield (t/ha) 360 days
		240 d						
1	Co 11015	22.93	20.74	90.47	14.50	66.56	9.65	85.49
2	Co 16001 (2007-291)	22.35	19.60	87.71	13.51	73.70	9.96	97.36
3	Co 16002 (2013-197)	21.78	19.42	89.15	13.48	72.66	9.82	95.56
4	PZVT 2014-224	21.05	18.96	90.07	13.23	68.60	9.08	100.81
Standards								
1	CoC 671	20.80	18.87	90.69	13.21	89.86	11.93	125.19
2	Co 8338	21.55	19.61	91.01	13.75	58.13	7.98	80.14
3	Co 86032	19.98	18.00	90.08	12.56	76.27	9.61	149.38
4	Co 99004	20.45	18.16	88.80	12.59	79.00	9.94	138.10
	Mean	21.36	19.17	89.75	13.35	73.10	9.75	109.00
	CD at 5%	1.46	NS	1.92	NS	15.08	NS	13.28
	CV%	2.84	3.64	0.89	4.02	8.58	10.56	5.26

Breeding special varieties for high biomass and total sugars for cogeneration and ethanol production

(P. Govindaraj and *M.R. Meena)*

Twenty one energy canes were evaluated in multiplication cum observation trial at M/s. KIAAR, Sameerwadi and fibre content analysis was carried out at 12 months. Fibre percentage cane was the highest in SBIEC 11003 (34.00) followed by IA 1167 (33.00), SBIEC 11001 (32.00), SBIEC 13010 (31.00), SBIEC 11008 (30.80) and IA 3135 (30.45). All the clones produced more than 100 canes per 6m row length which ranged from 175 (SBIEC 11004) to 101 (SBIEC 13008). Fourteen out of 21 clones recorded more than 3m cane height and the clone SBIEC 14006 recorded the longest cane of 3.87m. Ten energy canes *viz.,* SBIEC 13009, SBIEC 11002, SBIEC 13010, SBIEC 13002, SBIEC 14006, SBIEC 13005, SBIEC 14002, SBIEC 13008, SBIEC 14003 and IA 1167 were selected. SBIEC 14006 was planted in 6 acres for large scale evaluation of mill technological parameters.

A total of 15 energy canes along with two standards namely Co 0238 (Early) and CoS 767 (Midlate) were evaluated for harvestable biomass, cane yield and physiological parameters under subtropical climate at Karnal. The experimental mean harvestable biomass yield recorded was 56.86 t/ha and Co 0238 was the best standard with 99.93 t/ha. The value ranged from 37.20 (SBI-EC 13009) to 78.59 (SBI-EC 11005) among the test clones. Out of 15 test clones, the top ranking clones for higher biomass were SBI-EC 11005 (78.59 t/ha), SBI-EC 11003(69.9 t/ha), SBI-EC 13007 (67.58t/ha) and SBI-EC 11006 (65.78 t/ha) and average harvestable biomass were recorded by SBI-EC 11008 (61.22),SBI-EC 14006 (57.19), SBI-EC 11002 (52.81), SBI-EC 13008 (52.64) and SBI-EC 13005 (51.72) t/ha.

The mean experimental cane yield was 47.64 t/ha and Co 0238 was best standard with 85.55t/ha. The test clones with higher cane yield (t/ha) were SBI-EC 11005 (75.13), SBI-EC 11003 (67.62), SBI-EC 14006 (64.31) and SBI-EC 13007(55.0). The triplicate readings using SPAD meter were taken around the midpoint near midrib of each entry. The test entries *viz*., SBI-EC 11003 (47.53), SBI-EC 13005 (47.53), SBI-EC 14002 (46.0) and SBI-EC 13001 (45.10) recorded higher value of SPAD reading which indicated that those clones had more greenness (chlorophyll content) compared to others.

Identification of superior sugarcane varieties suitable for different agro-eco climatic regions of Tamil Nadu (CAE trials in collaboration with TNAU)

(A.Anna Durai, C. Mahadevaiah and *C. Appunu)*

2016-18 season trials: CAE- Early I plant trial with five entries (Co 08020, 29 C 090, 29 C 229, 07G 017, 08Si 05 and CAE-mid-late I plant trial with five entries (Co 08009, Co 08016, 07G 023, 08Si 06 and 29G 442) were conducted along with Co 86032 and local checks of factory choice at Sathyamangalam, Appakudal (Bhavani) and Erode.

CAE – Early I plant trial (2016-2018): At Sakthi Sugars Ltd, Appakudal, Co 08020 (79.11t/ha) was superior to the standard Co 86032 (71.82 t/ha) for cane yield, while, Co 08020 (9.89t/ha) performed on par with Co 86032 (9.72) for CCS yield. Co 86032 recorded 19.38 % sucrose and none of the test entries was found superior to it. At Bannariamman Sugars, Sathyamanagalam and Ponni Sugars, Erode, none of test entries was superior to best standard Co 86032 for cane yield, sugar yield and juice quality traits.

CAE – Mid-late I plant trial (2016-2018): At Sakthi Sugars Ltd, Appakudal, Co 86032 was the best standard with 10.80 t/ha of sugar yield and 90.22 t/ha of cane yield. Among the test entries 07G 023 was significantly superior to the best standard for cane yield (99.11 t /ha). The test entry Co 08009 (10.84 t/ha) was on par with Co 86032 for CCS yield (10.84 t/ha). Two test entries *viz.,* Co 08016 (19.60 sucrose %) and Co 08009 (18.44% sucrose) were found to have superior juice quality traits than Co 86032. At Ponni Sugars Erode and Bannariamman Sugars, Sathyamangalam, none of test entries was superior to best standard Co 86032 for cane yield, sugar yield. However Co 08009

(18.90% sucrose) and Co 08016 (19.34% sucrose %) were superior than Co 86032 (18.69% sucrose %) at Sathyamangalam.

CAE –II plant Early and Mid-late trials: Two trials viz., CAE- II plant (Early) with Co 08020, 29 C 090, 29C 229 and CAE-II plant (mid-late) with Co 08009, Co 08016, and 29 C 442 along with Co 86032 and local standards were planted at Bannariamman Sugars Ltd., Sathyamangalam and ratoon trials were conducted at Bannariamman Sugars Sathyamangalam and Sakthi Sugars Ltd, Appakudal. At Appakudal, Co 08020 and 07 G 023 were found have good ratooning potential while in Sathyamangalam, 29C 229 and Co 08020 recorded more number of tillers. In the early second plant crop trial at Sathyamangalam, 29C 090 was found with good initial vigour.

Development of commercial sugarcane varieties with *Saccharum spontaneum* and *Erianthus arundinaceus* cytoplasm

(Adhini S. Pazhany)

Sixty five cytoplasmically diverse hybrids have been evaluated in clonal trial and CYM 11-85 recorded the highest sucrose content of 20.99% while the best standard CoC 671 recorded 19.84% at 300 days. Two hybrids with near commercial yield and quality (CYMA 10-1730 and CYM 13-253) have been advanced to PZVT multiplication. A total of 514 advance generation backcross hybrids of sugarcane with *Erianthus arundinaceus* or *Saccharum sponatneum* cytoplasm, hybrid derivatives selected and parental clones have been field maintained. Another 95 clones including 84 CD clones and 11 BC and 70 CYM hybrids with *S.spontaneum* and *S.barberi* cytoplasm are also being maintained. Seedlings have been raised from the cross CYM 05-228 x IK 76-9, the amphiploid of CYM 04-420 (*E. arundinaceus* x *S. spontaneum*; 2n=124) had flowered and it was further crossed with sugarcane and seedlings have been raised. Co 16018, a 5th generation back cross hybrid of *S. spontaneum* x *E. bengalense* with high cane yield of 202.8 t/ha has been accepted for multilocation testing under AICRP(S) in Peninzular Zone.

Evaluation of in vitro methodology for production of disease free biotized tissue culture plants through direct regeneration in sugarcane

(D. Neelamathi, A. Selvi and *R. Vasantha)*

In order to assess the growth promoting effect of PGPR inoculation in tissue culture plant derived through direct regeneration technique, Indole acetic acid (IAA) was estimated in leaf and root at hardening stage. It was found that IAA estimated in leaf tissue collected at hardening stage in all treatments showed highest value (67.77 µg/g) in the *Gluconactobactor* + *Bacillus* combination followed by 64.92 µg/g (*Pseudomonas*+ *Bacillus*). In unbacterized the IAA content was 41.55 µg/g. The highest IAA content indicated the vigour of the plant. In root tissue IAA content was high in *Bacillus* (43.64 µg/g) and *Pseudomonas*+*Bacillus* (42.76 µg/g) compared to other treatment combinations and unbacterized (33.24 µg/g). Thus the *Bacillus* showed the ability to produce higher amount of IAA that may facilitate plant growth.

Field performance of direct regenerated plants inoculated with dual combination of plant growth promoting rhizobacteria

Field planted bacterized direct regenerated crop at 10th month numerically showed 10-15% improvement in dual inoculation of *Gluconacetobacter* + *Bacillus* and *Gluconacetobacter* + *Methylobacterium* in terms of number of millable cane, cane height, single cane weight and finally the estimated yield. And 0.5 units higher in sucrose percent were noticed in *Gluconacetobacter* + *Bacillus* and *Pseudomonas*+ *Azospirillum*. Therefore *Gluconacetobacter* + *Bacillus* was found to be the suitable PGPR combination to enhance the initial vigour of tissue culture plants.

Production of virus free plant through direct regeneration from young leaf disc: In vitro plantlets developed through direct regeneration from leaf disc inoculated in medium containing 10 and 11 mg/l ribavarin were found to be optimum for shoot regeneration and elimination of viruses. Results indicated that increasing ribavarin concentration to 12 mg/l reduced shoot formation from leaf disc. Five plantlets of the variety Co 86032, comprising of one meristem tip cultured plantlet, one direct regenerated plantlet from leaf disc without ribavirin treatment and three direct regenerated plantlets with ribavirin treatment at 10mg, 11mg and 12mg respectively were tested for genetic fidelity. Ten primer pairs from the core set of sugarcane microsatellite primers identified for fidelity testing, were used to profile the plantlets and were found uniform for all the primers tested.

Study on the mechanism of chromosome elimination and allelic variation in centromeric region in sugarcane

(V.P. Sobhakumari)

The centromere is a chromosomal domain that directs the assembly of kinetochore, which mediates chromosome segregation by interacting with spindle microtubules. To obtain the information on the DNA composition of the centromere region of sugarcane a wide analysis of DNA sequences associated with CENH3 from other crops has been done. CENH3 primers were designed with conserved regions of CENH3 from various crops like maize, sorghum, rice, wheat, rye etc. These primers were amplified in genomic DNA of Co cane (Co 7201), *S. officinarum* (28 NG 210), *E. arundinaceus* (IK 76-78) and in hybrids involving these species. Sequencing analysis has been done for the amplicon obtained by using primers designed from maize CENH3 gene. Analysis revealed that it is a full length gene with a size of 474bp with start and stop codons. It showed 88% homology with maize and sorghum NUF2 family proteins which are available in the kinetochore region of chromosomes that is responsible for chromosome segregation. Sequences of amplicons obtained with other primers did not show any homology to reported sugarcane CENH3.

CENH3 primer designed from CENH3 sequences of *Hordeum vulgare* amplified in *Erianthus* (250 bp) and in two intergeneric hybrids (IGH-43, IGH-39) (330 bp). The bands were eluted, purified, cloned and sequenced. The sequence data from *Erianthus* (IK 76-78) did not show any sequence similarity with centromere related genes available in the data base. The sequences from IGH 43 showed similarity to maize gene for dHLH (Helix-Loop-Helix) which

is a protein required for optimal centromere function. The sequences from IGH-39 showed 93% similarity to centromere binding protein (CENP-B) of a *Saccharum* hybrid R 570. As the centromeric DNA is composed of many tandem repeats and centromeric retrotransposons (CRs) most of the sequenced data were showing homology to different types of centromere related genes rather than CENH3 genes.

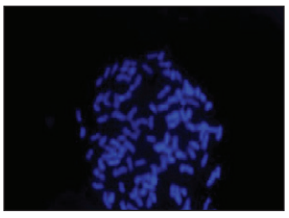


Fig. 4 DAPI stained somatic metaphase cell of Co 7201

The expression profiling of the CENH3 gene which were isolated and characterized from *S. officinarum* (28 NG 210) showed that it was not amplifying in some of the hybrids involving this species. This may be due to the rapid turnover events of centromere related genes during hybridization and selection.

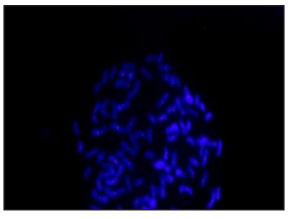


Fig. 5 FISH signals derived from CENH3 probe in Co 7201

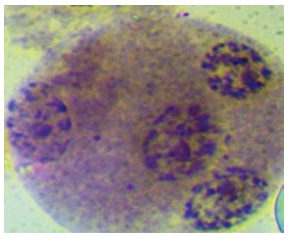
Cytological confirmation has been done for the localization of CENH3 genes in the centromere by FISH (Fluorescent i*n situ* Hybridization) assay. PCR amplified product of CENH3 from *S. officinarum* labeled with digoxigenin was used as probe. This was detected in the metaphase chromosome spreads using antidigoxigenin conjugated rhodamine. Strong and weak signal spots were obtained in most of the chromosome centromeres and this confirmed that these sequences are components of centromere DNAs (Fig.4 and 5). However the signal intensities from different centromeres varied for this sequence suggesting that each centromere might have a different copy number of this gene. In few chromosomes signals were absent and this indicates that this sequence may be chromosome specific or they may be having very short and loose signal spots which were difficult to detect.

Cytological behaviour in the interspecific hybrids derived with different cytotypes of *S. spontaneum*

(A. Suganya and *R. Karuppaiyan)*

Seedling evaluation: 110 seedlings from five backcrosses raised at Agali centre were evaluated for NMC, cane height, thickness and HR Brix. Twenty clones were selected. Vigourous progenies with tall erect canes were observed with NMC of 15-28 /seedling and 11.0-19.0% of Brix in the backcross progenies of Co 86032 x (Co 1148 x IND 84-415, 2n=80). The progenies of Co 85002 involving the F_1's with the cytotype 2n=72 and 112 were very tall with maximum height of 390 cm and possessed curved canes. Single cane weight was high in the cross MS 6847 x 04-2065 with 2.5kg /cane involving the cytotype 2n=40.

a)



b)

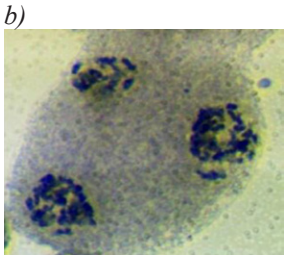


Fig. 6 a,b: Asynchronous division and tripolarity in 04-52 derived with 2n=88

Clonal evaluation of 60 hybrids indicated highest Brix in clone 13-BC_2-53 derived from 2n=80 cytotype with 21.5% of Brix. Single cane weight was maximum in a hybrid of 14-BC -555 [MS 6847 x (BO 102 x SH 216, 2n=72)] with 1.125Kg/cane.

'n+n' transmission was observed in 14 hybrids derived with the cytotype 2n=40 and 60. Two genotypes were selfs. In the cross of Co 86032 x (Co 1148 x IND 84-415, 2n=80), four hybrids possessed chromosome number ranging from 2n=84-93.

Meiotic studies in 32 BC_1 and F_1 hybrids derived with the cytotype 2n=88, 80, 64 and 60 indicated closed bivalents at higher frequency. The hybrid 04-1467 of the cytotype 2n=60 had shown secondary association of bivalents. Maximum of 12 laggards and 9 micronuclei were observed in the BC_1 hybrids

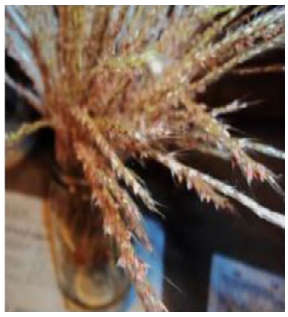


Fig .7. Hydroponic induction of anthesis

Fig. 8. Tall S. spontaneum collected from Punjab state

Fig. 9. High tillering S. spontaneum spotted in Punjab

of the cytotype 2n=80. Abnormalities with asynchrony, absence of cytokinesis in anaphase II and micronuclei were observed in the cross derived with the cytotype 2n=88 (Fig. 6).

Fifteen backcrosses were effected with the progenies of the cytotypes 2n=56 and 80. Hydroponic induction of anthesis in the panicle branches enhanced pollen yield.

Collection, maintenance, evaluation and cataloguing of sugarcane germplasm at coimbatore

(a) Collection

(P. Govindaraj and *S. Karthigeyan)*

An exploration was conducted to collect the sugarcane wild germplasm in the unexplored areas of Punjab and Haryana states. A total of 49 and 48 *S. spontaneum* were collected from Haryana and Punjab states respectively which were found mostly as small population. *S. spontaneum* was distributed throughout both the states and collections could be made from all the districts and rivers surveyed. In the exploration route union territory of Chandigarh was also surveyed and two *S. spontaneum* were collected. Five *E. bengalense* were also collected from Haryana (4) and Punjab (1). Among the collections from Haryana state, plant height showed high variability which ranged between 362 cm and 51 cm with the standards deviation of 71.16 cm. Variation for leaf length (144 cm to 48 cm), leaf width (1 cm to 0.1 cm), peduncle length (120 cm to 18 cm), arrow length (62 cm to 22 cm), stalk diameter (1.1 cm to 0.2 cm) and internode length (29 cm to 2.5 cm) were observed. *S. spontaneum* was distributed throughout the state and showed high variability for different agronomical traits. Collections form Punjab state indicated that plant height varied between 46 cm and 450 cm and arrow length ranged from 14 cm to 66 cm. Leaf width varied greatly from 0.1 cm to 1.3 cm with standard deviation of 0.29 cm. The shortest internode length was observed with IND 16-1813 (4 cm) and the longest internode length was recorded by IND 16-1827 (24 cm). Fig. 8-10 show the variations in *S. spontaneum* accessions collected.

b) Maintenance at Coimbatore and Wellington

(S. Karthigeyan, Adhini S. Pazhany and *M. Sivaswamy (ICAR-IARI Regional Station, Wellington)*

A total of 1963 wild germplasm clones comprising *Saccharum spontaneum, Erianthus arundinaceus, Erianthus* spp., allied genera, improved *Erianthus* and other *Saccharum* clones (cane forming types) have been replanted for field maintenance at Coimbatore. Poorly established clones have been replanted in polybags.

Genus/species	No. of accessions
Saccharum spontaneum	1451
Erianthus arundinaceus	215
Erianthus spp.	168
Allied genera	59
Improved *Erianthus*	48
Other *Saccharum* clones	22
Total	**1963**

Fig. 10. Large population of S. spontaneum occurring in the canal bed in Haryana state

A total of 56 clones comprising *S. spontaneum* (47) clones from Arunachal Pradesh, *E. fulvus*(1) , *E. procerus*(6) and *Miscanthus nepalensis* (2) collected from Meghalya are maintained at ICAR - IARI Regional Station, Wellington, The Nilgiris.

(c) Maintenance of commercial hybrids and genetic stocks

(C. Mahadevaiah and *K.Mohanraj)*

A total of 1793 clones consisting of 1320 'Co' canes, 27 'Co' allied clones, 36 exotic clones, 282 ISH clones, 39 IGH clones and 89 other clones were maintained in the field.

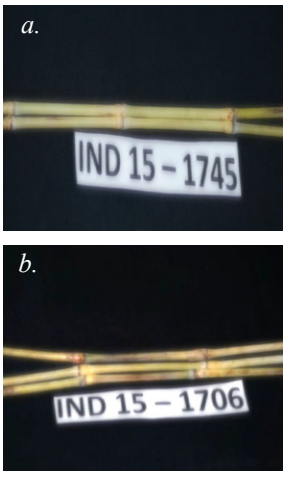


Fig.11 a, b. Bobbin shaped internodes in IND 15-1745 and IND 15-1706

(d) National active germplasm maintenance

(C. Jayabose and *S. Alarmelu)*

Index numbers have been assigned to ten varieties *viz*., CoP 09437, CoP 11437, BO 154, CoVC 14061, CoPb 08212, CoPb 08217 CoN 09072, LG 95123, LG 01118 and LG 97050 from different parts of the country. During the 2016 flowering season, 56 clones flowered in NAG which was high in comparison to the previous year. The clones maintained under quarantine were monitored and four varieties: CoPb 09181, CoOr 10346, CoOr 12346 and BO 146 established well. Six varieties *viz*., CoA 11321, CoA 11323, CoA 12323, CoA 12324, CoA 13322 and PI 07131 showed poor germination. During this period 226 (Co canes, Co allied clones and registered genetic stocks) clones were planted during February 2017 in the field for maintenance.

(e) Characterisation, Evaluation and Cataloguing

(C. Jayabose, Adhini S. Pazhany and *S. Karthigeyan)*

Maharashtra collection: A total of 41 *S. spontaneum* clones collected from Maharashtra have been characterized morphologically. The plant height ranged from 74.3 cm (IND15- 1720) to 239.6 cm (IND 15 – 1713). The ligule shape in the collection was dominated by crescent and deltoid shapes except IND 15-1730 with strap shape. The internode shape varied among the collections with 20 conoidal, 19 cylindrical and two bobbin shaped clones (IND 15-1745 and IND 15-1706). The clone IND 15-1721 recorded the maximum HR Brix of 15.2% and the minimum of 5.3% was recorded in IND 15-1740. Figures 11- 13 show the variability among the collections.

Fig. 12. The clone IND 15-1721 with HR Brix 15.2%

Flowering behaviour: Among the 1451 S. *spontaneum* accessions planted in 2015, 237 clones flowered in February, 2016 and flowering continued upto 2nd week of September, 2016. In the clones planted during 2016 season, flowering commenced during April 1st week and as on date, 72 accessions flowered. Flowering behavior and pollen fertility of 59 clones belonging to allied genera have been studied. Among these IND 81-21 (*Sclerostachya)* recorded the highest pollen fertility of 97.9% followed by IND 81-79 (*Vetiveria;* 94%) and *Narenga* 57.8%. Among different *Erianthus* spp., *E. bengalense* clone IND 81-47 recorded the highest pollen fertility of 97.6% followed by *E. elephantinus*; SES 305 (95.9%), *E.elegans* (85.7%) and IND 90-777; *Erianthus* sp. 8.3%. Open pollinated fluff of 91 *S. spontaneum* clones were collected and germination percentage was studied. The number of germinants per gram of sample ranged from 5 (IND 07-1462, IND 07-1468, IND 05-1405 and IND 08-1491) to 125 (SES 162A). IND 01-1117 recorded 105 germinants per gram of sample and nil germinant was observed in thirty accessions.

Fig. 13.Variability in stem thickness among the accessions

(f) Cytological studies in *Saccharum* and allied genera – *S. spontaneum*

(V.P. Sobhakumari)

Somatic chromosome number has been determined in 80 clones of *S. spontaneum*. It consist the clones from IND- 09, IND- 11, IND- 15 and IND-04 collections. Different cytotypes like 2n=54, 56, 58, 60, 64, 70, 72, 76, 80 and 86 were identified.

Clone	2n	Clone	2n	Clone	2n	Clone	2n
IND 11-1669	80	IND 11-1694	80	IND 09- 1546	58	IND 15- 1705	72
IND 11-1654	64	IND 11- 1692	80	IND 09- 1540	54	IND 15- 1711	60
IND 11-1650	80	IND 11- 1686	58	IND 10- 1565	60	IND 15- 1709	64
IND 11- 1652	64	IND 11- 1695	80	IND 10- 1574	60	IND 15- 1737	64
IND 11- 1634	56	IND 11- 1690	64	IND 10- 1577	72	IND 15- 1721	64
IND 11- 1633	72	IND 11- 1685	80	IND 10- 1585	72	IND 15- 1747	80
IND 11-1681	56	IND 11- 1642	64	IND 15- 1735	64	IND 15- 1740	64
IND 11- 1682	80	IND 11- 1663	64	IND 15- 1712	64	IND 15- 1742	64
IND 11- 1673	80	IND 11- 1600	64	IND 15- 1704	64	IND 15- 1744	80
IND 11- 1683	56	IND 11- 1669	64	IND 15- 1732	64	IND 15- 1746	64
IND 11- 1655	70	IND 11- 1691	64	IND 15- 1710	64	IND 15- 1728	64
IND 11- 1679	80	IND 11- 1613	64	IND 15- 1727	64	IND 15- 1733	64
IND 11- 1664	64	IND 11- 1619	64	IND 15- 1718	64	IND 15- 1726	64
IND 11- 1667	64	IND 11- 1628	64	IND 15- 1743	64	IND 04- 1349	64
IND 11- 1632	72	IND 11-1612	78	IND 15- 1723	62	IND 04- 1351	56
IND 11- 1599	70	IND 09- 1520	54	IND 15- 1724	66	IND 04- 1354	60
IND 11- 1701	64	IND 09- 1535	54	IND 15- 1725	64	IND 04- 1331	80
IND 11- 1638	64	IND 09- 1541	64	IND 15- 1745	64	IND 04- 1373	58
IND 11- 1598	64	IND 09- 1551	76	IND 15- 1716	64	IND 04- 1352	80
IND 11- 1605	72	IND 09- 1552	76	IND 15- 1719	64	IND 04- 1361	64

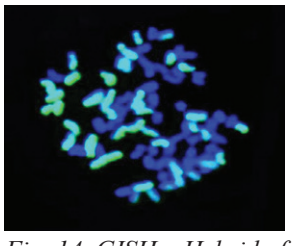


Fig. 14. GISH – Hybrid of E. procerus (green) x S. officinarum (blue)

GISH has been done in F_1 hybrid of *E. procerus* (IND 90-776) x *S. officinarum* (PIO 96-435) by using *E. procerus*(2n=40) as the labelled probe. Forty chromosomes of *E. procerus* have been identified in the hybrid which revealed 2n+n chromosome segregation (Fig 14). *In situ* hybridization in the BC_1 of this hybrid with labelled *E. procerus* genome revealed n+n segregation with 20 chromosomes of *Erianthus*.

(g) Floral biological and cytological characterization of *E. arundinaceus*

(A. Suganya)

Ploidy studies in 82 clones of *E. arundinaceus* indicated 2n=30 in EA B Munja, EA Sarkender, EA Layalpur, EA thornless, Timer wild and US3-1 (Fig 15). Indian clones were predominant with 2n=40. The clones of EA Glagong, EA Andaman and Nicobar, IND 03-1262,1208 from India exhibited 2n=60 as observed in IJ, IK and IM series. The frequency distribution of the three cytotypes of 2n=30, 2n=40, 2n=60 varied with 7.3%, 58.5%, 34.1%

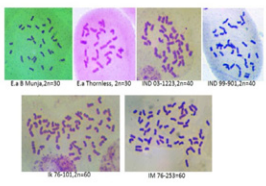


Fig 15. Cytotypes of E. arundinaceus

respectively. Molecular analysis of 11 clones with three ploidies, 2n=30,2n=40 and 2n=60 with SSR markers indicated maximum polymorphic fragments in the Indian collections while the Indonesian clones showed less variation with limited fragments. The Indian clones with 2n=30 and 2n=40 shared about 30 fragments among the 78 fragments generated. A fragment specific to cytotype 2n=30 has been identified (Fig 16).

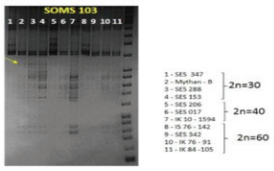


Fig. 16. Molecular polymorphism in the cytotypes of E. arundinaceus.

(h) Evaluation of sugarcane germplasm for abiotic and biotic stress tolerance related traits

(Vinu.T. Lakshmi Pathy, R. Valarmathi and *H.K. Mahadevaswamy)*

Two hundred and three clones of *Erianthus arundinaceus* along with five standards *viz*, Co 99004, Co 06022, Co 86032, Co 0212, Co 775, and 100 clones of *Saccharum spontaneum* accessions along with four standards *viz*, Pamba, Ponape1, Taiwan 96 and IND 85-503 have been planted in augmented design for evaluation of drought tolerance related traits. Morphological and physiological parameters contributing to drought tolerance are being recorded before imposing stress. Genetic diversity analysis using molecular markers has been initiated.

Utilisation of sugarcane germplasm resources for broadening the genetic base

Exploitation of *Saccharum* spp. (improved *officinarum*, improved *robustum, S. robustum* and *S. barberi*) for broadening the genetic base

(S. Alarmelu, C. Jayabose and *Adhini. S. Pazhany)*

S. robustum hybrid group: Among 350 *S. robustum* hybrid (BC_2) derivatives, seven clones had high NMC and 13 clones recorded juice Brix in the range of 20.0 % - 21.50 % and 18.80 % - 19.43% sucrose at 300 days. At 360 days, 11 clones recorded juice Brix in the range of 20.14 % - 22.10 % and 18.20 – 20.26 % sucrose. The progenies of PIR 001057 x CoC 671 and PIR 001058 x Co 86011 contributed more number of red rot resistant types.

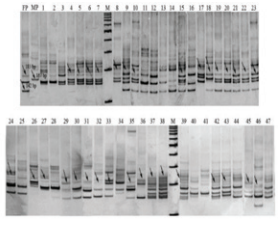


Fig. 17. SSR analysis of interspecific hybrids of S. robustum

S. barberi hybrid group: Among the 135 hybrid derivatives 40 clones had juice sucrose above 18.25 % at 300 days and sucrose % ranged between 17.98 - 20.31 % in the population. The clone 13-176 recorded the highest Brix value of 21.86 % and sucrose of 20.31%. At 360 days, 13 clones had juice sucrose in the range of 19.21-19.82%. The crosses Co 7201 x Pathri, Co 06024 x Co 11012 and Co 0240 x 07-554 were promising with more recombinants for quality and yield traits**.** Flowering intensity was observed upto 60 % in the hybrid clones and 23 back crosses were effected utilizing *S.barberi* hybrids.

Characterization of interspecific hybrids of S. robustum and S. barberi (Pathri) using SSR markers: Nine SSR primers (NKS 2, NKS 3, NKS 8, NKS 14, SMC 863 GC, SMC 319 GC, mSSCIR 54, NKS 28 and NKS 34) were used to evaluate polymorphism levels between *S. robustum* (PIR 00 1057) and CoC 671. Primer NKS 34 showed the greatest capacity for distinguishing the polymorphism between the parents (Fig. 17). Markers *viz*., NKS $34_{142\ \&\ 185}$ were specific to PIR 00 1057, NKS 34_{167} was specific to CoC 671; marker NKS $8_{181,\ 312\ \&\ 336}$ were specific to PIR 00 1057, NKS $8_{250\ \&\ 263}$ were specific to CoC 671. Forty seven interspecific hybrids obtained from the cross PIR 00 1057 x CoC 671 were assessed with primer NKS 34 (Fig. 18), the results of DNA pattern showed 32 interspecific hybrids were heterozygous possessing

the specific DNA patterns of both male and female parents and also with more additive bands. Primer NKS 14 was polymorphic between *S. barberi* (Pathri) and Co 7201. Marker NKS $14_{390\ \&\ 400}$ were specific to *S. barberi* (Pathri), NKS 14_{288} was specific to Co 7201(Fig. 18)

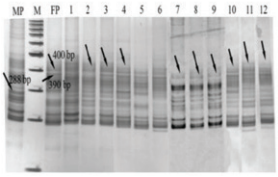


Fig. 18. SSR analysis of interspecific hybrids of (PIR 00 1057 x CoC 671) with primer NKS 34.

Lane MP: S. barberi (Pathri) x Co 7201 amplifiedmale parent, FP: female parent,

Arrows indicates male female parent specific polymorphic markers. Lanes 1-23: F1.Lanes 24-47: BC1.

Maintenance breeding: A total of 560 pre- breeding stocks are maintained for utilization.

(iii) Development of Multiparent Advanced Generation Inter-Cross (MAGIC) population for drought tolerance in sugarcane

(K. Mohanraj, G. Hemaprabh and *S. Vasantha)*

*Developing four way cross populations***:** Forty crosses were made using randomly selected progenies from two way cross populations during the crossing season 2016. The fluffs are yet to be sown.

Screening two-way cross populations: A total of 1060 seedlings from 12 crosses were screened for cane height, no. of canes, cane diameter and HR Brix at 10th month. The cross Co 95005 x CYMA 09-1369 recorded a mean cane height of 231.4cm with a mean HR Brix of 20.6%

Screening founder parents for drought tolerance: Twenty parental clones were evaluated for drought tolerance and maximum reduction was observed for cane height (32.83%) followed by cane weight (33.02%). The performance of the parental clones along with susceptible check Co 775 under both drought and control condition is given in the Fig. 19. The clones were evaluated for physiological traits *viz*., total dry matter production, leaf area index, RWC, wax content and MDA content at the end of stress period. The leaf area index ranged from 4.48 (Co 09013 and Co 95005) to 7.80 (Co 775) in control and from 0.68 (Co 775) to 5.15 (ISH 176) under water stress condition. The highest relative water content was observed in Co 06022 (68.09%) followed by GU 12-21 (67.75%) under water stress. The clones CYM 08-922, ISH 176, Co 06022, GU 12-21 recorded higher total dry biomass under drought. The changes in the physiological traits of parental clones under drought are given in the Fig. 20.

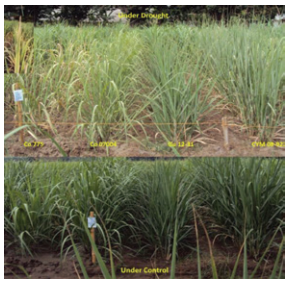


Fig. 19. Relative performance of parental clones under drought

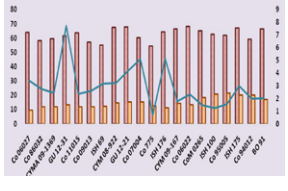


Fig. 20. Relative water content, Wax and Leaf area Index of parental clones under drought during 2016-17

Evaluation of clones from two way cross populations for drought tolerance: From the two way cross populations, 96 clones were selected and planted in the field with two replications in both control as well as drought condition to evaluate their relative drought tolerance. Drought stress was imposed on 75 DAP by withholding irrigation. Pre stress observations *viz*., no. of tillers and stalk height were recorded. The clone 2015-83 from the cross CYM 08-922 x ISH 176 recorded the highest stalk height of 104.5cm @ 75 DAP.

(v) Utilisation of sugarcane germplasm resources for broadening the genetic base

Utilisation of germplasm resources for developing new genetic stocks Coimbatore

(K. Mohanraj, A. Suganya and *A.J. Prabakaran)*

Hybridization: During the crossing season 2016**,** 20 back crosses were made involving BC_1 hybrids of *E. procerus* and other derivatives. The fluffs are yet to be sown.

Ground nursery: A total of 773 seedlings from 26 crosses were transplanted in

the field. Maximum of 214 seedlings were from the cross Co 7201 x S1-GU 04(28) EO-2 and 177 from GU 12-33 x Co 94008. The back cross progenies from GU 04 (28)EO-2 self x Co 97015 recorded a mean stalk number of 11.0, Brix of 15.08% and stalk diameter of 2.07cm.

Screening BC_1 hybrids of E. procerus for drought tolerance: Screened 17 BC hybrids along with their parents and susceptible check Co 775 for drought tolerance and the hybrids GU 12-28 and GU 12-30 recorded the significantly higher stalk height and tillers compared to susceptible check Co 775 under drought condition at the end of drought stress. Highest mean reduction was observed for stalk height (24.28%) followed by internode length (18.68%) in water stress. Among the BC hybrids, least reduction in stalk height was observed in the clones GU 12-22, GU 12-26 and GU 12-30.

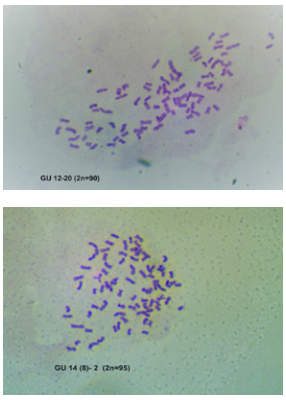


Fig. 21. Somatic chromosome number of GU 12-20 and GU 14 (8)-2 23

Effect of drought on flowering: Water stress significantly reduced the flowering in BC hybrids of *E. procerus*. Among the 17 clones, 14 clones flowered under control and only six clones flowered under water stress condition.

Cytological characterization: Twenty five back cross hybrids involving *Erianthus* were characterized cytologically and their observed somatic chromosome number is given in the table 10. The somatic chromosome number of the four BC_1 hybrids ranged from 90 to 92 and the parent Co 06027 had 2n=108. The BC hybrids GU 12-20 and GU 12-21 and GU 12-34 recorded a somatic chromosome number of 2n=90 (Fig. 23). In the back cross progenies from the cross GU 04(50) RE-24 x BO 91, two progenies *viz*., GU 14 (8) -2 and 3 had a somatic chromosome number of 2n=95 and confirmed as true hybrids (Fig 21.).

Table 10. Somatic chromosome number of back cross hybrids involving Erianthus

Clones	Cross	Observed chromosome no.
GU 12- 20, GU 12- 21, GU 12- 29, GU 12- 34	GU 04(28) EO-2 (2n=80) x Co 06027 (2n=108)	90,90,92,90
GU 14 (37)-1,3,4,5,6,7,8,10	CoC 671 (2n=110) x GU 04(28)EO-2 self (2n=80)	98,102,98,102,98,92,102,100
GU 14 (38)-8,9,10	GU 04(28)EO-2 self (2n=80) x Co 97015	80,94,112
GU 14(17)-1,2,4	GU 04 (6)OE-3(2n=86) x Co 0209	108,100,102
GU 14 (8)-1,2,3,4,5,6,7	GU 04 (50)RE-24 (2n=80)xBO 91 (2n=106)	80,95,95,106,80,80,80

Sugarcane genomics and molecular markers

Development of transcript SSR markers for sucrose synthesis and WRKY transcription factors among the elite sugarcane clones used as parents in breeding programmes

(R.M. Shanthi and *G. Hemaprabha)*

Molecular diversity analysis of sucrose specific microsatellite alleles: Microsatellite allele data sets pertaining to key enzymes involved in sucrose metabolism was analysed through the program PopGene 1.31. Molecular genetic diversity was estimated through Shannon's information index (I),

genetic diversity (GD), heterozygosity (H_o, H_e) and inbreeding coefficient (F_{IS}). A total of seventeen alleles were found averaging 2.05 alleles /locus. The expected number of alleles (N_e) was almost same as that of observed indicating the non-existence of few high frequency alleles in this population. Shannon's Information Index ranged from 0.4506 (CWI1) to 0.8743 (NI1.) with an average of 0.6743. Out of 17 SSR alleles, observed heterozygosity (H_o) was found to be higher than the expected heterozygosity (H_e) for 15 SSR alleles which may be indicative of higher frequency of observed heterozygotes. Lowest H_o value of 0.1429 was observed for the loci PFK2 followed by NI3 (0.2727). Gene diversity estimates of these 17 sucrose specific alleles ranged from 0.2778 (CWI1) to 0.5519 (NI1) with an average of 0.4751. Negative F_{IS} values indicate heterozygote excess (outbreeding) and positive values indicate heterozygote deficiency (inbreeding) compared with HWE expectations. Two alleles *viz*., NI3 (0.3714) and PFK2 (0.7083) registered positive F_{IS} values that represent excess of observed homozygotes and could be correlated with low observed heterozygosity values for these two alleles. Ewens-Watterson neutrality test was performed using Manly's algorithm to investigate the selection events in these sucrose specific microsatellite alleles. Out of 17 alleles investigated, ten allelic variants registered 0.50 observed F values emphasizing the balancing selection employed in our population.The graphical output of the four neutrality parameters (Observed F, Mean, L95, U95) indicated that five allelic variants *viz*., NI3 (0.57), PFK1 (0.59), CWI1 (0.72), CWI2 (0.53), and SAI1 (0.54) exhibited a positive selection in this population of high sugared Co canes developed over decades (Fig. 22).

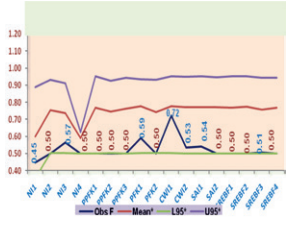


Fig. 22 Manly's Algorithm to test for neutrality of microsatellite alleles specific to sucrose metabolizing enzymes

Functional genomics for water deficit stress in sugarcane

(A. Selvi, R. Manimekalai, P.T. Prathima and *R. Gomathi)*

Morphological and physio-biochemical analysis: Seven Co varieties (Co 8021, Co 775, Co 97010, Co 06022, Co 06015, Co 0315 and Co 99004) were tested in control and drought imposed situations in pot experiments. Differential responses of varieties to water deficit conditions were observed. Chlorophyll fluorescence in severe stress was high in Co 99004 with Fv/Fm value of 0.696. Chlorophyll meter (SPAD) value showed highest reduction in 10 days stress (29.86%), and Co 8021 (65.9%) showed highest reduction. During rehydration Co 06022, Co 99004 and C0 7336 recovered to their control values while Co 8021 and Co 775 did not show any recovery. Co 8021 also showed highest reduction in relative water content while Co 06022, Co 99004 showed least reduction. Co 06022 maintained high chlorophyll stability index. Cellular membrane injury (CMI) under severe stress was maximum in Co 8021 (67.8%). Proline accumulation in leaf at severe stress was maximum in Co 06022 as compared to Co 8021.

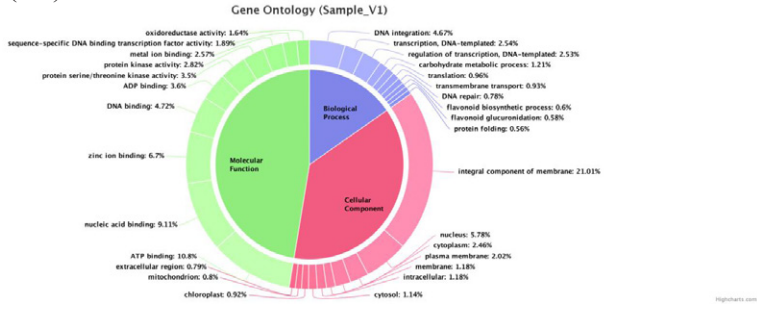
Transcriptome sequencing: The whole transcriptome sequencing of the control and drought treated, tolerant (Co 06022-V2) and susceptible (Co 8021-V1) varieties were carried out by Illumina NextSeq500 (Fig. 23.). The samples were analysed at different drought regimes and recovery after rewatering, to identify transcripts that are associated with drought tolerance in sugarcane. The total transcripts length ranged from 15 and 17 million reads for V1 and V2. The number of transcripts generated before annotation was 1,88,983 for V1 and 2,02,195 for V2. The maximum transcript length was 15,539 for

V1 and 15,573 for V2 whereas the minimum transcript length was 300 for both. The average transcript length was 837.9 for V1 and 870.1 for V2. The number of transcripts >= 300bp was 1,88,983 and 2,02,195 and the number of transcripts >=500bp was 1,11,178 and 1,22,952 for V1, V2 respectively. The number of transcript >=1Kb was 48,723 and 55,872 both V1 and V2.

Analysis of RNA seq data: Analysis of the transcriptome data for candidate genes that are differentially expressed in drought stress was done. The fold change of the differentially expressed genes ranged from 13.00 to 1.00. Several proteins like Peroxidases, Glycosyltransferase, Thaumatin like protein, Zinc finger protein, Ethylene responsive element binding protein, NAC, WRKY DNA binding domain superfamily protein, Embryogenesis transmembrane protein and several transporters like calcium transporter, ammonium transporter etc were seen to be differentially expressed. On a total 64349 unigenes were differentially expressed in drought tolerant and susceptible varieties. Of these 35596 unigenes were upregulated whereas 12907 unigenes were downregulated. Some of the unigenes were found to be uniquely expressed in each of the variety.

Quantitative real time PCR analysis: Expression of genes implicated in drought stress was studied. Expression of dehydrin was 0.9 fold higher in

Co 8021 (V1)



Co 06022 (V2)

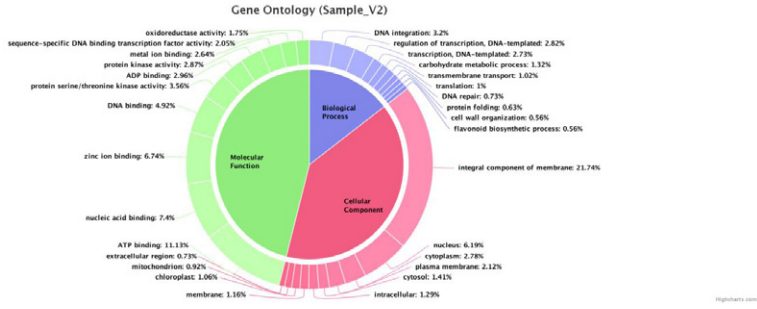


Fig. 23. Gene ontology classification in drought tolerant (Co 06022) and susceptible (Co 8021) sugarcane genotypes

drought tolerant genotype of Co 06022 leaf compared with drought sensitive genotype of Co 8021 leaf. Transcript accumulation of Drought Responsive Protein1 was 1.7 fold higher in Co 06022 leaf compared Co 8021 leaf and 1.9 fold higher in Co 06022 shoot. In the case of DREB2 there was 1.7 fold increase in Co 06022 shoot compared Co 8021 shoot and 1.1 fold increases

in Co 06022 leaf. Transcript accumulation of Sucrose phosphate synthase was 1.2 fold higher in Co 06022 leaf compared to Co 8021 leaf and 0.8 fold higher in Co 06022 shoot.

Field experiments: Drought stress during formative phase of the crop (90-150 DAP) indicated 18.75, and 3.45 reduction in cane length and cane girth respectively, however tolerant varieties (Co 06022, Co 99004, Co 0315 & Co 06015) maintained good yield attributing characters compared to susceptible varieties (Co 775, Co 97010 and Co 8021). There was no significant difference among the varieties in the number of internodes in the treatments studied. Yield in drought treated showed a reduction of 31.70% over control. Results on juice quality parameters at 10th and 12th month of crop indicated that, drought induced 4.80%, 2.29, 0.33% and 6.01% reduction in brix%, sucrose%, purity%, and CCS% over control respectively. Irrespective of the treatments, the variety Co 0315 recorded higher quality parameters compared to other varieties studied. Under drought situation, highest sucrose% was recorded in Co 0315 (20.02%) and lowest recorded in Co 06015 (15.54 %).

Oxidative stress tolerance in light of climate change: Gene discovery and regulation by micro RNAs in *Erianthus sp.* and *Saccharum spontaneum*

(R. Manimekalai, A. Selvi and *R. Gomathi)*

Transcriptome of sugarcane, S. spontaneum and E. arundinaceus under oxidative stress: Whole genome transcriptome was developed under oxidative stress in sugarcane (Co 86032) and wild sp (table 11). The gene expression pattern in terms of fragments per kilo base million (FPKM) values showed that during oxidative stress, the cell wall-associated hydrolase, Dehydration responsive protein and AP2-EREBP transcription factor are differentially expressed between Co 86032, *Erianthus sp* and *spontaneum*. The annotation of the differentially expressed transcripts showed that zinc ion containing gene are differentially expressed in wild sp compared to the Co 86032 (Fig. 24).

Table. 11. Transcripts profile of Erianthus sp., Saccharum spontaneum and Co 86032 under oxidative stress

	Ea Control	Ea Treated	Sp Control	Sp Treated	Variety Con	Variety Treat
Transcripts Generated	69742	48164	59154	44915	59963	63379
Maximum Transcript Length	15488	12126	9783	14117	9760	11327
Median Transcript Length	355	936.5	1526.5	1190	725	985
Transcripts >=300 b	69742	48164	59154	44915	59963	63379
Transcripts >=500 b	42692	32802	34143	31577	41239	42741
Median Transcript Length	22004	16902	14770	16937	20730	22215
Transcripts > 10 Kb	11	6	0	4	0	1

Ea : Erianthus arundinaceus, Sp: Saccharum spontaneum

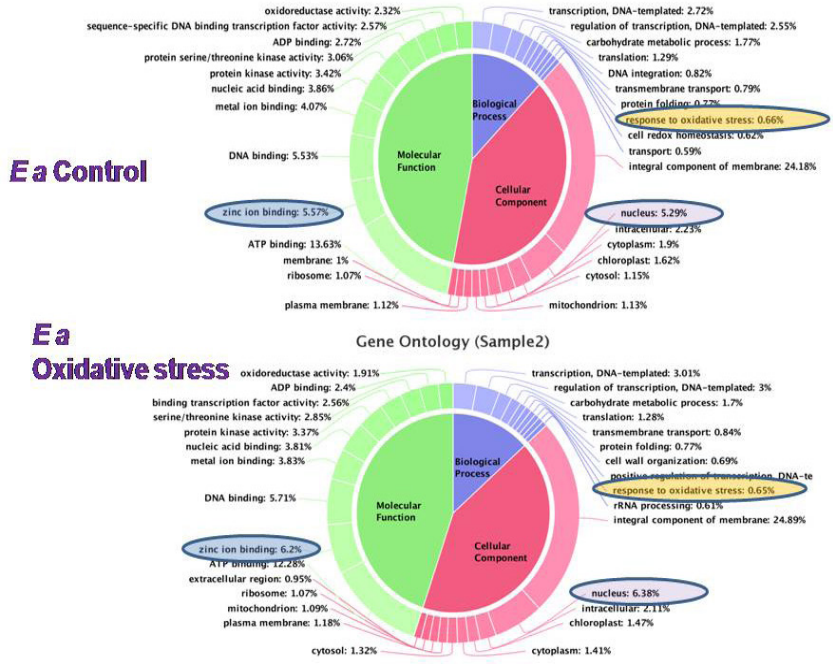


Fig. 24. Annotation of differentially expressed transcripts in Erianthus arundinaceus

Screening of Saccharum spontaneum for oxidative stress tolerance: Screening for oxidative stress tolerance was performed on five different genotypes of *spontaneum (*IMP-564, IS76-216, Pamba, SES-90 and Taiwan) by analysing physiological parameters. Three different concentrations (300 ppm, 500 ppm and 1000 ppm) of 30% H_2O_2 were used. Controls for each type were maintained by spraying with water. Adaptive response in wild species was estimated in terms of Chlorophyll fluorescence, chlorophyll stability index (CSI), peroxidase assay, super oxide dismutase (SOD) assay, lipid peroxidation, protein content, and proline content for 48 hrs and 72 hrs of H_2O_2 treatment. Based on lipid peroxidation, SOD activity and protein content, a high efficiency was indicated for *spontaneum* clone IMP-564. Based on chlorophyll fluorescence, CSI, peroxidase, SOD activity and lipid peroxidation values, high performance was observed for the clone SES-90. Most of the clones showed a consistent increase in stress tolerance when they are subjected to 48 hrs of treatment which implies the genes contributing oxidative stress tolerance express during 48 hrs of treatment. But proline got expressed on prolonged exposure of H_2O_2 (in SES 90 with 72 h treatment) implying its osmolytic activity.

Gene expression pattern under oxidative stress treatment – Quantitative Real Time PCR: The expression pattern of seven of multiple stress responsive genes (HSP, APX, NAC, ERF, GST, MYBAS and CAT) were studied in *Erianthus*- IJ76-389 and IK76-91; *Spontaneum*- SES-90. For MYBAS transcription factor, *Erianthus* clones IJ76-389 and IK76-91 showed a remarkable increase at 500ppm and 1000ppm H_2O_2 respectively for both 48 and 72h. At 500ppm, all three clones showed a remarkable increase in expression of GST during 48h induction of H_2O_2. IK76-91 showed an increase in NAC gene expression under both 48 and 72h of treatment with 500ppm H_2O_2. IK76-91 also showed an increase in APX expression on treatment with 500 and 1000 ppm for 48 and 72h.

Micro RNAs of sugarcane, Erianthus sp *and Saccharum spontaneum under oxidative stress:* Micro RNA profiles of sugarcane, *Erianthus* sp and *spontaneum* showed that there is only a small number of common miRNA between *Erianthus arundinaceus* and *spontaneum* (6.2% control and 2.4% treated samples), the miRNA which were significantly expressed during the stress, followed the same expression pattern. Thirty eight such miRNA were found to be differentially expressed and 10 miRNA were further filtered for their significant differential expression.

Cloning of NAC gene responsive for oxidative stress tolerance from Erianthus sp.*:* Primers were designed using available sequence information from EST database to amplify NAC gene responsive for oxidative stress tolerance from *Erianthus* sp. PCR was performed with the above said primers and *Erianthus* DNA as template. Expected fragment size (1.8kb) thus obtained was gel eluted. It was then cloned using pTZ57R/T vector (TA cloning kit, Thermo scientific). The gene was transformed into *E. coli* (DH5α) host. Plasmid isolation was performed and sequenced for gene confirmation. The cultures were maintained in LA amp plates.

Subcloning of NAC gene from T/A vector to the binary Vector pRI: To perform the subcloning of NAC into the binary vector, the primers were designed with restriction enzyme (KpnI and Hind III) over hangings in their forward and reverse primers respectively, following directional cloning strategy. The NAC gene was then amplified with those primers using pTZ57R-NAC plasmid DNA as the template. The expected PCR fragment size of 1.8 kb was gel eluted and subjected to double digestion with Kpn I and Hind III. Simultaneously the vector pRI was also subjected to the double digestion with the same restriction enzymes. Then the insert (Size 1.8 kb) and the vector pRI (Size 9.6 kb) are ligated and transformed into *E. coli*. The resultant colonies were confirmed through colony PCR and restriction digestion for the NAC gene.

Establishment of callus cultures in sugarcane: The apical shoots of 3-4 months old crop (Co 86032) was harvested and surface sterilized with 0.1% $HgCl_2$ and the leaf whorls were excised aseptically. These leaf whorls were inoculated in callus induction medium with 2, 4 D in dark for a month. Embryonic calli were selected and subcultured once in 15 days for maintenance.

Establishment of callus induction in sugarcane and tobacco: The apical shoots of 3-4 months old crop (Co 86032) was harvested and surface sterilized with 0.1% $HgCl_2$ and the leaf whorls were excised aseptically. These leaf whorls were inoculated in callus induction medium with 2, 4 D in dark for a month. Embryonic calli were selected and subcultured once in 15 days for calli maintenance. Tobacco seeds were sterilized with 0.1% $HgCl_2$ and were germinated and grown under sterile conditions. Callus induction was performed using MS medium with 2, 4 D in dark from young shoots of 1 month old tobacco plants. Subculturing was performed once in 15 days for calli maintenance.

Characterization of flowering genes in sugarcane

(R. Manimekalai, S. Vasantha A. Selvi and *K. Mohanraj)*

Genomic DNA was isolated from 12 clones of flowering and non – flowering types using CTAB method. The DNA of Co 86032 and Co 99004 were used for optimization of annealing temperature for the primers of flowering

associated genes. All the 4 sets of primer were optimized using Gradient PCR from 55°C-65°C. After optimization the optimum annealing temperature for the following primer was found to be: Lfy 55°C; FT64°C; FD57°C ; CO 62°C. The flowering associated genes were amplified using PCR. The expected product size obtained were LFY (522 bp), Fd (561 bp), FT (750 bp) and CO (568 bp). Obtained a partial gene Lfy (522 bp); a partial fragment of Flowering locus D of 561 bp and a partial gene of FT of 750 bp. All PCR products are eluted and sequenced with respective primers. The blast N result showed that, LFY gene had the similarity of 80 % with query coverage of 98 % with transcription factor floricaula/leafy and putative cell wall-associated receptor kinase-like pseudogene.

Gene discovery and genetic transformation in sugarcane

(C. Appunu)

Gene Discovery: With a view to isolate abiotic stress responsive genes and understand the allelic diversity, *E.arundinaceus*, *S. officinarum* and *S. spontaneum* were used. Total RNA was isolated from 3rd open leaf of the plant after 10 days drought stressed plants, purified and stored at -80ºC until further use. cDNA was synthesized using Fermentas first strand cDNA synthesis kit by following manufacturers instruction (Fermentas International Inc, Ontario, Canada). The cDNA was stored at -20°C.

Myo-inositol-1-phosphate synthase (MIPS), Glyoxylase III (GLY III), Expansin Alpha1 (EXPA1), Expansin Beta 5 (EXPB5), Expansin Beta 6 (EXPB6), Expansin Beta 7 (EXPB7) were cloned from species clones *arundinaceus*, *S. officinarum* and *S. spontaneum* using gene specific primers designed from *Sorghum bicolor* and *Zea mays (Table 11)*. These genes were named as EaMIPS, EaGLY III, EaEXPA1, SoEXPA1, ShEXPA1, EaEXPB5, EaEXPB6 and EaEXPB7. Coding sequence length of these genes were EaMIPS – 1533bp, EaGLY III – 1164bp, EaEXPA1 – 1330bp, SoEXPA1 – 1282bp, ShEXPA1 – 1267bp, EaEXPB5 – 1319bp, EaEXPB6 – 1274bp and EaEXPB7 - 1388bp. Primers used for PCR amplification of these genes are given in Table 12. The amplified products were separated in a 1% agarose gel and were eluted from the gel using MEGA-Spin TM Agarose gel extraction kit (Intron Biotechnology INC, Korea).

Table 12. Primers used for PCR amplification of abiotic stress responsive genes

Primers	Sequence (5' – 3')
MIPS F	ATGTTCATCGAGAGCTTCCGCGTCGAGA
MIPS R	TCACTTGTACTCCAGGATCATGTTGTTCTCTGGGGCCA
GLY IIIF	ATGGCGGCGAAGAAGGTGCTCATGCTCT
GLY III R	TCAGAAGGAAACCTTGACGCCGAGCAA
EXPA1F	ATGGCAGCTGACAATGTCCTGCTC
EXPA1R	CTAGAACTGGGCGCCCTCGAAG
EXPB 5F	ATGGCATCCTCCTTCTCCAAGGTGGTC
EXPB 5R	CTAGTACTGAATGATGGAGCGGTAGTAGGT
EXPB 6F	ATGGCACCGCGCTCTCCTTCAA
EXPB 6R	TTAGTACTGGACGAAGGAGCGGTAGTCGA
EXPB 7F	ATGGCCACAACCTTGTCCTCCACAGTA
EXPB 7R	CTAATACTGGACGATAGAACGGTAGTAGGTGTTG

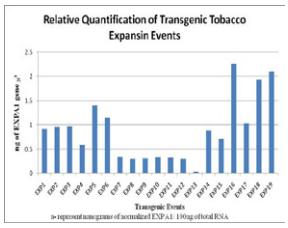


Fig. 25. Relative quantification analysis of EXPA1 in T0 generation of tobacco events.

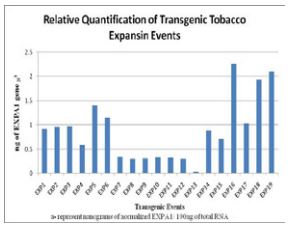


Fig. 26.Relative water content in sugarcane transgenic events and untransformed control (Co 86032) with and without soil moisture stress. Data followed by an (*) showed a significant difference with respect to control Co 86032 (P≤0.05; Student's t-test). Data are presented as mean ± SD (n=5) and error bars represent SD

Genetic transformation: Expansin genes cloned from wild sugarcane were functionally validated through plant transformation. EXPA1 from *E. arundinaceus* (IK76-81) which is of 1330 bp long with two introns and CDS of size 762 bp was cloned in pCAMBIA1305.1 vector driven by Port ubi882 promoter by replacing β-glucuronidase (GUS) and CaMV 35S promoter, respectively. By *Agrobacterium* mediated transformation Port ubi 882+EXPA1 was transformed both in tobacco and sugarcane. Total of 18 independent PCR confirmed tobacco transgenic events were obtained and relative quantification analysis was carried out in T_0 generation (Fig. 25). Based on the relative quantification analysis events were selected and further multiplication is in progress to obtain T_1 generation.

In sugarcane, V_0 generation putative transgenic events were screened and positive plants were taken to next generation (V_1). A total of 18 V_1 events were subjected to the drought stress for 10 days in completely randomized design with five replications. Physiological parameters such as photosynthetic efficiency (Fv/Fm), chlorophyll content, relative water content (RWC), cell membrane injury (CMI) and visual scoring was carried out. The results of these experiment showed that there is significant difference in the transgenic events compared to non-transgenic plant (Fig 26). The transgenic events has increased RWC, chlorophyll content, photosynthetic efficiency and it could even recover faster when compared to non-transgenic plant after the release of drought stress (reirrigation).

Genetic engineering of sugarcane for enhanced salinity stress tolerance

(K. Lakshmi and *C. Appunu)*

Genetic transformation of sugarcane clone Co 86032 with *pCAMBIA 1302 :: GLY I & II* was done. The transformed explants were placed on primary selection medium with hygromycin as the plant selection marker. Batches of sugarcane calli were transformed with the gene construct and the transient expression was studied through GUS staining. The T_o transformants are in the selection medium with hygromycin.

Isolation of genes governing salinity stress tolerance was initiated in *Saccharum* complex. The salinity genes targeted were NHX, SOS, RAB, HKT, CDPK, LEA group of proteins, MYB, as well as osmoprotectant governing genes like (Trehalose and Pyroline). Conserved regions of three genes were cloned from *Erianthus viz.,* NHX (320 bp), SOS (480 bp) and RAB (620 bp). The sequences were analyzed and found that SOS showed 89% similarity with *Setaria italica* sodium/hydrogen exchanger and RAB which is a dehydrin coding gene involved in solute exclusion showed 98% similarity to SOS1 of sugarcane. Further the isolation of full length of these genes is in progress through 5' and 3' RACE.

Isolation, cloning and characterisation of novel stem specific promoter from *Erianthus arundinaceus*

(Lovejot Kaur and *C. Appunu)*

Two stem specific genes i.e. Dirigent (DIR) and O-Methyl Transferase (OMT) were amplified using the primer pairs DIR F: 5'-CTGCGACAGCTAGAGGCGC -3' and DIR R: 5'-GCATGGGCCCTCCCAATTTTGAG -3' and OMT F:

5'-GCATAGGCATTGTAAAAGCGGT- 3'; OMT R: 5'-CCCATGAAACTCTCTCT ACTCGC), respectively. These genes were isolated both from *E. arundinaceus* Bethuadahari and Co 86032. Sequence analysis of dirigent gene revealed that the complete sequence was 837 bp and 864 bp for *Erianthus* and *Saccharum*, respectively, with two intervening intron and a coding sequence of 563bp. In case of OMT gene (1.2 kb), with one intervening intron and a coding sequence of 1073 bp. The sequences were found to be 96% and 91% similar respectively with other reported dirigent and OMT genes from *Saccharum* hybrid cultivar CP72-1210. The 5' regulatory sequence of these two genes was amplified through RACE. Sequence analysis of cloned regulatory region of the dirigent gene (in case of both *Erianthus* and *Saccharum)* revealed a 377bp sequence of which 50bp is 5' UTR and 327bp is a putative promoter sequence. Similarly, 438 bp of OMT regulatory region sequence was obtained with a 40 bp 5' UTR and 398 bp putative promoter sequence (Fig.27). Standardization of subtractive hybridization technique to isolate stem specific genes from *Erianthus* by comparing two populations of mRNA i.e from stem and leaf is in progress.

Fig.27. Regulatory sequence of 377bp sequence of dirigent gene with 50bp 5'UTR and 327bp putative promoter sequence (a) and regulatory sequence of 438 bp sequence of OMT gene with 40bp 5'UTR and 398bp putative promoter sequence (b).

Investigation on the role of invertase inhibitory proteins in sugarcane.

(G. S. Suresha and *Lovejot Kaur)*

A project was initiated with the objective to understand the functional role of sugarcane invertase inhibitory proteins in improving sucrose yield by stabilizing the sucrose accumulation at/after crop maturity. Sugarcane genotypes with contrasting phenotype for sucrose i.e. Co11015 (high sucrose) and BO 91 (low sucrose) were field planted to study differential expression pattern of invertase inhibitor genes. Invertase inhibitor gene constructs already developed at CSIRO, Australia as part of IACBGF were received with MTA between ICAR-SBI and CSIRO, Australia. The plasmid DNA of the invertase inhibitor gene constructs was transformed into *E. coli* DH5α for sub cloning into binary plant transformation vector.

MULTI-DISCIPLINARY PROJECTS

Standardization of true seed production technique through developing homozygous parental lines and apomixes

(Bakshi Ram and G. Hemaprabha)

a) Inbreeding

At Coimbatore

(G. Hemaprabha, A. Anna Durai and *T. Lakshmi Pathy)*

Screening of new inbreds : Selfs of ten sub-tropical sugarcane genotypes effected during 2015 were studied along with those of tropical genotype (S_1 progenies of Co 775) for H.R. Brix, cane diameter and NMC at 300 days of crop age. The highest variation for H. R. brix was observed in Co 775 (0.12) which had lowest parental mean while the lowest was in LG 99183 (0.07). For NMC, LG 99122 produced the maximum variation (0.61) on selfing, in contrast to Co 775 with the lowest variation (0.54) among their progenies. Similarly for cane diameter LG 99122 (0.17) produced the highest variation and LG 99183 (0.09) the lowest variation.

Another set of 336 new self populations from nine parents at different generations of selfing were screened and putative selfs were field planted for confirming their selfed status and for utilization in selfing/ crossing.

Screening of available inbreds: Out of 300 available selfs, eight S_1 generation selfs from six parents, five S_2 generation selfs of Co 775, six S_5 generation selfs from a specific S_4 parent of Co 1148 viz 1148-13-11-2-252 and two S_6 generation selfs of Co 1148 recorded >22 % Brix at 270 days (October, 2016) of planting. Among these the flowered selfs that surpassed a threshold level for cane yield parameters and /or combining red rot resistance were used in crossing /further selfing.

Red rot reaction of inbreds: Fifty inbreds of Co 1148, Co 99008, Co 775, Co 0304, Co 98006, Co 97015, Co 88025, Co 8371, and Co 86011 were studied for their reaction against red rot pathogen by CCT method. There were 17 susceptible, 11 moderately resistant, 11 moderately susceptible and four highly susceptible inbreds. Six inbreds viz., 99008-113-257, 1148-13-11-2-237-97, 99008-113-238, 1148-S4-242-12, 671-1 and 97015-269 showed resistance reaction.

Selfing /crossing during 2016 flowering season: Selfing was effected in 25 genotypes including eight tropical, five subtropical clones. Among the 615 available inbreds, selfing was done in 33 inbreds.

Crossing : Sixteen crosses were effected making use of selfs at different generations of selfing (S1xS5-2, S2xS4-2, S2xS5- 4, S2xS6: 3, S3xS4 -1, S4xS6- 1, S6xS2- 1, S6xS4-1, S6xS5-1) and the fluff will be transferred to the group dealing with hybrid evaluation.

Arrow length of inbred generations: 37 Inbreds of Co 1148 and Co 775 were assessed for arrow length . The arrow of Co 775 recorded 61 cm while its selfs at S_1 and S_2 generations had mean length of 54.5 cm and 64 cm respectively, showing reduction in the length of arrows through selfing. However, Co 1148 showed a contrasting behaviour. The arrow length of Co 1148 was 62 cm, while its fourth, fifth and sixth selfing generations had corresponding lengths

of 63, 67.18 and 69.25 cm. There was variation in the number of panicles. A elaborate study on arrow legth and weight will be taken up during ideal flowering season.

At Kannur

(K.Chandran)

372 progenies from 11 selfs were observed for tillering, cane thickness, pre monsoon shoot height, leaf length and leaf width to check the uniformity among the progenies, The inbred progenies of CP 94-1100 and NCo 310 were more uniform with respect to cane thickness and NCo 310 for leaf width and shoot height. For leaf length progenies CPCL 41-111 and CP 70-1133 were more uniform. First inbreds of six parents were further selfed and 431 seedlings replanted in ground nursery. Five selfings on exotic hybrids were repeated and 594 seedlings were raised

Chromosome elimination

(P. V. Sobhakumari)

In order to develop the mutant population two varieties, Co 1148 and Co 775 were selfed and selfed seeds were treated with 0.3% (v/v) EMS solution. The concentration of the chemical mutant has been standardized after considering LD 50. Three hundred seedlings from Co 775 and 140 seedlings from Co 1148 were raised from the mutated seeds. Hundred seedlings of Co 775 and 90 seedlings of Co 1148 were planted in the field. Survival of the mutant population was poor in the field. Genomic DNA has been isolated from the control plants of these varieties and centromeric related gene (CENH3) has been amplified and sequenced. This will be used as reference sequence for characterizing CENH3 gene in mutant population. Isolation of genomic DNA from the mutant population is in progress.

As only few clones survived in the field, a set of somaclones were developed from Co 775 by inducing callus and treating the callus with two concentrations of EMS, i.e., 0.2% (v/v) and 0.05% (v/v). The calli were transferred to differentiating medium after EMS treatment. Plants were regenerated, rooted and hardened. Around 300 somaclones were developed and replanted to polythene bags for further evaluation. A set of mutated population has been developed from the variety Co 0238 by treating its calli. Selected clones were replanted with control. The mutant populations will be analysed for centromeric gene variation and the variants will be used as female or male parent in the crossing programme.

Wide hybridization

(K. Mohanraj, R. Karuppaiyan and *A.Suganya)*

Morphological characterization: One hundred and sixty seven progenies from five wide crosses of 2015 were screened morphologically and distinct progenies were characterized cytologically to determine the somatic chromosome number.

Co 86032 (2n=108) x *Sorghum bicolor (2n=20):* Fifty seedlings were planted in the field for characterization. The number of stalks ranged from 1 to 34 with a mean of 7.77. The HR brix ranged from 14.0 to 24.0 with a mean of 21.00. Ten progenies were examined cytologically and the somatic chromosome number ranged from 2n=65 to 2n=110. One of the seedlings viz., TS (15)

8-10 is identified as a true hybrid between Co 86032 x *Sorghum bicolor* with a somatic chromosome number of 2n=65 resembling the sugarcane parent and lacked vegetative vigour. It recorded 34 stalks with a diameter of 1.18cm and HR brix of 19.0% at 10th month. The remaining progenies will be characterized to identify any possible haploids.

CoC 671(2n=110) x *Dendrocalamus giganteus (2n=72):* Twenty four seedlings were screened morphologically. The stalk number in this cross ranged from 1.0 to 8.00 with a mean of 4.63 and the stalk diameter ranged from 2.02 cm to 3.76 cm. The cross had a mean HR brix of 20.77. Most of the clones resembled female parent. Eight progenies were studied cytologically and the somatic chromosome number ranged from 2n=108-110 and are probable selfs.

Hybridization: Three sugarcane clones viz., CoC 671, CoJ 83 and CoLk 8102 were crossed with *Sorghum bicolor*, *Zea mays* and *Cynodon dactylon* grass at Coimbatore during the crossing season 2016. The fluff was sown and seven seedlings were obtained. At Agali centre, 11 wide crosses were made during Oct-Nov 2016 between sugarcane x *Zea mays*, *S. officinarumx Zea mays*, *S. sinense* x *Zea mays*, sugarcane x *Cenchrus* grass, *S. sinense* x *Neyrudia* with an objective of obtaining haploid sugarcane and the fluffs are yet to be sown.

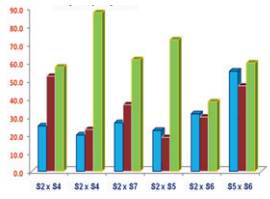


Fig. 28. Extent of variation in the inbred population for cane yield and juice quality traits

Evaluation of hybrids

i) Tropical (Coimbatore)

(R.M. Shanthi, S. Alarmelu and *R. Karuppaiyan)*

Variability for cane colour in different combinations of inbreds: Six combinations of inbreds had the required progeny size (80 seedlings/cross) for evaluation at Coimbatore centre. Pattern of segregation indicated 2-6 color classes for cane color**.** Percent population resembling the stalk color of female parent ranged from 19.20% (S2xS7) to 65.00% (S2xS4) while it ranged from 13% (S5xS6) to 38% (S2xS4) at Agali centre. In crosses viz., S2 x S4, S2 x S6, rare segregants for stalk color that had no resemblance with either of the parents could be observed.

Variability for cane parameters & juice quality traits: Considerable amount of variation for cane color, stalk height, stalk diameter and HR Brix could be observed despite the inbred population with progenies from advanced stages of selfing viz., S5 x S6 (Fig.28). Overall, the inbred population appeared to be tall, medium thick with moderate levels of Brix. Comparative studies on the selfs, GCs of the parents and the intermated progenies might be useful to understand the extent of variability available in inbreds at different stages of selfing.

Evaluation for diseases

(V. Jayakumar and *K. Nithya)*

Isolation and characterization of seed borne, seedling and soil borne pathogens: From sugarcane true seed samples 83 fungi were isolated and characterized. Analysis of sporulation properties of fungi showed that except 10 fungal cultures the remaining 73 fungi produced spores and their sporulation in PDA varied from minimum to profuse sporulation.Based on cultural, morphological and spore characters 61 fungi were identified at genus level and grouped in 7 genus viz., *Claviceps*, *Fusarium*, *Alternaria*,

Curvularia, *Bipolaris*, *Cochliobolus*, *Drechslera*. The unknown fungi were identified by molecular characterization and the identity were established as *Nigrospora sphaerica, Phoma herbarum, Nigrospora oryzae, Daldinia eschscholtzii, Xylaria* sp, *Preussia* sp, *Rosellinia* sp, *Chaetomium globosum*. Altogether the true seeds of sugarcane showed presence of 8 fungi belonging to genus *Claviceps*, *Fusarium*, *Alternaria*, *Curvularia*, *Bipolaris*, *Cochliobolus*, *Drechslera* and *Nigrospora* and among them *Cochliobolus, Curvularia, Bipolaris* and *Drechslera* complex was commonly found in many seeds. The fluff seedlings bearing various types of symptoms were collected and isolated on PDA medium. The isolated fungi were characterized and identified at genus level as *Curvularia* sp, *Helminthosporium* sp, *Fusarium* sp, and *Alternaria* sp. These are the frequently occurring fungi that were reported on true seeds. *Pythium* sp causing damping off of sugarcane seedlings were isolated and characterized. Pathogenicity of the most common frequently occurring fungi i.e., *Curvularia* sp, *Helminthosporium* sp, *Fusarium* sp and *Alternaria* sp were proved by inoculating these fungi on seedlings.

Assessing seed mycoflora of fuzzed and defuzzed seeds: A set of 23 fuzzed and mechanically defuzzed seeds were assessed for presence of pathogens by inoculating them in agar medium. In fuzzed seeds 10-100% seeds showed presence of fungi, whereas in defuzzed seeds only 0-46.6% seeds showed the presence of pathogen, i.e., nearly 50% of fungi present in fuzz were eliminated by mechanical defuzzing. Among the identified fungi *Curvularia, Cochliobolus, Drechslera* and *Alternaria* were not eliminated by defuzzing.

Agronomic practices for seedlings

(A.S.Tayade, P. Geetha and *S. Anusha)*

With the objective of developing agro-techniques for true seed seedling a field experiment with split plot design replicated thrice was conducted wherein, seedling nursery of Co 12014 was raised from the fluff. In main field true seed seedlings were transplanted along with tissue culture and bud chip settlings with two intra-row spacings of 45 and 60 cm and three planting depths of 2.5,5 and 7.5 cm. Shoot count data at 45 DAT reveled that tissue culture seedling (122183 shoots/ha) and true seed seedling (90906 shoots/ha) recorded significantly higher shoots than bud chip settling whereas, the differences for shoot count in intra row plant spacing's (45 and 60 cm) and planting depths (2.5, 5.0 and 7.5 cm) were nonsignificant. Striking differences were observed in yield contributing parameters of three planting materials, wherein bud chip settling recorded higher plant height (237.77 cm), number of internodes (30.81), cane girth(30.99 mm) and single cane weight (1.77 kg) than tissue culture seedling and true seed seedling. At harvest, tissue culture seedling (105982 NMC/ha) and true seed seedling (100854 NMC/ha) recorded significantly higher NMC than bud chip settling. As far as cane yield is concerned all the three planting materials i.e. tissue culture seedling, bud chip settling and true seed seedling recorded the on par cane yield of 124.44, 121.30 and 118.57 t/ha, respectively. Amongst two intra-rows spacing planting sugarcane seedlings/settling at 60 cm intra row spacing was found beneficial in increasing cane yield and recorded significantly higher cane yield (125.94 t/ha) than 45 cm intra row spacing, whereas, in case of seedling/settling planting depth the differences for cane yield were non-significant.

Seed processing, packaging and storage

(N. Rajendra Prasad)

During 2016-17, hybridization season, open pollinated seed fluff of 161 clones were collected, dried and observations were made on weight of seed fluff per arrow, 100-seed weight, germination percent. Defuzzing by hammer mill was successful. The defuzzed seed was cleaned by shaker and hand sieving.

Observations were made on defuzzed seed recovery, 100-seed weight and germination percent. The defuzzed seed of 161 clones was stored for future use.

The data analysed revealed that the mean weight of fluff from each arrow has been 4.942 g and the weight of fluff/arrow ranged from 1.08 g (Co 841) to 11.635g (Co 8311). Mean 100-seed weight of seed fluff was 88.0 mg. and 100-seed weight among 161 clones ranged from 22 mg. (Co 97014) and 141 mg. (Co Se 92423).The mean germination percent of seed fluff was 4.006 and it ranged from 0 (ISH 100 and 80 others) to 50% (Co 1251 and 1148.13.11) among 161 clones.

From defuzzed seed, mean 100-seed weight of defuzzed seed has been 76.32 mg and 100-seed weight among 161 clones ranged from 32 mg. (Co 62422) to 126 mg.(Co 97004). The mean germination percent of defuzzed seed was 2.93% and it ranged from 0% (54 Clones) to 56% (Co 8311) among 161 clones. As compared to previous year either in seed fluff or defuzzed seed, the seed setting ability has declined as evident from seed germination test. This might be due to the severe drought prevailing during crop growth

All India Coordinated Research Project (Sugarcane)

Initial Varietal Trial (Early)

(G. Hemaprabha)

Out of eight entries evaluated with three standards, two entries viz. MS 13081 and Co 13003 were significantly superior for CCS yield and cane yield over the best standard CoC 671. However for sucrose %, all the entries were poorer than CoC 671 (21.00). Among the entries CoSnk 13101(19.49) and Co 13002 (19.37) were the best, and three more entries Co 13003, CoN 13072 and MS 13081 recorded above 18 % sucrose at 300 days. Combining yield and quality, the entries MS 13081, Co 13003, Co 13002 and CoN 13072 were found to be promising.

Advanced Varietal Trial (Early) I Plant

(Adhini S. Pazhany)

Five entries *viz*., Co 11001, Co 11004, CoM 11081, CoM 11082 and CoM 11084 along with three standards (Co 85004, Co 94008 and CoC 671) were evaluated and the entry Co 11001 recorded the highest cane yield of 136.87 t/ha followed by CoM 11082 (133.88 t/ha) which were numerically superior to the standard CoC 671(125.03t/ha) and Co 94008(115.58 t/ha). The juice quality was evaluated at 300 days and the entry Co 11004 recorded the highest juice sucrose of 20.07% while the best standard CoC 671 recorded 20.92%.

Advanced Varietal Trial (Early)

(A. Anna Durai and *C. Mahadevaiah)*

Eight test entries (Co 10004, Co 10005, Co 10006, Co 10024, Co 10026, Co 100027, CoT 10366 & CoT 10367) and three standards (CoC 671, Co 94008 & Co 85004) were evaluated in Advanced Varietal Trial (Early) II Plant. Among the test entries, Co 10026 (22.31 t/ha), Co 10005 (19.99 t/ha) and Co 10024 (17.81 t/ha) recorded significantly superior CCS yield as compared to the best standard CoC 671 (17.11 t/ha). Maximum cane yield of 177.05 t/ha was recorded by Co 10026 followed by Co 10005 (157.40 t/ha), CoT 10366 (137.35 t/ha) and Co 10024 (136.05 t/ha). None of the entries was found superior to sucrose content as compared to CoC 671 (19.07%). However, CoT 10367 recorded maximum sucrose content (19.06%) among test entries followed by Co 10004 (18.54%), Co 10024 (18.46%) and Co 10005 (18.30%).

In the Advanced Varietal Trial (Early) Ratoon, Co 85004 was the best among the standards with 16.08 t/ha sugar yield and 118.29 t/ha cane yield. Among the test entries, Co 10026 was the best with 16.40 t/ha sugar yield and 131.75 t/ha cane yield. Juice analysis indicated that CoC 671 was the best standard for juice sucrose (21.09 %). None of the test entries was superior to the standard CoC 671 for juice characters.

Pooled analysis of two plant and one ratoon crops of the eight test clones and three standards had shown that CoC 671 was the best standard for sugar yield (16.36 t/ha) and four test entries viz., Co 10005 (16.66), Co 10024 (17.21), Co 10026 (20.47) and Co 10027 (16.43) surpassed best standard for sugar yield (t/ha). For cane yield, among the standards, Co 85004 was the best (126.87 t/ha). The clone Co 10026 (160.62 t/ha) was found superior to the best standard for cane yield. For juice quality parameters, none of the entries was superior to the best standard CoC 671 (14.6 and 20.49 of CCS % and sucrose % respectively) (Table 13). For cane yield Co 10026 showed 26.60 % improvement over the standard Co 85004. For sugar yield, Co 10026 recorded 25.1% improvement over the best standard CoC 671 followed by Co 10024 (5.18%), Co 10005 (1.81%) and Co 10027 (0.41%) (Fig.29)

Table 13. Mean Performance of two plant crops and one ratoon crop in AVT- early trial 2015-2017

Entries	Cane yield (t/ha)	CCS yield (t/ha)	CCS (%)	Sucrose (%)
Co 10004	96.13	12.99	13.51	19.18
Co 10005	125.68	16.66	13.41	18.96
Co 10006	82.35	10.31	12.64	18.05
Co 10024	125.29	17.21	13.77	19.48
Co 10026	160.62	20.47	12.73	18.19
Co 10027	119.21	16.43	13.84	19.58
CoT 10366	112.73	13.90	12.47	18.02
CoT 10367	99.59	13.57	13.63	19.53
Standards				
Co 85004	126.87	16.15	12.76	18.26
Co 94008	95.79	11.54	12.06	17.36
CoC 671	112.96	16.36	14.60	20.49

Initial Varietal Trial (Midlate)

(K. Mohanraj)

Twenty mid-late sugarcane clones were evaluated with two standards and the clone PI 13132 recorded the highest cane yield of 159.30 t/ha followed by Co 13013 (144.95 t/ha) compared to the best standard Co 99004 (123.25 t/ha). The entry Co 13013 also recorded the highest sugar yield of 19.99 t/ha. The clone Co 13020 recoded the highest pol% cane of 17.21 followed by Co 13018 (16.70). The mean fibre ranged from 10.96 (Co 13016) to 13.63% (Co 13005 and PI 13131). The entries Co 13006, Co 13008, Co 13009, Co 13013, Co 13014, Co 13018, CoM 13082 and PI 13132 were found to be promising for cane and sugar yield.

Advanced Varietal Trial (Mid-late) I Plant

(S. Karthigeyan)

Six entries *viz.*, Co 11005, Co 11007, Co 11012, Co 11019, CoM 11085 and CoM 11086 were evaluated with two standards (Co 86032 and Co 99004). At harvest, the standard Co 99004 exhibited better performance than Co 86032 for cane yield, CCS yield, CCS% and sucrose %. The entries Co 11005, CoM 11086 and Co 11007 were significantly superior over both the checks for CCS t/ha. The best entry for cane yield was Co 11005 (142.33 t/ha) followed by CoM 11086 (141.89 t/ha) and Co 11007 (140.23 t/ha). The entries CoM 11086 (18.29 t/ha), Co 11007 (17.95 t/ha) and Co 11005 (16.93 t/ha) were significantly superior to both the checks for CCS yield. For CCS (%) the entries Co 11012 and CoM 11085 were found to be better than the standards. Based on yield, quality and field stand the entries CoM 11086 and Co 11007 were identified promising.

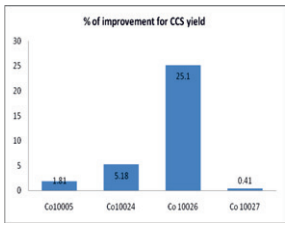


Fig. 29. Percentage of improvement over the best standard (CoC 671) for CCS yield shown by test entries

Advanced Varietal Trial (Mid-late)

(R.M. Shanthi and *S. Karuppaiyan)*

Eleven midlate clones (Co 09009, Co 10015, Co 10017, Co 10031, Co 10033, CoM 10083, CoT 10368, CoT 10369, CoVc 10061, PI 10131, PI 1013211) were evaluated along with to standards (Co 86032 and Co 99004) in Advanced Varietal Trial (Midlate) II Plant. Significantly higher cane yield and CCS yield was recorded by two clones namely, Co 10017 and Co 10033. The cane yield of the clone Co 10017 and Co 10033 were 163.96 t/ha and 153.55 t/ha respectively whereas the cane yield of the best standard Co 99004 was 131.11 t/ha. The CCS yield of Co 10017 and Co 10033 were 21.06 t/ha and 19.83 t/ha respectively whereas the CCS yield of the best standard Co 99004 was 16.86 t/ha.

In Advanced Varietal Trial (Mid-late) Ratoon, Co 86032 (14.13 t/ha) was the better standard for CCS yield. Two midlate clones viz., Co 10017 (17.13 t/ha) and Co 10033 (16.70 t/ha) were found to record significantly higher ratoon cane yield over Co 86032. However, the entry Co 10015 (14.83 t/ha) also registered numerically superior values over Co 86032 for CCS yield. Among the two standards, Co 86032 (102.76 t/ha) was the better yielder in the ratoon crop. Two clones viz., Co 10033 (127.77 t/ha), Co 10017 (121.98 t/ha) recorded significantly superior cane yield over Co 86032. For juice quality parameters, Co 86032 was the better standard for CCS% (13.75) and juice sucrose % (19.47) at 330 days. None of the test entries was found to be

significantly superior over Co 86032 for CCS% and sucrose %. However, three clones viz., Co 10015, Co 10017 and PI 10132 was found to register numerically superior values for CCS% (14.17, 14.04 and 13.78, respectively) and sucrose % (20.02, 19.84 and 19.51, respectively) over Co 86032.

Pooled data analysis of two plant and one ratoon crops indicated that Co 86032 was the better standard that recorded a mean CCS yield of 16.41 t/ha. Of the eleven test entries, three clones *viz*., Co 10015 (17.60 t/ha), Co 10017 (18.98 t/ha) and Co 10033 (18.63 t/ha) were found to perform well across three seasons for CCS yield. The clone Co 10017 (18.41%) recorded the maximum improvement for CCS yield over Co 86032 followed by Co 10033 (13.53 %) and Co 10015 (7.23%). For cane yield, Co 86032 was the better standard with a mean of 116.76 t/ha and four clones Co 10033 (142.53 t/ha), Co 10017 (138.25 t/ha), Co 10015 (124.73 t/ha) and Co 09009 (123.08 t/ha) recorded higher mean cane yield over the standard Co 86032. Among the eleven test entries, Co 10033 registered maximum improvement of 22.08% for cane yield over Co 86032 followed by Co 10017 (18.41%), Co 10015 (6.83%) and Co 09009 (5.42%). For juice quality traits, *viz*., CCS% and sucrose %, Co 86032 (14.02% and 19.78% respectively) was the better standard. Among the eleven test clones, only one entry (Co 10015) surpassed the performance of the standard Co 86032 for CCS % (14.11%) and sucrose (19.94%) with an improvement of 0.64% and 0.81 % respectively (Table14.). Of the eleven test clones, Co 10015 was the only entry that showed improvement over the standard Co 86032 for all the four traits viz., CCS yield (7.23%), cane yield (6.83%), CCS% (0.64%) and sucrose% (0.81) (Fig.30.)

Table 14. Mean performance of two plant & ratoon crops of AVT (Midlate) conducted during 2015-17

Clone	CCS t/ha	Cane Yield t/ha	CCS %	Sucrose %
Co 09009	15.47	**123.08**	12.57	17.94
Co 10015	**17.60**	**124.73**	**14.11**	**19.94**
Co 10017	**18.98**	**138.25**	13.82	19.55
Co 10031	10.75	85.39	12.58	17.91
Co 10033	**18.63**	**142.53**	13.09	18.68
CoM 10083	13.59	103.96	13.09	18.52
CoT 10368	11.59	89.64	13.05	18.48
CoT 10369	14.34	106.98	13.36	19.01
CoVC 10061	11.96	98.15	12.22	17.58
PI 10131	14.78	106.05	13.87	19.65
PI 10132	13.88	102.21	13.63	19.32
Standards				
Co 86032	**16.41**	**116.76**	**14.02**	**19.78**
Co 99004	14.96	113.62	13.17	18.75

Seed multiplication and exchange :

(S. Alarmelu and *P. Govindaraj)*

Seed exchange: The following entries were supplied to Mandya, Perumalapalle, Powarkheda, Pugalur, Rudrur, Sameerwadi and Thiruvalla for multiplication

Early (8) : Co 14005, Co 15002, Co 15005, Co 15006, Co 15007, CoSnk 15101, CoSnk 15102 and CoVSI 15121

Midlate (18) : Co 15009, Co 15010, Co 15015, Co 15017, Co 15018, Co 15020, Co 15021, CoN 15071, CoN 15072, CoSnk 15103, CoSnk 15104, CoVC 15061, CoVC15062, CoVC 15063, CoVC 15064, PI 15131, PI 15132 and VSI 15122.

Seed multiplication: Twelve early and twenty five mid-late clones of 2014 series were multiplied and supplied for planting IVT. Twelve early and fifteen midlate clones of 2012 series were multiplied and supplied for planting AVT. In addition four clones and one standard were sent to Thiruvalla and four clones were supplied to Rudrur, Six Co canes of 2016 series were supplied to Padegaon centre for multiplication.

Jaggery characteristics of AVT Early and AVT Mid-late entries

(A. Bhaskara and *A. Vennila)*

AVT Early Plant I (2016-17) Co clones *viz.,* Co 11001 and Co 11004 were evaluated for jaggery recovery and quality with three check varieties (CoC 671, Co 85004 and Co 94008). The clone Co 11001 had significantly higher juice extraction (62.6%) than any other clone and check varieties tested. The jaggery recovery of entries and clones did not vary significantly and ranged from 11.2 to 12.7 per cent. Among the entries, Co 11001 had significantly higher jaggery yield of 17.3 t/ha which was on par with the check variety Co 85004 (16.5 t/ha) while the entry Co 11004 had a jaggery yield of 14.6 t/ ha. Jaggery quality of all the entries was categorized as Grade I based on the quality parameters. All the entries yielded A1 Grade and Excellent quality when categorized based on Net Rendement (NR) value. The entry Co 11004 yielded golden brown colour jaggery and the entry Co 11001 yielded yellowish brown colour jaggery. The check varies, CoC 671, Co 85004 and Co 94008 yielded golden brown, golden yellow and brown colour jaggery, respectively.

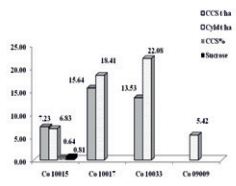


Fig. 30. Percent improvement of AVT(Midlate) entries over Co 86032

AVT Midlate Plant I (2016-17 clones *viz.,*Co 11005, Co 11007, Co 11012 and Co 11019 were evaluated for jaggery recovery and quality with two check varieties (Co 86032 and Co 99004). The clone Co 11007 had the highest juice extraction (60.4%) but was on par with Co 11005 (59.4%) and Co 11012 (58.1%). The jaggery recovery of the entries ranged from 11.0 to 13.6% which were on par. The entry Co 11007 had the highest jaggery yield of 19.1 t/ha which was on par with Co 11005 (16.6 t/ha) but significantly higher than the other entries and check varieties. All the entries yielded A1 Grade and Excellent quality jaggery when categorized based on NR value. Based on quality parameters, jaggery quality of all the entries was categorized as Grade I. All the entries yielded golden brown colour jaggery except the entry Co 11019, which yielded golden yellow colour jaggery.

Physiological parameters - Screening AVT clones for salinity tolerance

(S. Vasantha)

For the crop season 2016-17, six AVT clones (Co 11001, Co 11004, Co 11005,Co 11007, Co 11012 and Co 11019) were screened for salinity tolerance in micro plots. CoC 671 and Co 99004 were used as standards. Soil electrical conductivity was raised to 8dS/m and maintained by irrigating with salt water. Relative performance of the genotypes in terms of cane yield and sugar yield was assessed by plotting the cane yield under treatment against yield under normal condition. Similarly for sugar yield also the relative performance was

worked out. Co 11019 was rated as tolerant and Co 11007 as moderately tolerant to soil salinity, at soil EC of 8 d S m^{-1}.

Physiological parameters - Screening AVT clones for drought tolerance.

(R. Gomathi)

Ten AVT entries pertaining to 2010 series (Co canes only) and 6 AVT entries pertaining to 2011 series (Co canes only) were planted in strip plot design along with 2 resistant standards (Co 86032 and Co 99004). Drought stress was given during formative phase of the crop by withholding irrigation. The percentage of soil moisture depletion at 30, 60 and 90 days after drought treatment through gravimetric method was 30.5%, 41.5% and 62.5% over control respectively. Drought had induced 23.9%, 62.10%, 36.87% and 21.90% reduction in shoot population, plant height, LAI and SPAD value respectively. Under drought, Co 10015 recorded maximum shoot population and plant height. The clone Co 10015 and Co 10006 comparatively recorded higher LAI (5.21) and SPAD value (32.0) respectively under drought condition. Results of 12th month juice quality parameters indicated that, drought induced 18.0, 22.7, 6.30 and 25.0 percent reduction in Brix%, sucrose%, purity% and CCS% over control respectively. Under drought Co 10026 recorded higher Brix%, sucrose%, purity%, and CCS% over control. For the year 2017-18, confirmation trail has been initiated by utilizing 16 AVT clones pertaining to 2010 and 2011 series along with resistant standard (Co 86032). Drought stress has been initiated.

Identification of pathotypes / races of red rot pathogen

(V. Jayakumar and *R. Selvakumar)*

Two new isolates (Cfv09356-Keerangudi and CfPI1110-Nathakadu) along with five old isolates (Cf0323-Pettavaithalai, Cf92012-Kanjanur, Cf91017-Nellikuppam, CfPI1110-Kothangudi and CfPI1401- Kadaganur and two standards (CF06 and CF12) were inoculated by plug method on 19 sugarcane differentials and disease intensity was assessed. The red rot development on differential hosts indicated that all the isolates except CF12 exhibited more or less similar reactions of standard isolate CF06 and among the tested isolates, CF12 exhibited more virulence followed by CfPI1401- Kadaganur and CfV09356-Keerangudi isolates.

Survey of sugarcane diseases naturally occurring in the area on important sugarcane varieties

(R. Viswanathan, A. Ramesh Sundar, P. Malathi, R. Selvakumar, V. Jayakumar and *K. Nithya)*

Detailed surveys for red rot smut, wilt and YLD were conducted in Karnataka and Tamil Nadu. Occurrence of red rot in Co 86027 and TNAU Si8 was found in Namakkal and Tiruvannamalai Districts, respectively. Trace incidence of red rot was found in a ratoon crop of Co 06022 in Nagapattinam Dt. Sudden outbreak of smut in Co 86032 was found in Villupuram and Tiruvannamalai districts. Continuation of the old varieties such as Co 97009 and PI-96-843 with severe smut was found to be the reason for the sudden outbreak of the disease. Further severe wilt outbreak was found in both the states. The varieties Co 62175, Co 86032 and Co 0323 were affected in the Karnataka state and in many varieties in Tamil Nadu. Severe occurrence of brown rust was found in Co 0323 in Karnataka. Degeneration in the cvs Co 86032, CoA 92081 and

CoV 94101 was found due to YLD and mosaic. Occurrence of GSD was found in many districts in the popular variety Co 86032 where healthy seed nursery programme is not followed. Degeneration due to YLD was addressed through raising YLD-free nurseries. Disease-free crops raised from such nurseries recorded ~250 t/ha in Erode and Namakkal Districts in Tamil Nadu.

Evaluation of IET / Zonal varieties for resistance to red rot, smut & YLD

(R. Viswanathan, A. Ramesh Sundar and *K. Nithya)*

Thirty three entries of IVT were evaluated for red rot by plug and nodal methods for CF06 and CF 12 pathotypes. About 22 clones were identified as resistant to CF 06 as against four for CF12 in plug method. In nodal method 30 and 15 were resistant to the two pathotypes, respectively. Of the 28 IVT entries evaluated for smut resistance, 10 were found to be susceptible or highly susceptible. Of the remaining, eight were moderately susceptible, six moderately resistant and four were resistant. For the current season (2017-18), 37 clones (2014 series) were planted after challenge inoculation with smut teliospores and the clones are being evaluated for smut reaction.

During the season, about 28 IVT entries and 31 AVT entries were evaluated for the YLD severity based on the 0-5 scale. Among the IVT and AVT entries, 10 each were apparently free from the disease symptoms and had shown R reaction. The disease severity in rest of the entries were in the category of MS to MR. Three IVT mid late entries viz., Co 13016, CoT 13366 and PI 13131 and one AVT mid late II plant entry Co 10031 were found to be susceptible to YLD. Similarly, the ratoon fields of AVT early I plant and AVT mid late I plant were monitored throughout the season, where two entries such as, Co 10006 and Co 10027 in AVT Early I plant ratoon were found apparently free from the disease symptoms. In AVT mid late I plant ratoon, the entry Co 10031 had shown YLD score more than 3 with severe stunting symptoms and none of the entries in that were found to be free from the disease

Assessment of elite ISH clones for resistance to red rot

(R. Viswanathan)

Twenty seven ISH clones were evaluated for red rot by plug and nodal methods for CF06 and CF12 pathotypes. About 14 clones were identified as resistant to CF06 as against eight clones for CF12 in plug method. In nodal method 18 and 19 were resistant to the two pathotypes, respectively.

Entomology

(K.P. Salin, J. Srikanth, P. Mahesh, N. Geetha, B. Singaravelu, T. Ramsubramanian and *M. Punithavalli)*

Evaluation of zonal varieties/genotypes for their reaction against major insect pests

Top borer incidence: Top borer incidence in AICRP(S) trials was recorded in 7th month after planting. Overall incidence of the borer was very low. In IVT (Early), minimum incidence (0.1%) was recorded in Co 13003 and the entry MS 13081 recorded the maximum incidence (1.61%). In IVT (Midlate), CoSnk 13105 was free of incidence while Co 13005 recorded maximum (1.20%) incidence. In AVT (Early)-I Plant, minimum incidence (0.36%) was in Co 85004 and the entry CoM 11082 recorded maximum incidence (1.73%). In AVT (Midlate)-I Plant, Co 11005 recorded minimum incidence (0.74%) whereas Co 11019 recorded maximum incidence (1.82%). In AVT (Early)-II

Plant, Co 10027 was free of incidence and the entry CoT 10366 recorded the maximum incidence (1.46%). In AVT (Midlate)-II Plant, Co 10017 was free from the borer whereas CoM 10083 recorded the maximum incidence (2.32).

Internode borer incidence: At harvest, internode borer infestation was recorded in the AICRP trials, in terms of both percent incidence and intensity in all the three replications of IVT (Early), IVT (Midlate), AVT (Early) – II Plant and AVT (Midlate) – II Plant. Percent incidence ranged up to 55% while the maximum percent intensity was up to 3.5% in the different clones screened.

Survey and surveillance of sugarcane insect pests: Surveys in sugar factory areas in South Tamilnadu during January 2017 indicated that the pest incidence was in correspondence with age of the crop though sporadic outbreak of whitefly intensified by drought was observed. At Coimbatore, trap sampling showed 0-16.5% termite incidence. Incidence of top borer was < 5% and INB was > 30%. Incidence of White grub was low in Bannari Amman Sugars area.

Monitoring of insect pests and bio-agents in sugarcane agro-ecosystem: Incidence of top borer was < 5% in 7th month crop and the incidence of internode borer was > 30% in 12th month crop. Termite incidence was severe (>50%) in 12th month crop whereas only traces of other pests such as mealybug, woolly aphid and whitefly were recorded.

Fluff supply and National Hybridization Programme

(A. Anna Durai and *Adhini S. Pazhany)*

National Hybridisation Garden (NHG) was maintained with cafeteria of 629 parental clones for generating genetic variability for different agronomic traits for the breeders of 24 participating centers of fluff supply programme. Fowering was delayed by two weeks and the first flowering was noticed in LG 99122, LG 99183 and NCo 310. The data on flowering of parental clones were hosted in the institute website and the same was updated at weekly interval. Out of 629 parents, only 330 flowered and the per cent of clones flowered during 2016 was 52.46 % against 58.26 % in the previous year.

A total of 19 centres attended the crossing programme during the year 2016-17 and these centers were facilitated to make 502 bi-parental crosses and 42 selfs at NHG at ICAR-SBI, Coimbatore. Besides bi-parental crosses, 12 poly crosses, 94 general collections of open pollinated fluff (GCs) were also made for these centers. Further, 12 centers were facilitated to effect 60 bi-parental crosses and 40 general collections at National Distant Hybridization Facility (NDHF) available at ICAR-SBI RC, Agali. Altogether 562 bi-parental test crosses, 42 selfs, 12 poly crosses and 134 GCs were effected. Fluff weighing 19.52 kg of crosses made at NHG and NDHF during 2016 flowering season was supplied to the 20 participating centers of fluff supply programme. Maximum quantity of 6.73 kg of fluff was sent to Peninsular Zone followed by North West Zone (5.68), North Central Zone (4.46) and East Coast Zone (2.64). Number of crosses / selfs made and quantity of fluff supplied to different participating centers of fluff supply programme during 2016-17 is given in Table15.

Six hundred and thirty seven clones including 19 introductions viz., CoC 22 and CoC 08336 from Cuddalore, CoH 160 and CoH 167 from Uchani, CoLk 09202, CoLk 09204, CoLK 11201, CoLk 13201, LG 05464, LG 07443, LG 07503, LG 07518, LG 07590, LG 09810 and LG 09814 from Lucknow, CoPant 10221 from Pantnagar, CoPb 08212C from Kapurthala and CoOr 10346 and CoOr 12346 from Nayagarh were planted in NHG 2017.

Table 15. Number of crosses effected and quantity of fluff supplied to the participating centers of fluff supply programme during 2016-17

Zone / Centre	NHG, ICAR-SBI, Coimbatore						NDHF, ICAR-SBI RC, Agali				Total quantity of fluff sent (g)
	Station crosses		Poly crosses		General collections		Station crosses		General collections		
	No.	Fluff weight (g)	No.	Fluff weight (g)	No.	Fluff weight (g)	No.	Fluff weight (g)	No.	Fluff weight (g)	
PENINSULAR ZONE											
Mandya	17	266.5	7	49.5	7	211.5	4	72.0	6	153.5	753.0
Navasari	19	356.8	7	37.5	6	196.5					590.8
Padegaon	32(2)	763.0	7	46.5	6	50.5	10	154.5	8	189.5	1204.0
Perumalapalle	28	647.5	7	44.5	19	336.0			15	224.0	1252.0
Pune	20	456.0	7	45.0	3	17.0	7	109.5			627.5
Rudrur	21	556.0	7	49.0	8	139.5					744.5
Sankeshwar	27(7)	623.0	7	42.5	7	68.5	4	95.5	5	108.0	937.5
Thiruvalla	15(1)	359.5	7	45.5	9	186.5	1	33.5			625.0
TOTAL	**179 (10)**	**4028.3**	7	**360.0**	65	**1206.0**	26	**465.0**	34	**675.0**	**6734.3**
EAST COAST ZONE											
Anakapalle	30	807.5	7	46.5	5	29.0					883.0
Cuddalore	37 (2)	565.5	7	44.5	20	595.5					1205.5
Vuyyuru	26	420.5	7	43.5	6	79.0			1	9.0	552.0
TOTAL	**93 (2)**	**1793.5**	**7**	**134.5**	**31**	**703.5**				**9.0**	**2640.5**
NORTH WEST ZONE											
Faridkot	31(3)	769.5	5	40.5	2	51.0					861.0
Kapurthala	38 (4)	1019.5	5	42.0	7	125.5	6	82.5	3	59.5	1329.0
Lucknow	30(8)	824.0	5	38.0	12	656.0	8	100.0			1618.0
Shajahanpur	30 (4)	714.7	5	37.5	12	385.5	9	153.0	2	22.0	1312.7
Pantnagar	17	375.0	5	43.5			10	140.5			559.0
TOTAL	**146 (19)**	**3702.7**	**5**	**201.5**	**33**	**1218.0**	**33**	**476.0**	**5**	**81.5**	**5679.7**
NORTH CENTRAL ZONE											
Bethuadahari	14	324.5	5	41.5	3	211.0	1	12.50			589.5
Seorahi	35 (4)	901.5	5	40.5							942.0
Pusa	17(7)	421.5	5	38.5	30	1207.0					1667.0
Burlikson	18	466.50	5	40.0	13	756.0					1262.5
TOTAL	**84(11)**	**2114.0**	**5**	**160.5**	**46**	**2174.0**	**1**				**4461.0**
GRAND TOTAL	**502 (42)**	**11638.5**	**12**	**856.5**	**94**	**5301.5**	**60**	**962.5**	**40**	**765.5**	**19515.5**

Parental Diversity Index: Narrowing down of genetic base of parental clones utilized in the hybridization is one of the drawbacks in achieving the potential yield and quality in sugarcane. Analysis of parents utilized by the breeders of participating centers of fluff supply programme inferred that Parental Diversity Index (PDI) of these 24 centers was found ranged from 30 to 50 % and pattern of utilization of parental clones was restricted to parents from particulars centers /zone. In order to diversify the parental clones utilized in the crossing programme, the centers were advised to utilize the parents in such way that the parental diversity of the crosses is more than 70 % and care was taken to include parents from all the category available in NHG v*iz,* parental from the zone in which the particulars center is located, parents from others four zones, genetic stocks, foreign hybrids and interspecific hybrids. Accordingly, the parental diversity index of most of the centers during 2016 hybridization programme was more than 50 % other than Seorahi (47.1) and Navsari (47.4). The parental diversity index of the crosses done by the centers is presented in Table 16.

Table 16. Parental diversity index of crosses done by the fluff receiving centres

Peninsular Zone		North West Zone		North Central Zone	
Centre	**PDI**	**Centre**	**PDI**	**Centre**	**PDI**
Mandya	64.7	Faridkot	61.3	Pusa	62.5
Navasari	47.4	Kapurthala	56.6	**PDI of NWZ**	60.3
Padegaon	65.6	Lucknow	70.0	**North East Zone**	
Perumalapalle	67.9	Shajahanpur	66.7	Burlalikson	77.8
Pune	62.5	Pantnagar	76.5	**East Coast Zone**	
Rudrur	66.7	PDI of NWZ	66.2	Anakapalle	53.4
Sankeshwar	66.7	**North Central Zone**		Cuddalore	51.3
Thiruvalla	66.7	Bathuadahari	71.4	Vuyyuru	67.3
PDI of PZ	**63.5**	Seorahi	47.1	**PDI of ECZ**	**57.3**

EXTERNALLY FUNDED PROJECTS

Identification, characterisation and verification of new sugarcane varieties for DUS testing DUS test for Farmer's Variety /New Variety at Coimbatore

(S. Alarmelu and *C. Jayabose)*

During 2016-17, the second year of DUS testing for the three test varieties namely Co 0403, Co 06030 and Co 06027 along with reference varieties namely CoA 7602, CoA 90081, CoC 671, CoM 6806, Co 94008, Co 85004 and Co 86032 was completed.The field design was RBD and the number of replications were two. The plot size per entry was 4 rows x 6 m length x 0.9 m row to row spacing. Data on 27 morphological descriptors were recorded as per the DUS test guidelines issued by the PPV & FR Authority. The DUS test results indicate that the test varieties were distinct from each other and also from the existing reference varieties. The population of these varieties was uniform during subsequent propagation and the essential characters were stable.

During 2016-17, the observations recorded for the farmers varieties indicates that the farmer's variety Shiddhgiri-1234 did not differ from the earlier released variety Co 92005 and Dhyaneshwar-16 did not differ from the popular variety Co 86032.

Maintenance breeding: One hundred and eighty six reference collections of tropical sugarcane varieties were planted at DUS Centre, Coimbatore during March, 2016. In addition, the seed material of the variety CoVSI 9805 received from VSI, Pune and four Farmers' Varieties (FV) namely DESI- I, DESI-II, Kudrat Ka Karishma (KKK) and Kaptan Basti from SBI-RC, Karnal were raised in polybags and transplanted in field for maintenance. All varieties were maintained free of pests and diseases.

New Planting: DUS Reference varieties (189) and four farmer's varieties have been planted during second week of February, 2017 for maintenance during 2017-18. Two farmer's varieties Meitei Chu Angangba Selection and Meitei Chu Angouba Selection were received during second week of May, 2017 and were raised in polybags.

Participation in Meeting: 11th DUS review meeting was attended during 27-28, February, 2017 at IGKV at Raipur, Chhattisgarh

Fig. 31. Seed crop of Co 0212 at Vellamadai village harvested during February 2017

Sugarcane seed production: Mega seed project – seed production in agricultural crops and fisheries – sugarcane

(A.J. Prabakaran, S. Karthigeyan, A. Anna Durai and *K. Mohanraj)*

The seed production programme of sugarcane at the Institute has become more viable and effective after all seed production activities being undertaken under this project have been streamlined. A few new activities initiated during the period had strengthened the seed programme so as to deliver large quantity of seeds with high genetic purity and adequate quality to the indenters.

Fig. 32. Director visits participatory seed production site at Veerapandi

Maintenance breeding

The new initiative to maintain and multiply nucleus clones of all released varieties of the Institute in seed chain viz., Co 86032, Co 0212, Co 06030, Co 06022 and Co 0403 was initiated at ICAR-SBI. In the absence of a structured maintenance breeding programme in sugarcane to produce nucleus seeds, a methodology was arrived at after a brainstorming discussion with all Breeders. The nucleus clones thus maintained under the supervision of the breeders were again planted during March 2017 following cane to row method. This will be a continuous activity and the selected canes will be micropropagated to supply disease free plantlets for further multiplication as Breeder seed. Anticipating the release of the newly proposed variety Co 09004 to CVRC, this clone also included in the maintenance breeding programme.

Breeder seed production

From the initial source of the tissue culture plants produced from the nucleus clones, breeder seed multiplication was taken up both at the Institute and a progressive farmers' field (as the field availability was limited at the Institute) during July 2016 and January 2017. The varieties included were Co 86032, Co 0403, Co 06030 and Co 0212, the newly released variety for Tamil Nadu. About 33.3 tonnes of breeder seed thus produced have been supplied to the selected farmers to undertake the quality seed production during June 2016 under the guidance from ICAR-SBI in addition to the indents from sugar

factories. A total of 28.25 tonnes of breeder seed of Co 86032, Co 0212 and Co 06030 have been multiplied during Jul 2016 – Feb 2017 and supplied to the selected seed farmers for further multiplication as breeder seed for supply during September, 2017. Further multiplication to satisfy the seed requirement for August 2017 planting for supply during March 2018 has been taken up at the Institute.

Farmers' participatory quality seed production

Fig. 33. Interaction meeting held at Veerapandi village in January 2017

The demand for large quantity of quality seed cane and the limited resources available in the Institute provided an opportunity to explore the other alternatives under ICAR Seed Project. The seed requirements received from sugar factories for supply during September 2016 and February 2017 were consolidated for production during Jan – Sep 2016 (2016-Phase I) and Jul 2016-Feb 2017 (2016-Phase II). After ascertaining the field conditions, suitability, infrastructure, expertise and resources available a few farmers have been selected to undertake this seed production activity. Accordingly, planting was done at Vedapatti, Coimbatore district and Vaiyapurigoundenpudur, Tirupur district during January 2016 and at Vaiyapurigoundenpudur, Tirupur district and Veerapandi and Vellamadai, Coimbatore district during July 2016. The crop was monitored by a team of Breeders time to time and most of the demands received for quality seedcane have been fulfilled (Fig.31,32 and 33). A total quantity of 220.980 and 595.250 tons of quality seedcane were thus produced and supplied to the indenters during September 2016 and February 2017, respectively. A net revenue of Rs. 4,08,115/- was received during 2016-17 (Table 17 and 18).

Table 17. Details of farmers' participatory seed production- 2016-17

S No	Name and address of the farmer	Seed crop area (ac)	Total Quantity produced (T)	Quantity supplied to Indenters (T)				
				Co 86032	Co 0212	Co 06030	Co0403	Total
1.	Mr. B. Jeyapal Vaiyapurigoundanpudur Tirupur dt	3.00	124.290	35.290	45.000	26.000	18.000	124.290
2.	Mrs. Deepika Karthikeyan Vedapatty Coimbatore dt	0.88	49.925	49.925	-	-	-	49.925
3.	ECC farm	2.50	46.765					
Total		**6.38**	220.980					

Table 18. Details of farmers' participatory seed production- 2016-17

S No	Name and address of the farmer	Seed crop area (ac)	Total Quantity produced (T)	Quantity supplied to Indenters (T)			
				Co 86032	Co 0212	Co 06030	Total
1.	Mr. B. Jeyapal Vaiyapurigoundanpudur Tirupur dt	3.00	**103.265** (34.42 T/ac)	-	46.775	32.130	78.905
2.	Mrs. S. Chitra Veerapandi Coimbatore dt	4.75	**229.360** (48.28 T/ac)	192.420	32.970	-	225.390
3.	Mr. A.T. Selvaraj Vellamadai Coimbatore dt	4.50	**211.535** (47.01 T/ac)	139.495	32.740	37.380	209.615
4.	Mrs. S. Packiam Veerapandi Coimbatore dt	1.80	**81.340** (45.19 T/ac)	81.340	-	-	81.340
Total		**14.05**	**625.500** (44.52 T/ac)	**413.255**	**112.485**	**69.510**	**595.250**

Production of tissue culture plants

(D. Neelamathi and *S. Sheelamary)*

Through apical meristem tip culture, the varieties Co 86032, Co 0212,Co 0238,Co M 0265,C0 06022, C0 06030 and clone 11015 was multiplied in vitro and 50,700 tissue culture plants were supplied to the sugar factories, progressive farmers and for breeder seed production at the institute. New cultures were developed in varieties Co 86032 , Co 0212, Co 0238, Co 5011 and clones Co 11015, Co 15007, Co 9004 are in multiplication stage. A total of 211 virus free mother culture flasks of varieties Co 86032, Co 0212 and Co 0238 were supplied to tissue culture laboratories of Tamil Nadu, Karnataka, Andhra Pradesh, Gujarat and Maharashtra.

Enhancing Sugar Productivity in Tamil Nadu through Institute-Industry Participatory Approach (SISMA funded)

(Bakshi Ram, G. Hemaprabha, A.J. Prabakaran, R.M. Shanthi, S. Alarmelu, P. Govindaraj, D. Neelamathi, S. Karthigeyan, A. Anna Durai, R. Karuppaiyyan, K. Mohanraj, C. Appunu, C. Mahadevaiah, V. Sreenivasa, Adhini S. Pazhany, S. Sheelamary, H.K. Mahadevaswamy, T. Lakshmi Pathy, V. Vinu, K. Elayaraja, R. Viswanathan, A. Ramesh Sundar, P. Malathi, C. Sankaranarayanan, R. Selvakumar, V. Jayakumar, K. Nithya, R. Gopi, K.P. Salin, J. Srikanth, N. Geetha, B. Singaravelu, T. Ramasubramanian, M. Punithavalli and P. Mahesh)

Programme Initiation: A MoU was signed between the Director, ICAR-SBI, Coimbatore and the President, SISMA-TN, Chennai on 07.10.2016 for the first time to initiate the institute-industry participatory collaborative project with financial support from SISMA-TN, Chennai.

Identification of location specific varieties: A total of twenty promising genotypes (Co 0238, Co 0240, Co 06031, Co 09004, Co 11015, Co 13001, Co 13003, Co 13006, Co 13014, Co 13018, Co 13020, Co 13021, Co 14008, Co 14016, Co 14026, Co 15005, Co 15007, Co 15021, Co 16001 and Co 16002) were multiplied at ICAR-SBI, Coimbatore during January-July 2016 and supplied to nine sugar factories *viz.,* Bannari Amman Sugars Ltd., Alathukombai, Sathyamangalam, Dharani Sugars & Chemicals Ltd., Polur, EID Parry (India) Ltd., Nellikuppam, Kothari Sugars & Chemicals Ltd., Sathamangalam, Ponni Sugars (Erode) Ltd., Erode, Rajshree Sugars & Chemicals Ltd., Mundiampakkam, Sakthi Sugars Ltd., Sivaganga, Thiru Arooran Sugars Ltd., Tirumandangudi, V.V. Sugars Pvt. Ltd., Perambalur for multiplication.

Field stand of all twenty clones was good in multiplication plot in all factory locations. HR Brix data was recorded in the multiplication field. Many of the clones recorded HR Brix value more than 18 after 180 days of planting. The clones Co 11015 and Co 09004 recorded the highest HR Brix value of 23.0. Clones Co 0238, Co 13018, Co 13020, Co 15005, Co 15007, Co 16001 and Co 16002 recorded brix more than >21.0 at Bannari Amman Sugar Mills, Sathyamangalam. Similar trend was observed in other factories as well. Trial planting was done in randomized block design (three replications) with three to four standards (Co 86032, PI 1110, CoV 09356, Co 0212, CoC 671) with plot size of 6m X 6 rows x 1.2 m/replication in nine factory locations. Very good germination was recorded in evaluation trial plot.

Survey and surveillance of pests and diseases: Survey and surveillance of pests and diseases was combined with drought survey across Tamil Nadu during January 2017. The crop stand with poor establishment has weakened the physiology of sugarcane dynamics, which has facilitated more incidences of pests and diseases. Precisely in variety Co 86032, internode borer infestation was high, followed by incidences of root borer. It is interpreted that the prevalence of high temperature and drought situation further aggravated the incidence of sucking pests like white flies, scale insects and mealy bugs. The overall disease scenario is also aggravated due to poor crop stand and establishment. Incidence of yellow leaf disease (YLD) was more pronounced in Co 86032. Wilt was observed combined with root borer incidence in typical drought affected crop in most of the districts. Isolated incidences of Grassy shoot and sett rot was also observed in a few sugar factory areas.

Supply of healthy seed programme: To meet the demand of factories for tissue culture plantlets, mother culture stock preparation is in progress for varieties Co 86032, Co 11015 and CoV 09356.

SISMA - Special season evaluation: Randomized replicated design trial was laid with twenty entries (being tested under SISMA –SBI collaborative project) along with two AVT selections (Co 10033 and Co 10026) and two standards (Co 86032 and CoC 671) to find their suitability for special season planting (July planting). At 240 days, CoC 671 recorded 19.61% sucrose and three entries viz. Co 16002 (20.01%), Co 11015 (19.91%) and Co 09004 (19.89%) were numerically better than CoC 671 and were superior to Co 86032. At 270 days, the entry Co 11015 recorded 20.33% sucrose. At 300 days, Co 11015, Co 09004 and Co 15007 were significantly superior to Co 86032.

Other activities:

1. One day workshop was conducted for cane managers and cane officials from nine different sugar mills (68 participants) across Tamil Nadu on 7.10.2016.

2. One day training was conducted for cane staff, cane assistant and progressive farmers from nine different sugar mills (260 participants) across Tamil Nadu on 03.11.2016.

Molecular cloning and characterization of genes involved in lignin biosynthesis pathway of sugarcane

(K. Lakshmi)

In order to study the pattern of lignin deposition in stem tissues of sugarcane, histochemical analysis with phloroglucinol-HCL staining was performed. Immature (second node from top), and mature (tenth node from top) culm of all the five clones (EC11003, EC11010, IK 76-91, IK 76-99, and Co 86032) were studied. The microscopic analysis of the culm contains at least seven distinguishable cell types (metaxylem vessels, tracheids and vessel elements; phloem, sieve tubes, and companion cells; parenchyma; sclerenchyma; and epidermis). Lignin content is revealed by the intensity of phloroglucinol staining of the cell walls. Lignin deposition studied through phloroglucinol staining of the cell walls implied that the sclerenchyma cells of the energy canes (EC11010 and EC11003) have more lignin deposition followed by the *Erianthus* (IK 76-91 and IK 76-99) clones, whereas Co86032 has the minimum amount of lignin deposition.

Expression pattern of COMT, CCR, and PAL transcripts that are likely to be involved in sugarcane stem lignification was investigated, by comparing their abundance in five different sugarcane clones, through qRT-PCR. The qRT-PCR data was normalized against the expression of 25S rRNA, the reference gene. The expression of *EaPAL*, *EaCCR* and *Ea COMT* genes were high in energy canes EC11010 while there was no significant difference in its expression among the Erianthus clones (IK76-91, IK 76-99) as well as the commercial hybrid Co86032. We were able to identify a clone EC11010 for the genetic manipulation of lignin for effective biofuel conversion which showed higher expression levels of lignin genes as well as higher amount of lignin deposition in the Sclerenchymatic tissues.

Isolation and functional characterization of low temperature tolerance responsive genes from high cold tolerant *Saccharum spontaneum* Arunachal Pradesh collection

(C. Appunu)

Root transcriptome under low temperature conditions: To investigate functional response of genes in roots under low temperature (LT) stress condition, a hydroponic experiment was performed with the *S. spontaneum* at five different LT durations (3, 6, 12, 24, 48 h) during the formative stage and gene expression was analyzed using next generation sequencing technology.

Illumina raw, processed data and reference alignment of S. spontaneum root transcriptome: IlluminaNextSeq 500 platform yielded paired-end raw data consisting of 32,685,119 (32.68 million), 28,601,806 (28.60 million), 31,473,243 (31.47 million), 35,706,360 (35.70 million), 27,216,376 (27.21

million) and 25,850,965 (25.85 million) raw reads in control, 3, 6, 12, 24 and 48 hours of LT stress, respectively. It generated 181.51 million reads accounting 23.68 GB of raw data. Processing and removal of adaptor resulted in 131.11 million clean reads (19.67 GB) with average of 26.22 million reads per sample. *De novo* assembly has resulted in 125009 transcripts and identified 105516 unigenes. The average length of *de novo* assembled transcripts and unigenes was 953.2 ± 799.0 and 918.7 ± 773.4 bases. N50 length of *de novo* assembled transcripts and unigenes was 1323 and 1260 bases.

Functional annotation of assembled transcriptome: Functional annotation of the assembled unigenes was assessed using a BLASTX search against Nr (NCBI non-redundant protein sequences), Pfam protein domain, GO (Gene Ontology), COG (cluster of orthologous groups), KEGG (Kyoto Encyclopedia of Genes and Genomes), SOGI3 (Sugarcane Gene Index version 3) and SUCEST (Sugarcane EST) databases. Among 105516 unigenes, 60454 (57.29%), 804 (0.76%), 61801 (58.57%), 15781 (14.96%), 59411 (56.31%), 49385 (46.80%) and 51046 (48.38%) were annotated using Nr, Pfam, GO, COG, KEGG, SUCEST and SOGI3 databases respectively. To determine the gene function and their relationships, GO terms were used to assign 61801 unigenes into cellular component**,** molecular function and biological process. Transcriptional factors were topped in cold stressed samples followed biosynthesis process, metabolic process, signal transduction, phytohormones and oxidation indicating that plants were metabolically, biosynthetically and transcriptionally active during cold stress (Fig. 34 & 35). Unigenes were majorly assigned to ATP binding (12.59%), nucleic acid binding (5.88%) and zinc ion binding (5.74%) under molecular function. In cellular components, GO terms were majorly assigned to unigenes belongs integral component of membrane (22.51%) and nucleus (5.23%). Unigenes belongs translation (2.62%), transcription (2.33%) and regulation of transcription (2.3%) subsets were predominant in biological process.

Mapping unigenes with KEGG pathway database using KASS server (http://www.genome.jp/tools/kaas/) revealed five specific categories and unigenes were classified into cellular process, metabolism, genetic information processing, environmental information processing and organismal systems (Fig. 36).In the metabolism category, unigenes were frequently assigned to carbohydrate metabolism (13.32%) and amino acid metabolism (8.52). Unigenes assigned to metabolism of antioxidants like biosynthesis of secondary metabolites (2.87%) and, terpenoids and polyketides (2.19%) were significant for their role in ROS detoxification. Cluster of Orthologous Groups (COG) of proteins has classified the 20309 unigenes into 24 clusters. Among them, cluster of 'General function prediction' represented 18% of unigenes followed by 'Replication, recombination and repair' (10.55%), 'Translation, ribosomal structure and biogenesis' (10.18%) and 'Transcription' (9.65%). 'Nuclear structure' and 'Cell motility' were representing the smallest among the COG clustering.

Identification of cold responsive genes: The clean processed reads of all samples were aligned on *de novo* assembled transcripts using Tophat. Differential gene expression (DEG) was estimated in *S. spontaneum* by comparing the abundance or read counts between cold-acclimated and non-acclimated samples. A total of 97201, 96941, 97585, 95282 and 94029 DEGs

were identified in 3, 6, 12, 24 and 48 hours of cold acclimation. Among them 45, 42, 48, 38 and 55 were unique DEG observed only under 3, 6, 12, 24 and 48 h after cold acclimation. Total of 25789 DEGs were upregulated in *S. spontaneum* during cold acclimation, rapidly increased at 6 hour (13068) and reaches maximum of 21039 at 48 hour of cold acclimatization. Whereas 5923 unigenes were both down and upregulated unigenes in *S. spontaneum* and maximum of 43496 unigenes at 48 hour of cold acclimation (Fig. 36).

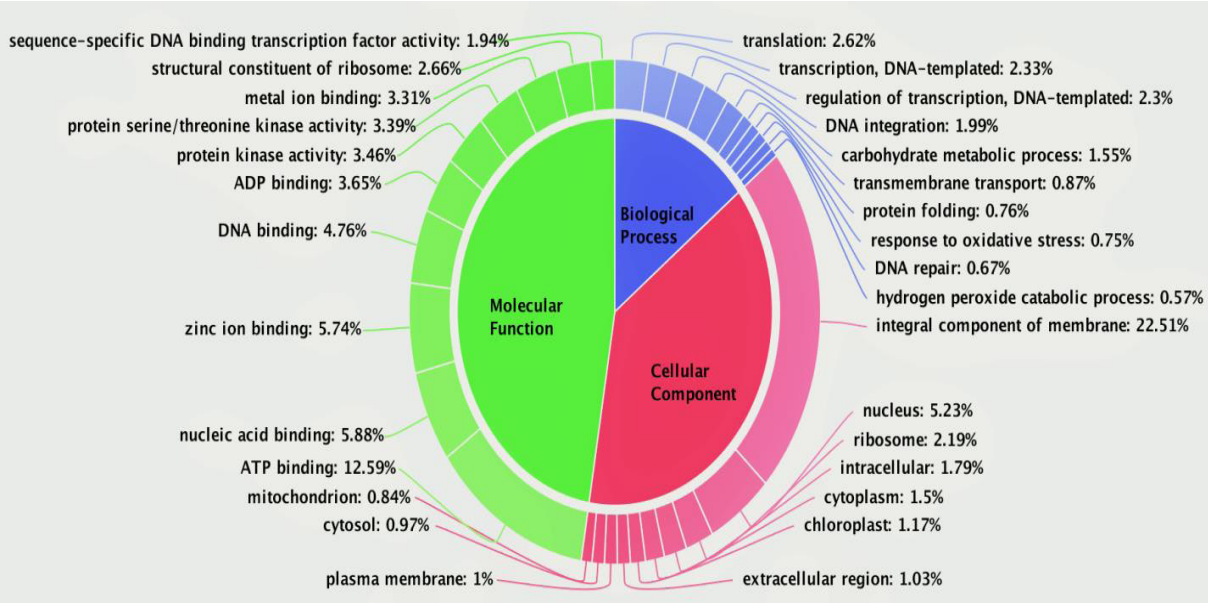


Fig. 34. Classification of unigenes KEGG pathways at different time points of low temperature stress (3, 6, 12, 24 and 48 hours)

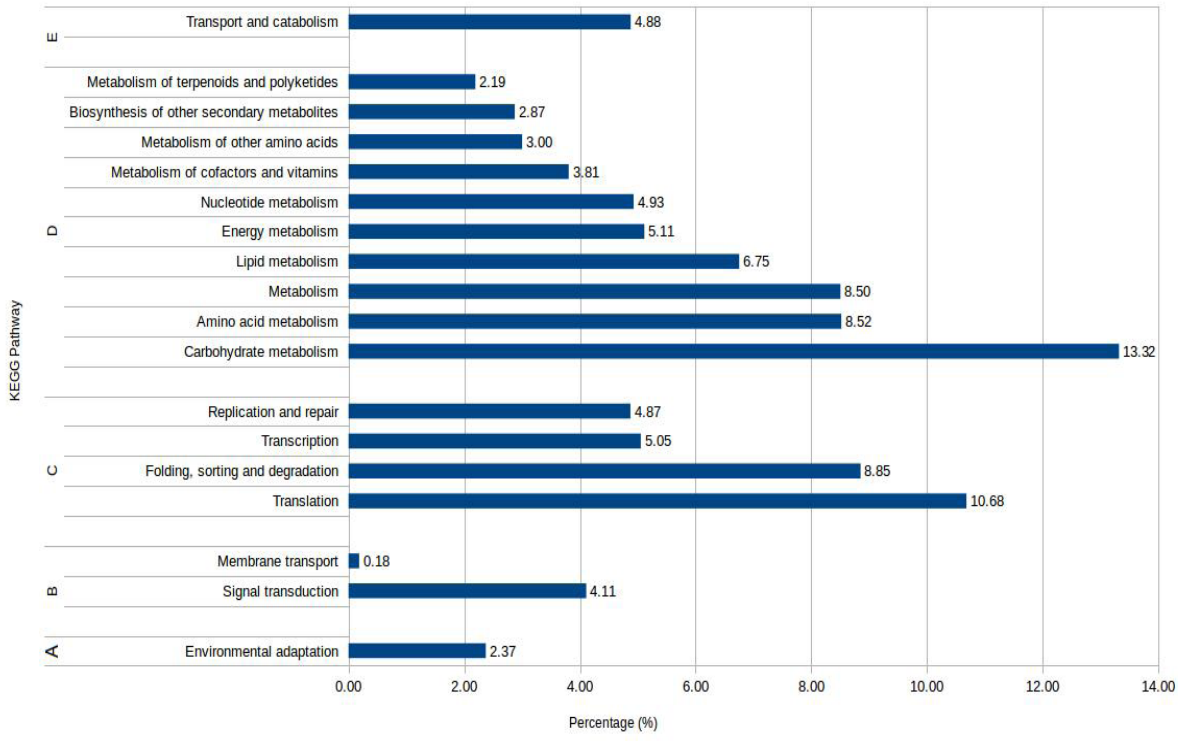


Fig. 35. Classifications of Gene ontology (GO); the results are summarized in three main categories: Biological process, Cellular component, and molecular function under low temperature stress.

Transcription factors (TF): Total of 10503 unigenes belongs to 80 families were expressed and among them, 6624 belongs to 76 families were differentially expressed in root tissue. Among these, FAR1 was the largest family (704, 10.63%) followed by WRKY (461, 6.96%), MYB-related (434, 6.55%) and MADS (414, 6.25%) families. Number of upregulated was almost equal to down regulated in WRKY, MADS and bHLH families. Whereas number of down

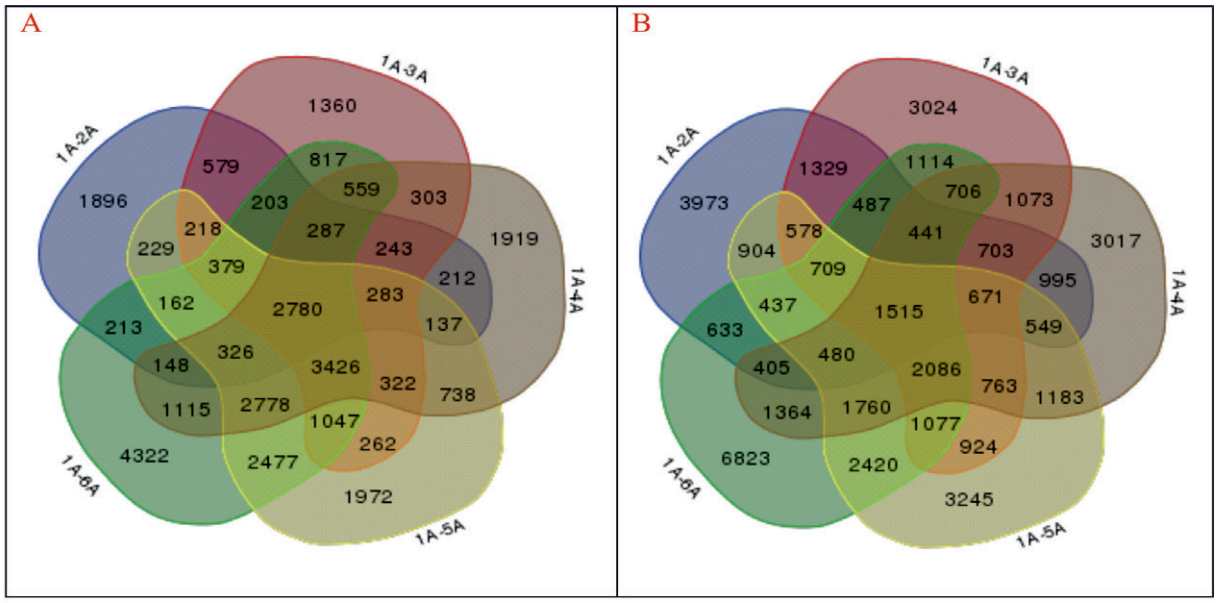


Fig. 36 Differential upregulation (A) and downregulation (B) of genes in S. spontaneum at different duration of low temperature treatments (1A, Control (0 hr); 2A, 3 hrs; 3A, 6 hrs; 4A, 12 hrs; 5A, 24hrs; 6A, 48 hrs).

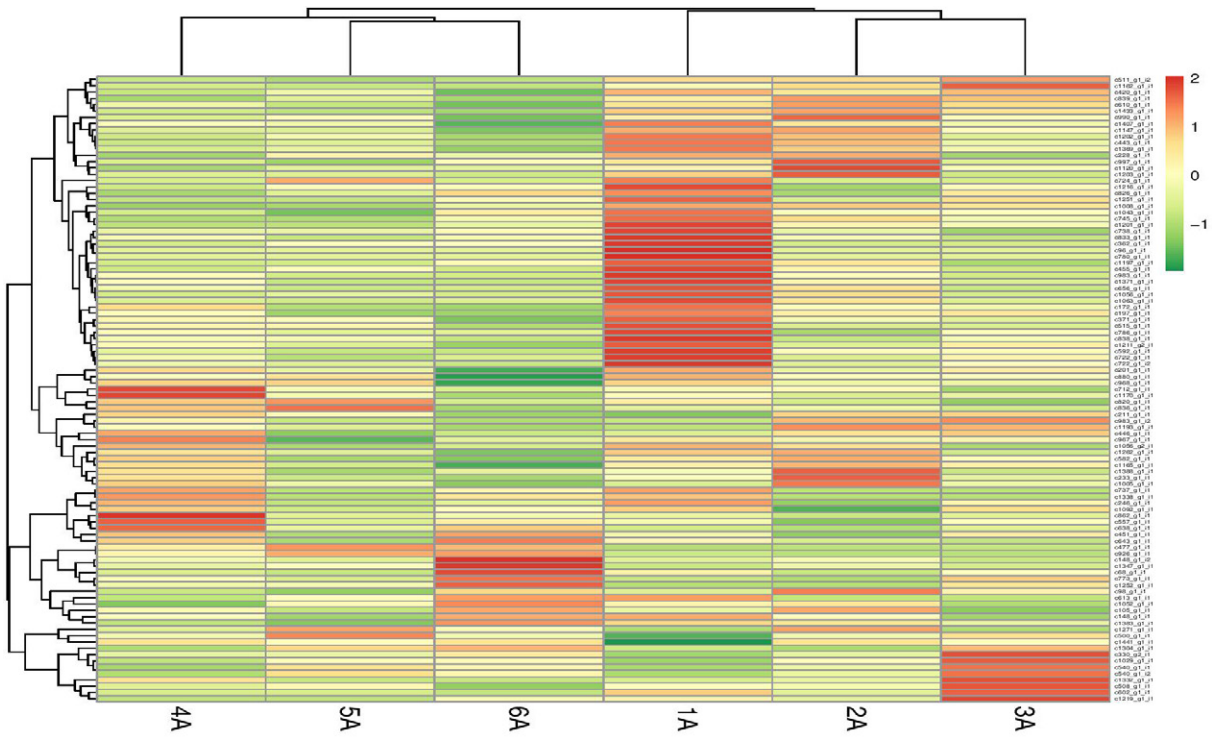


Fig. 37. Heat map showing the differential expression of low temperature responsive

regulated were higher than upregulated in FAR1 and MYB-related families. Heat map showing the differential expression of low temperature responsive transcriptional factor in roots of *S. spontaneum* at different duration of treatments (1A, Control (0 h); 2A, 3 h; 3A, 6 h; 4A, 12 h; 5A, 24h; 6A, 48 h) (Fig. 37).

Genetic engineering of sugarcane for water deficit stress tolerance

(C. Appunu and *Lovejot Kaur)*

A total of 128 transgenic events (EaHSP70 transgenics – 35 events; EaDREB2 transgenics – 25 events; PDH45 transgenics – 24 events; EaDREB2 and PDH45 co-transformed – 44 events) were generated and evaluated. The new lead obtained from the screening of these events is that transformants of DREB2, HSP70, PDH45 and pyramiding (DREB2 & PDH45) genes play an important role in improving the cell membrane thermostability, higher level of abiotic stress related genes expression, higher relative water content and gas exchange parameters, chlorophyll content and photosynthetic efficiency, which might contribute for the increased drought stress tolerance in transgenic sugarcane. Further to confirm the drought tolerance of eighteen selected transgenic events (4-5 events/construct) under field conditions, an application was submitted to RCGM for confined field trial for selection of drought tolerant sugarcane transgenic events. These events were planted for further multiplication and maintenance.

Pyramiding of transcriptional factor and ROS candidate genes for improved drought tolerance in sugarcane

(C. Appunu, G. Hemaprabha and *Lovejot Kaur)*

Construction of pSBI-DREB2, pSBI-SOD, pSBI-CAT and pSBI-APX: The *EaDREB2*, *EaSOD*, *EaCAT* and *EaAPX* sequences were amplified using gene specific primers with flanking restriction sites that were not present in the gene sequences. All these genes were from *Erianthus arundinaceus*. The *EaDREB2* (KJ670161), *EaSOD* (KX235993), *EaCAT* (KX235994) and *EaAPX* (KX235995) genes were deposited in NCBI GenBank. Primers were designed in such a way that *EaDREB2* sequence with *BglII* (AGATCT) anchored to the forward primer and *BstEII* (GGTNACC) anchored to the reverse primer. *EaSOD* gene sequences with *Sbf*I (CCTGCAGG) anchored to the forward primer and *Nhe*I (GCTAGC) anchored to the reverse primer. *EaCAT* sequence contained *Bam*HI (GGATCC) restriction site at the 5' end of the forward primer and *Bst*EII (GGTNACC) site in the reverse primer. *EaAPX* sequence with *Sbf*I (CCTGCAGG) restriction site is anchored to the forward primer and *Nhe*I (GCTAGC) in the reverse primer. For these constructs the candidate gene is driven by port ubi2.3/port ubi882, which was isolated from *Porteresia coarctata* at ICAR-SBI, Coimbatore. The cloning was confirmed through PCR using gene specific primers and also the promoter specific forward primer and the gene specific reverse primers.

Sugarcane Transformation: Sugarcane variety Co 86032 was transformed with pSBI- DREB2, pSBI- SOD, pSBI- CAT and pSBI- APX through *Agrobacterium* mediated transformation. For pyramiding of these genes biolistic bombardment method was followed. The differentiated plantlets were rooted, hardened and transferred to 18'' pots in the transgenic green house.

PCR amplification with promoter-gene fusion primers & the selection marker primers: PCR was carried out in 28 *DREB2* putative transgenics events to confirm integration of the transgenes at V_0 stage using the promoter-gene fusion primers. Confirmation of the transgenics was again carried out with marker gene specific primers i.e., *Bar* as the marker gene for the pSBI-DREB2. These transgenic events are in V_1 generation. A total of 17 CAT transgenic events were confirmed for presence of transgene through PCR using marker specific primers for hygromycin (*hpt*) selection marker. These events are at V_0 stage under multiplication. Other batches of putative transgenic events (both single gene (pSBI-APX, pSBI-SOD) and combination of genes) are either in regeneration stage or in hardening stage.

Cell membrane thermostability studies: At V_0 stage the cell membrane thermo-stability (cell membrane injury) of each of the 25 transgenic events was measured along with the untransformed control (Co 86032) under normal irrigated condition in pots with 25% soil moisture. The cell membrane thermostability assay indirectly measures the integrity of cellular membrane through quantifying electrolyte leakage after drought stress treatment. The cell membrane stability of leaves was carried out following the conductivity meter method. Third leaves were collected from the drought induced and control plants and were quickly transferred to laboratory to avoid loss of leaf moisture.There was a significant decrease in the cell membrane injury in 25 events under normal irrigated conditions. Cell membrane thermostability of different DREB transgenics events are given in Fig. 38.

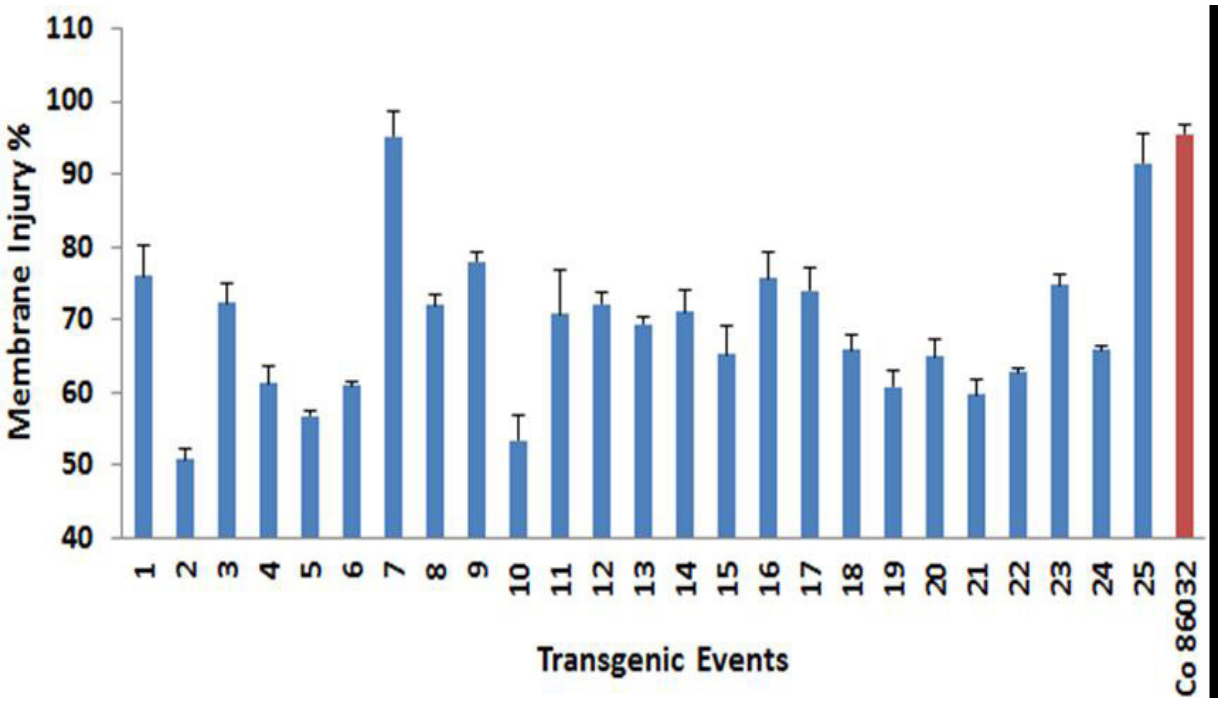


Fig. 38. Cell membrane injury in pSBI-DREB2 transgenics (T_0) at 25% soil moisture. All the transgenic events differ significantly from the untransformed control at $P \leq 0.05$, by Student's t-test. Data are presented as mean ± SD (n=5) and error bars represent SD. Events 7 and 25 were non significant.

Indo – Australia collaborative project: Genetic control and genomic selection for important traits in sugarcane, and comparison of elite Indian and Australian germplasm

(R. Manimekalai, G. Hemaprabha, R. Viswanathan, S. Vasantha, A. Selvi, and *K. Mohanraj)*

Field planting of bi parental cross population was done. The cross combination are CoM 0265 x Co 775 (drought), BO 91 x Co 775 (drought and sucrose); Co 86002 x BO 91 (Red rot); Co 1148 x Co 775 (sucrose). The drought condition is imposed by withholding the irrigation in drought treatment from 90 DAP. Regular irrigation schedule is maintained for the control. Germination count, tiller count and physiological observation (chlorophyll content, chlorophyll fluorescence, inter node elongation and wax content) were recorded. The scoring for drought based on visual observation on leaf rolling, tip drying, greenness and vigour of the plant was done. The drought index ranged from 1-5 (Greenness to drying of the plant).

Fig.39. Launch of Indo- Australia collaborative programme at ICAR SBI

5.2 CROP PRODUCTION

5.2.1 AGRONOMY AND MICROBIOLOGY

Effect of trash management on sugarcane production under wide row planting

(A.S. Tayade, R. Dhanapal and *K. Hari)*

This experiment was planted in wide row in January 2014 with sugarcane variety Co 86032 to study the effect of trash management on growth, development and juice quality. The crop was ratooned for the second time and 16 Green Cane Trash Blanketing (GCTB) treatments with three replication were imposed in a split plot design. Microbial consortia comprising *Trichoderma viride, Humicola* spp*, Paecilomyces lilacinus,* G*luconacetobacter diazotrophicus*, *Azospirillum brasilense* and *Bacillus subtilis* were applied twice along with composted coir pith and immediately after microbial consortia application field were irrigated. Soil moisture and soil temperature in sugarcane ratoon (II) crop for one irrigation cycle was monitored and it was observed that the soil moisture in trash mulching treatment was more by 4.75 per cent and soil temperature was less by 2.5^{O}C compared to non mulched plot on 10 days after irrigation. In-Situ Trash Management (ISTM) plus incorporation of sunnhemp in plant sugarcane crop influenced the cane yield of ratoon crop significantly and recorded the higher cane yield of 79.17 t/ha over the control. Similarly, GCTB treatments in second ratoon crop had significantly improved cane yield over the control (trash removal). In ratoon crop, shredding plus soil incorporation of sugarcane trash along with microbial consortia at 100 % recommended dose of fertilizer (100 % RDF) recorded the highest cane yield of 81.86 t/ha which was closely followed by the treatment GCTB alone.

Impact of integrated application of organics and inorganics in improving soil health and sugarcane productivity

(A.S. Tayade, A. Bhaskaran and *S. Anusha)*

A field experiment with the objective of developing nutrient management strategy for sustaining soil health and sugarcane production was laid out during the year 2016 in randomized block design with 15 nutrient management treatments replicated three times. In first ratoon sugarcane crop, 20 t FYM + 150 STCR based fertilizer application was found beneficial in improving cane yield by 65.49% over control (no fertilizer application). The treatment 20 t FYM + 150 STCR based fertilizer application recorded the highest NMC (119753 NMC/ha) and cane yield (137.74 t/ha) and was closely followed by the treatments 10 t FYM+ Biofertilizers+ 150 STCR (127.27 t/ha) and 20 t FYM + STCR 200 IPNS (125.23). Sugarcane juice analysis revealed that Brix, Sucrose%, Purity% and CCS% were not influenced significantly by application of organics and inorganics. Crop was ratooned during February 2017 and various INM treatments were imposed.

Productivity, nitrogen dynamics and economics of intercropping under wide row system of planting in sugarcane

(P. Geetha and *A.S. Tayade)*

This experiment was taken up to work out the productivity and economics of sugarcane based intercropping systems under wide row spacing and to evaluate

the performance of chip bud settlings in intercropping system. Settlings were raised during February 2016 and field planted during March along with 5 legumes *viz.,* greengram, blackgram, soybean, cowpea and sunnhemp as intercrops in wide row planting.

Yield of intercrops: The grain yield of green gram, black gram, soybean, cowpea and sunnhemp were 142, 416, 523, 310 and 12931 kg/ha, respectively.

Cane yield and yield parameters: The highest NMC was recorded in sugarcane intercropped in soybean (116481/ha) followed by green gram (110000/ha) and the lowest was recorded in sole crop of sugarcane (86111/ha). The NMC was significantly higher over the control, however, there was no variation among the intercropping system followed. Sugarcane intercropped with soybean has recorded significantly higher cane yield of 122.82 t/ha, followed by sugarcane intercropped with sunn hemp (117.31 t/ha) and black gram (116.38 t/ha) while the control (sole crop of sugarcane) has recorded 74.30 t/ha. The juice quality parameters did not vary among the treatments.

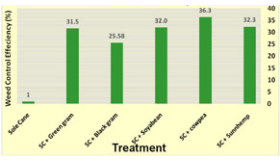


Fig. 40. Effect of sugarcane intercropping system on weed control efficiency

Weed control efficiency: Weed control efficiency which indicates the comparative magnitude of reduction in weed dry matter, was highly influenced by different intercropping systems. Weed count and weed dry biomass were recorded at 60 DAP by using a 1.0 m^2 quadrate randomly at six places in each plot. Weed control efficiency (WCE) was calculated. Among the different intercrops, weed control efficiency was significantly higher in sugarcane + cowpea (36.3%) intercropping system followed by sunnhemp (32.3%) and soybean (32.0%) over the sole sugarcane (control) (Fig. 40).

Sugarcane biomass based biochar as a source of organic manure/ amendment

(K. Sivaraman, A. Bhaskaran, T. Arumuganathan and *K. Hari)*

The biochar produced from sugarcane trash, tops, stubbles and bagasse were characterized. The carbon loss after 180 days of incubation under laboratory condition was undetectable. The EC of the biochar from trash was 4.5 dS/m and pH was 9.4. The nutrient loss due to pyrolysis of sugarcane dry trash was 93, 38 and <1% N, P and K, respectively.

Characterization of rhizosphere of selected sugarcane genotypes

(K. Hari, S. Vasantha and *A. Anna Durai)*

Twenty four varieties viz., BO 91, Co 8371, Co 99006, Co 98014, Co 0238, Co 85019, Co 62175, Co 86032, Co 99004, Co 0403, Co 740, Co 94008, CoLk 8102, Co 97010, Co 87009, Co 6806, CoJ 64, CoC 671, Co 95020, Co 89003, Co 06022, Co 92008, Co 2001-13 and Co 419 were planted in hydroponic and sand culture conditions and nutrients were provided using synthetic nutrient solution (Fig. 41-42). The plants were maintained for 10 months in hydroponic conditions. Highest root weight per pot was recorded by CoLk 8102 (1027 g) and Co 97010 (1011 g). This was followed by Co 06022 (830 g), Co 95020 (743 g), Co 99004 (658 g), CoJ 64 (632 g), Co 62175 (623 g) and Co 0238 (581 g). Lowest root weight was produced by Co 8371 (27 g) followed by Co 419 (103 g) and Co 94008 (118 g). Varieties Co 06022, CoLk 8102, Co 99004 and CoJ 64 recorded higher root volume (>1000 ml/ pot), and lowest

Fig. 41. A view of hydroponically grown sugarcane crop

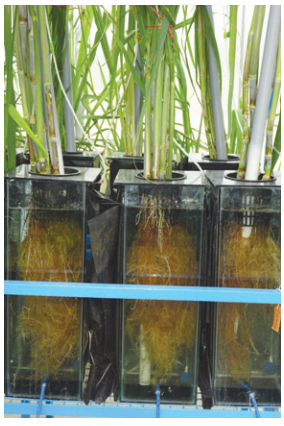


Fig. 42. Close view of sugarcane roots of hydroponically grown sugarcane

Fig. 43. Pocket manuring tool

Fig. 44. Capturing of sugarcane crop imagery using Drone

Fig. 45. Drone imagery of sugarcane crop

(<110 ml/pot) was recorded by Co 8371, Co 740 and Co 419. Highest cane yield was recorded by Co 06022 (3.73 kg/pot), Co 62175 (3.58 kg/pot), and lowest was recorded by Co 740 (0.49 kg/pot) and Co 8371 (0.61 kg/pot). Most of the varieties tested recorded root length between 50 to 80 cm, the shortest root length was recorded by Co 8371 (29.4 cm) and the longest by Co 87009 (117.7 cm). Root exudates were collected, filtered, concentrated and analysed for phenolics and organic acids using HPLC analysis. The samples gave large amounts of interfering substances which require method standardization. Qualitative HPLC analysis of root samples indicated the presence of phenolic acids viz., galic, caffeic, vanilic, syringic and ferulic acids.

Development of a modified pocket manuring tool for fertilizer application and field testing

(T. Arumuganathan, C. Palaniswami K. Sivaraman and *V. Venkatasubramanian)*

Based on the field trials conducted on the prototype of the pocket manuring tool, the tool was further modified to enhance the working efficiency. To reduce the drudgery involved in the pocket manuring practice and increasing the working efficiency, a modified pocket manuring tool has been designed using the software SOLID WORKS for making 2 inch diameter hole at a depth up to 10 cm. The objective of designing the tool was also to carry out the pocket manuring practice (hole making, applying fertilizer and closing the pits) by a single person. The height of the tool was increased to 3.5 feet and the upper diameter of the penetrating tool was changed to 5 cm for its efficient working. The prototype has been fabricated and field evaluation has been carried out (Fig.43)

The tool will release the fertilizers at the rate of 8 g of urea or 5 g of potash per pocket by operating the lever. The distance between two adjacent pockets is one feet. The weight of the tool is 6 kg excluding the weight of fertilizer. The fertilizer holding capacity of the tool is 9 kg. The field capacity of the tool is 0.3 acre per day.

Application of drone with satellite data for precision agriculture monitoring and yield prediction with drone assisted surveillance and diagnosis for biotic and abiotic stresses in sugarcane

(T. Arumuganathan, A. Bhaskaran C. Palaniswami and *P. Malathi)*

Capturing of field images of sugarcane crop using Drone: A Quadcopter Drone (DJI-Phantom 3 model with 4K resolution – FC 330X camera) was used to capture the field images of the sugarcane crop leaves. The drone was allowed to hover around the different fields at ICAR-Sugarcane Breeding Institute, Coimbatore and images of healthy sugarcane leaf and sugarcane leaf with iron deficiency symptom were recorded (Fig. 44 & 45)

Processing of field images using MATLAB software: The field images of the sugarcane leaves were processed using MATLAB software for defining the colour value through RGB values, L*a*b* values, Hue saturation value (HSV) and YCbCr values to clearly distinguish the micronutrient symptom leaves from healthy one based on the digital colour value.

It is observed that the RGB values (R 90 to 200, G 110 to 210, B 75 to 200),

L*a*b* values (50 to 70, -25 to 0, 0 to 25), Hue Saturation Value (S 0.2 to 0.3, V 0.4 to 0.7) and YCbCr values (Y 100 to 200, Cb 110 to 130, Cr 110 to 130) were recorded for normal/healthy sugarcane leaf images (Fig.46).

In case of iron deficiency symptom, the RGB values (R 150 to 230, G 175 to 240, B 100 to 160), L*a*b* values (70 to 90, -25 to +1, 0 to 48), Hue Saturation Value (S 0.3 to 0.45, V 0.7 to 0.9) and YCbCr values (Y 150 to 210, Cb 90 to 120, Cr 120 to 130) were obtained through image processing of iron deficient leaf images (Fig.47).

5.2.2 PLANT PHYSIOLOGY

Evaluation of Physiological Efficiency of Commercial hybrids and species clones of *Saccharum* for water use under water limited conditions

(S.Vasantha, AS Tayade, R. Arun Kumar and *S. Anusha)*

A field trial was conducted in a split plot design with two replications and 33 varieties, main plot being irrigation treatments and varieties as sub plot. The irrigation treatments were 1. Control (T1) normal irrigation, 2. T2: 50% reduction in irrigation water quantity, 3. T3: 50% irrigation by reducing number of irrigations. The crop was irrigated normally up to 60 DAP, to ensure uniform population. The treatments were imposed from 1DAP and will continue till harvest.

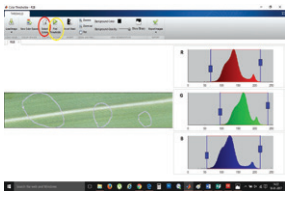


Fig. 46. Processing of field images

During formative phase soil moisture depletion was recorded on daily basis for a complete irrigation cycle (20 days) in all the treatments. The soil moisture depletion was from 21.8% on day one after irrigation to 11% on tenth day after irrigation in control. In T2 the soil moisture was 20.3% on day 1 and reduced to 10.1% on tenth day. In T3, the soil moisture on day 1 after irrigation was 20.7% and on 19th day after irrigation (a day prior to next irrigation) it was 5.2%. The soil moisture levels in between periods of irrigations indicate the intensity of stress and consequent response of the varieties.

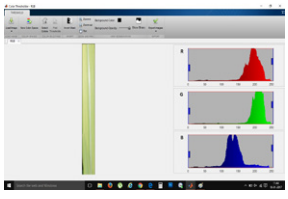


Fig. 47. Processing of sugarcane leaf images

At 100 DAP the shoot population varied from 41.8/row to 101.8/row (Co 0212) in control while in T2 it ranged from 49.2/row (Co 99004) to 116.8/row (Co 0212). In T_3 the shoot population varied from 52.8/row (Co 85002) to 98.1/row (BO 91). The mean shoot population in control, T_2 and T_3 were 75.7, 73.9 and 69.4/row, respectively.

Physiological traits: Photochemical efficiency measured as chlorophyll fluorescence decreased in all the varieties in 50% irrigation treatments (T2, T3). Mean chlorophyll fluorescence was 0.746, 0.687 and 0.654 in T1, T2 and T3, respectively. The leaf area index (LAI) was maximum in Co 95020 (3.9) and lowest is CoLk 8102 (1.6) in control. In reduced irrigation treatment *viz,* T2 and T3 the LAI ranged from a minimum of 1.0 (ISH 229, T2) and 0.8 (Co 8208, T3) to a maximum of 2.8 (Co 86010, T2) and 2.7 (Co 10026, T3). The mean LAI was 2.58, 1.74 and 1.70 in T1, T2 and T3 respectively.

During formative phase, the above ground biomass (TDMP) was highest in Co 8021 in control and least in CoLk 8102 220g/m^2. In T2, the dry biomass ranged from 187g/m^2 (Co 7717, Co 85002) to 595g/m^2 (CoM 265). In T3, the biomass ranged from 154 (BO 91) to 541g/m^2 (Co 99004). Overall reduction (mean) in treatments was 22% in T2 and 32% in T3.

CoM 0265, Co 10026, Co 86249, Co 99004 possessed better canopy temperature (35^{o}C average) compared to the other clones (37^{o}C average) in both reduced irrigation treatments. Under severe drought 74% of the clones

showed tight leaf rolling, while 26% of clones showed tight rolling one day after irrigation. Co 95020 has not shown leaf rolling under both conditions.

Evaluation of MIDAS on yield and quality of sugarcane

(S.Vasantha and *D. PuthiraPrathap)*

A trial was undertaken in a farmer's field at Pambhathiripet, Villupuram district, registered under the Rajshree Sugars and Chemicals limited, Mundiampakkam. The area of the selected plot was 5 acres and irrigated via sub- surface drip- fertigation. Each treatment was planned for an acre land. Recommended cultural operations were followed. The variety was Co 86032 and the setts were derived from a seed plot. The MIDAS- treatments were effected as per schedule and doses as per technical programme (Table 19). Growth physiological, quality and yield data were recorded at appropriate crop age and analyzed for significance.

Table 19. Treatment Details

Treatment	Dosage/ha	1st Application	2nd Application	3rd Application	4th Application
Control	-	-	-	-	-
T1	MIDAS 2.0 L	35-45 DAP	90-100 DAP	70 Days before harvest	30 Days before harvest
T2	MIDAS 2.5 L	35-45 DAP	90-100 DAP	70 Days before harvest	30 Days before harvest
T3	MIDAS 2.0 L	100 Days before harvest	70 Days before harvest	30-40 Days before harvest	--
T4	MIDAS 2.5 L	100 Days before harvest	70 Days before harvest	30-40 Days before harvest	

Growth and biomass production: Biomass production increased in all the treatments and partitioning towards stem has significant improvement in T2 and T4. In T4 (2.5 L/ha), at 30 days before harvest) the biomass (dry) in stalk doubled as compared to the control. Despite sustained higher biomass production during early stages T2 (2.5 L/ha), slackened at maturity stage in partitioning of biomass to stem. This may be due to higher LAI at maturity stage in this particular treatment. Crop growth worked out for different treatments suggests that T3 and T4 showed upward trend while in other treatment (Control, T1 and T2) it was not stable. Sustainable growth increments at every stage are essential, coupled with better partitioning towards economic plant part i.e. cane is observed in Treatments T3 and T4.

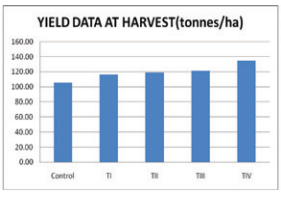


Fig.48. Influence of MIDAS on cane yield

Harvest data: Data on cane characteristics *viz.,* number of internodes, cane length, internode length, and cane girth showed significant improvement with respect to, number of internodes, cane length only. Cane yield was recorded from the control as well as treatment blocks and are presented in Fig.48. Cane yield varied from 105.5 t/ha (Control) to 134.93 (t/ha) in T4 (2.5L/ha). The cane yield improvement was 28%. In other treatments viz., T1, T2 & T3 the improvement was 10, 12 and 15, respectively.

SMT: Small mill test was carried out at 11th and 12th month after planting. At 11 months, the treatments T1 to T3 showed improvement in CCS %. At 12 months of crop age the CCS% was highest in T1 (10.3%). The other treatments *viz.,* T2, T3 and T4 recorded 10.1, 10.07 and 10.2% CCS, respectively. The improvement in CCS% was not significant. Nevertheless, the sugar yield

worked out from cane yield and CCS% showed significant improvement over control (10.8 t/ha). The treatments, T1, T2, T3 and T4 recorded sugar yield of 12.01, 12.37, 13.49 and 14.56t/ha respectively.

Climate resilience in sugarcane agriculture: Metabolic and molecular response to high temperature

(R. Gomathi)

Pot culture experiment was conducted by utilizing six commercial varieties four *S. spontaneum* clones to study the adaptive metabolic response and to investigate proteins and transcripts expressed to elevated temperature in response to elevated temperature. A set of plants were subjected to elevated temperature condition in growth chambers during formative phase and GGP for a period of 20 days each. The physiological and metabolic activities were assessed in plants subjected to elevated treatments (5°C above ambient temperature) at end of stress. A set of control plants was maintained for comparison purpose.

Physiological and metabolic changes in response to elevated temperature: Elevated temperature showed a significant reduction in chlorophyll pigment concentration, SPAD value and photochemical efficiency (fv/fm ratio) in both the 'Co' canes and *spontaneum* clones, however the variety Co 99004 and SES -150 recorded significantly higher values under stress condition (Fig. 49). Metabolic activities *viz.* free proline total phenolics and soluble sugars significantly induced under elevated temperature. Among the 'Co' canes, Co 06022 and Co 99004 and among the *spontaneum* clones, SES -150 and Taiwan 96 accumulated higher metabolites and thereby expressed higher cellular level tolerance towards high temperature stress.

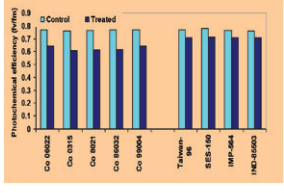


Fig. 49. Photochemical efficiency of Co canes and spontaneum clones in response to elevated temperature at GGP

In 'Co' canes, temperature influenced 12.6, 26.45%, 19.0% and 12.41% reduction in Tr, photosynthetic rate, stomatal conductance, and intercellular CO_2 concentration, respectively, however the reduction of photosynthetic characters was comparatively less in Co 99004, Co 06022 and Co 0315. Among the *S. spontaneum,* SES-150 was comparatively better for the above traits under elevated temperature.

Free radical scavenging enzyme activities *viz.,* peroxidase (POX) and superoxide dismutase (SOD) of both 'Co' canes and *S. spontaneum* clones showed a significant increase upon elevated temperature stress. However, the percentage of increase over control was comparatively high in *S. spontaneum* clones in both the stages (19.20 and 20.60% at FP and GGP, respectively for POX and 17.12 and 18.25% at FP and GGP, respectively for SOD) indicating their cellular level tolerance potential upon the heat stress. Results of lipid peroxidation and cell membrane injury index in Co canes indicates that, elevated temperature stress significantly influence the oxidation of membrane lipids by 34.20 and 37.50% increase over control at FP and GGP, respectively (Table 20), which resulted in 22.05 and 38.50% increase in cell membrane injury at FP and GGP, respectively. Among the co canes Co 06022 and Co 99004 recorded comparatively lower lipid peroxiation and cell membrane injury index. Similarly, *S. spontaneum* clones, observed lower level of lipid peroxidation of 14.50 and 19.25% increase over control at FP and GGP, respectively and cell membrane index of 7.50 and 12.25% increase over control at FP and GGP, respectively indicating their cellular level tolerance potential upon heat stress.

Proteomic study on 2-Dimentional gel electrophoresis

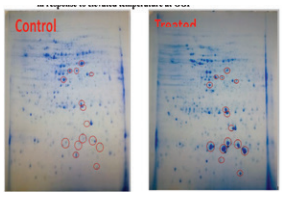


Fig. 50. Differentially expressed protein spots (through 2-DE) in response to elevated temperature in Co 99004

Protein extraction and separation: Three commercial varieties (Co 06022, Co 99004 and Co 0315) were used for proteomics study. Total proteins were extracted from treated and control samples of all the varieties. The protein concentrations were estimated by Bradford assay and 15 µg of each samples was used in SDS–PAGE. The SDS-PAGE (1D) analysis showed about four to five additional bands in heat treated samples of tolerant varieties *viz.,* Co 99004 and Co 06022 compared to control. Thus, the quality of the extracted protein samples was confirmed in Co 99004 and same was subjected for 2-DE analysis.

Protein separation through 2D-Gel: Protein was isolated from control and high temperature treated samples of Co 99004 through 2D-gel electrophoresis and purified differentially expressed protein spots were outsourced for MALDI-analysis (Fig. 50).

Transcript analysis: RNA was isolated from leaf tissues of control and high temperature treated samples of Co 99004 and same is under process for

Table 20. Lipid peroxidation and cell membrane injury index of 'Co' canes and S. spontaneum clones in response to elevated temperature

Varieties	Lipid Peroxidation (concentration of MDA u moles)				Membrane injury index (MII)			
	FP		GGP		FP		GGP	
	Control	Stress	Control	Stress	Control	Stress	Control	Stress
Co canes								
Co 06022	0.68	0.98	0.73	1.03	36.6	46.4	39.7	49.9
Co 0315	0.81	1.46	0.87	1.54	50.6	65.1	54.9	69.9
Co 8021	0.79	1.19	0.85	1.25	44.9	53.4	48.7	57.4
Co 86032	0.86	0.98	0.92	1.03	35.1	52.2	38.0	56.1
Co 99004	0.86	0.89	0.92	0.94	36.9	40.0	40.1	43.0
Mean	**0.80**	**1.10**	**0.86**	**1.16**	**40.8**	**51.4**	**44.3**	**55.3**
% increase	**34.20**		**37.50**		**22.05**		**38.50**	
Spontaneum								
Taiwan-96	1.79	1.90	1.93	2.01	31.8	31.8	34.5	34.1
SES-150	1.45	1.63	1.55	1.71	26.2	27.6	28.5	29.7
IMP-564	1.68	1.55	1.81	1.63	28.2	30.1	30.6	32.3
IND-85503	1.40	1.49	1.50	1.57	26.0	32.8	28.2	35.3
Mean	**1.58**	**1.64**	**1.70**	**1.73**	**28.1**	**30.6**	**30.5**	**32.9**
% increase	**14.50**		**19.25**		**7.50**		**12.25**	
Mean	**1.15**	**1.34**	**1.23**	**1.41**	**35.2**	**42.2**	**38.1**	**45.3**
Reduction %	14.17		12.76		16.58		15.89	
SEd	0.02	0.02	0.9	1.2	0.9	1.2	1.7	1.5
CD	0.03	0.04	2.0	2.6	2.0	2.6	3.5	3.3

De-novo transcriptome analysis. RNA integrated number was found good in both the control and treated samples, fastq quality check result was also found good at expected level

Evaluating the effect of Sea6-Biostimulant formulations on the quality and yield of sugarcane

(R.Gomathi)

The project has been initiated by planting of Co 86032 in RBD design in one acre at Bannari Amman Sugars Ltd., Sathiaymangalum. Foliar application of Sea6 formulations namely, LBS 3 @ 5 ml/L (T1), LBS 4 @ 1 ml/L (T2), LBS 4 @ 2 ml/L (T3), LBS 7 @ 1 ml/L (T4), LBS 6 @ 0.5 ml/L (T5), LBS 6 @ 1ml/L (T6), ASN 1 @ 1 ml/L (T7), LBS 7 @ 0.5 ml/L (T8) and T9 (as absolute control) was effected at 30, 60 and 90 days after planting.

Testing efficacy of Sea6 formulation: Shoot population was recorded at 60, 90, 120 and 150 DAP and the population was found higher in all the treatment studied over the control. Except for 60 DAP, the treatment effect was found to be significant at 90, 120 and 150 DAP. However at later stages, application of foliar spray of sea6 formulation particularly, (T_6) recorded maximum shoot population of 168.9 and 141.7 thousand ha^{-1} at 120 and 150 DAP, respectively. The higher plant height (149, 180.2 and 251.3 cm), LAI (3.84, 4.88 and 5.33) and SPAD value (40.9, 43.3 and 47.6) were recorded in foliar application of seaweed extract (T_6) at 120, 150 and 210 DAP, respectively. It was on par with (T_4), (T1) and followed by T_7 in all the stages studied. Results of crop growth and physiological parameters viz., plant height, leaf area index LAI, SPAD value and total dry matter production (TDMP) recorded at 120, 150 and 210 DAP showed that foliar application of seaweed formulations with different concentrations significantly improved plant growth compared to the control plants (Fig. 51).

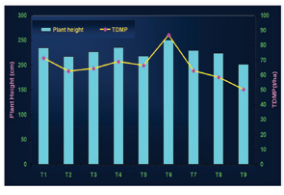


Fig. 51. Effect of sea6 formulations on plant height (210 DAP) and TDMP (320 DAP)

A mean TDMP at different growth phases was 42.6 (150 DAP), 48.9 (210 DAP) and 65.8 t/ha (360 DAP), in which LBS 6 @ 1 ml/L application showed maximum dry matter production of 59.4, 66.7 and 86.7 t/ha at 150, 210 DAP and 360 DAP, compared to control (31.5, 36.4, 50.2 t /ha, respectively). Foliar application of seaweed formulations with different concentrations significantly improved yield attributes compared to control. The yield attributes *viz.,* the number of internodes (27.7), cane length (261.5 cm), cane thickness (32.2 mm) and single cane weight (1.23 kg) were increased significantly by 17.31, 17.36, 12.09 and 19.41 per cent over control with foliar application of seaweed extract LBS 6 @ 1ml/l and it was followed by LBS 7 @ 1 ml/L, LBS 3 @ 5 ml/L and ASN 1 @ 1 ml/L. The significantly lower number of internodes (23.6), cane length (222.8 cm), cane thickness (28.7 mm) and single cane weight (1.03 kg) were recorded in control at harvest. The maximum NMC of 141.0 thousand /ha was obtained with foliar application of seaweed extract LBS 6 @ 1ml/L and it showed 11.64 per cent over control.

Yield: Among treatments studied, foliar application of seaweed extract LBS 6 @ 1 ml/ L recorded significantly higher cane yield of 161 t/ha^{-1} with 22.2% increase over control. It was followed by LBS 7@ 1 ml/L (T_4), LBS 3 @ 5ml/L and ASN 1 @ 1 ml/L.The juice quality parameters with respect to Brix, Sucrose, Purity and CCS per cent at 10^{th} and 12^{th} months indicated that the juice quality was not affected by foliar application of seaweed extract with different concentrations.

5.2.3 SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Development of a decision support system for sugarcane soil management

(A. Bhaskaran and *C. Palaniswami)*

Twenty nine soil samples collected from sugarcane farmer's fields were analysed and soil health cards were generated using the Decision Support System (DSS). The DSS was updated to provide soil test based package of practices from planting/ratooning to harvest. A test verification trial has been initiated in Split Plot Design with three replications. There are two main plot treatments *viz*., i) Conventional method of fertilizer application; ii) Pocket manuring and nine sub plot treatments *viz*., i) Blanket fertilizer dose in 2 splits at 45 and 90 DAP; ii) Blanket fertilizer dose in 4 splits at 30, 60, 90 and 120 DAP; iii) Blanket fertilizer dose in 6 splits at 30, 60, 90, 120, 150 and 180 DAP; iv) STCR based fertilizer dose for a target yield of 150 t/ha in 2 splits at 45 and 90 DAP; v) STCR based fertilizer dose for a target yield of 150 t/ha in 4 splits at 30, 60, 90 and 120 DAP; vi) STCR based fertilizer dose for a target yield of 150 t/ha in 6 splits at 30, 60, 90, 120, 150 and 180 DAP; vii) STCR based fertilizer dose for a target yield of 200 t/ha in 2 splits at 45 and 90 DAP; viii) STCR based fertilizer dose for a target yield of 200 t/ha in 4 splits at 30, 60, 90 and 120 DAP and ix) STCR based fertilizer dose for a target yield of 200 t/ha in 6 splits at 30, 60, 90, 120, 150 and 180 DAP. The experiment is in progress.

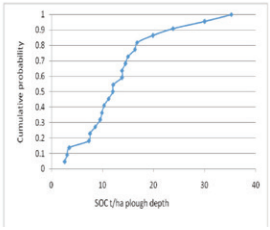


Fig. 52. Probability density function of the soil organic carbon storage in the plough depth

Assessment of carbon sequestration in sugarcane growing soils with reference to substrate dynamics

(C. Palaniswami, A. Bhaskaran and *A. Vennila)*

Soil samples from the sugarcane growing soils of Erode and Coimbatore districts were collected and organic carbon storage in the plough depth was estimated. Soil organic carbon in the sugarcane growing soil of Coimbatore and Erode district, Tamil Nadu ranged from 2.5 to 35.23 t/ha in the plough depth. The probability density function analysis of the organic carbon storage in the plough depth revealed that about 72 % of samples had more than 10.275 t/ha soil organic carbon in the plough depth (Fig. 52).

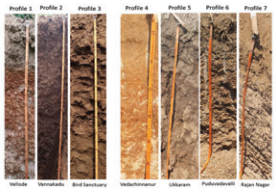


Fig. 53. View of profiles from study area in Perundurai and Sathyamangalam Taluk of Erode District

Organic carbon (OC) content of the organic substrates was analysed by wet oxidation method in three replications. The OC content of trash compost, FYM, vermicompost and biocompost was 12.73, 8.79, 14.03 and 17.96%, respectively. Two experiments are initiated to study the soil organic carbon dynamics when treated with these substrates and under different doses of gypsum in alkali soil.

Development of soil inference system for the management of sugarcane soils using pedotransfer function approach

(A. Vennila, C. Palaniswami and *A. Bhaskaran)*

Seven soil profiles were characterised in Erode District (Fig. 53). Layer-wise samples were collected from three sites in Perundurai Taluk. Depth of a profile at Vellode village was 85 cm with distinct Ap horizon. The depth of profiles at Vannakadu and Bird Sanctuary area were of 115 and 135 cm with the calcareousness rating of 2-4. Analysis of soil samples collected from these profiles showed organic carbon content of 0.56% at Vellode village, 0.83% at Vannakadu and 1.37% at Bird Sanctuary area in the surface layer, and the

subsurface layers in all the three profiles had low OC (<0.5%). The dry bulk density of different layers varied from 1.51 to 2.50 g/cc. The comparison of penetration resistance with soil depth showed the hardening below 20 cm depth with the penetration resistance of around 2 Mpa implying restriction to root growth. Saline-alkaline nature was observed in all the layers of the profile at Vannakadu village. An inverse relationship between bulk density and organic carbon content of different layers of the profile was observed (Fig. 54).

Soil profiles in Sathyamangalam Taluk of Erode were dug in the four sugarcane growing fields of the villages, Vedachinnanur, Ukkaram, Puduvadavalli and Rajan Nagar, and samples were collected from different soil layers. All the four profiles showed distinct Ap layer. The depth of profile at Vedachinnaur was 66 cm, more than 115 cm at Ukkaram village. The profile at Ukkaram showed buried soil formation. The profiles at Puduvadavalli and Rajan Nagar showed colluvial deposition. The depth of profiles at Puduvadavalli and Rajan Nagar was 90 and 85 cm, respectively. The organic carbon content in surface layers of the profiles at Vedachinnanur, Ukkaram, Puduvadavalli and Rajan Nagar was 0.58, 0.94, 0.37 and 0.40%, respectively. The organic carbon content of the subsurface layer of the profiles at Puduvadavalli and Rajan Nagar was below detectable by the Walkley and Black method of quantification. The dry bulk density ranged from 1.34 to 2.44 g/cc. All the soil layers showed alkaline reaction. The calcareous rating of the layers of the profile at Vedachinnanur and Ukkaram ranged from 1-4, while that of Puduvadavalli and Rajan Nagar was 4 in all the layers. The analysis of soil particle size distribution is in progress.

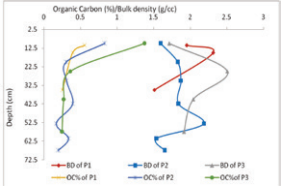


Fig. 54. Relationship of organic carbon (OC) and bulk density (BD) along the profile depth (P1 - Profile at Vellode; P2 - Profile at Vannakadu; P3 – Profile at Bird Sanctuary)

Evaluation of customized fertilizer on nutrient uptake, growth, yield and quality of sugarcane under field condition

(C. Palaniswami, A. Bhaskaran and *A. Vennila)*

Sugarcane variety Co 86032 was used as the test variety in Randomized Blocks Design, replicated thrice with nine treatments: T1: 100% Customized fertilizer recommendation; T2: 75% Customized fertilizer recommendation; T3: 125% Customized fertilizer recommendation; T4: Fertilizer recommendation by Ponni Sugars (Erode) Limited; T5: Fertilizer recommendation by Bannari Amman sugars Ltd.; T6: STCR based recommendation; T7: ICAR-SBI recommendation; T8: TNAU recommendation and T9: Farmers practices.

In the field experiment at M/s. Bannari Amman Sugars Pvt. Ltd. (BAS) Farm, there was no significant difference among the treatment with respect to number of millable canes, single cane weight, cane length, internode length, internode girth and number of internodes per cane and the mean values were 121159 / ha, 1.23 kg per cane, 2.45 m, 7.83 cm, 26.75 mm, and 31 nos. per cane, respectively. Cane yield of the treatment T1 (142.54 t/ha) was on par with T2 (133.24 t/ha) and significantly higher than all other treatments. Sugar yield of the treatment, T1 (16.13 t/ha) was on par with T2 (15.54 t/ha), T7 (15.35 t/ha), T9 (15.24 t/ha), T5 (14.97 t/ha), T8 (13.83 t/ha) and T3 (13.67 t/ha), and significantly higher than that of T4 and T6 (Table 21).

Table 21. Biometric data observed in the field experiment at R&D Farm, Bannari Amman Sugars Ltd., Sathyamangalam

Treatment	Single cane weight (kg)	Cane length (m)	Internode length (cm)	Internode girth (mm)	No. of internodes per cane	Cane yield (t/ha)	Sugar yield (t/ha)
T1	1.25	2.57	7.45	26.52	34.56	142.54	16.13
T2	1.13	2.32	7.67	27.87	30.33	133.23	15.54
T3	1.32	2.59	8.04	26.26	32.22	115.23	13.67
T4	1.33	2.46	8.04	27.61	30.56	100.06	11.40
T5	1.17	2.56	7.98	26.19	32.11	129.53	14.97
T6	1.15	2.30	7.59	27.64	30.22	101.44	11.54
T7	1.17	2.41	8.33	26.26	29.00	124.90	15.35
T8	1.07	2.25	7.63	24.84	29.56	119.44	13.83
T9	1.45	2.58	7.74	27.54	33.22	127.57	15.24
Mean	**1.23**	**2.45**	**7.83**	**26.75**	**31.31**	**121.55**	**14.18**
CD (5%)	**NS**	**NS**	**NS**	**NS**	**NS**	**12.89**	**3.00**

In the field experiment at Ponni Sugars (Erode) Ltd. (PS) Farm, there was no significant difference among the treatment with respect to number of millable cane, single cane weight, internode length, internode girth and number of internodes per cane and the mean values were 148457 /ha, 1.30 kg per cane, 7.89 cm, 29.25 mm, and 29 nos. per cane, respectively. However, the cane height varied significantly at p=0.05. Cane yield in the treatment, T3 (148.13 t/ha) was significantly higher than that of all other treatments. The treatment, T3 (17.20 t/ha) was on par with T6 (16.31 t/ha), T7 (16.18 t/ha), T2 (16.13 t/ha), T9 (14.85 t/h) and T1 (14.85 t/ha) with respect to sugar yield and significantly higher than that of T8 (13.29 t/ha), T4 (12.28 t/ha) and T5 (11.52 t/ha) (Table 22).

Table 22: Biometric data observed in the field experiment at sugarcane farm, Ponni Sugars, Erode

Treatment	Single cane weight (kg)	Cane length (m)	Internode length (cm)	Internode girth (mm)	No. of internodes per cane	Cane yield (t/ha)	Sugar yield (t/ha)
T1	1.22	2.23	7.03	30.05	31.89	125.72	14.85
T2	1.54	2.51	8.54	30.42	30.11	136.72	16.13
T3	1.42	2.39	7.74	29.73	30.89	148.13	17.20
T4	1.49	2.47	7.47	30.32	33.11	108.38	12.28
T5	1.17	1.87	7.27	30.16	26.00	102.94	11.52
T6	1.36	2.24	8.29	28.68	27.11	137.48	16.31
T7	1.32	2.41	7.79	30.05	31.67	134.04	16.18
T8	1.11	1.97	9.18	28.04	22.33	123.05	13.29
T9	1.08	2.03	7.73	25.79	26.22	131.05	14.85
Mean	1.30	2.23	7.89	29.25	28.81	127.50	14.73
CD (5%)	NS	0.36	NS	NS	NS	9.26	2.68

Application of customized fertilizer @ 100% of the recommended dose (T1) resulted in the highest cane yield of 142.54 t/ha in the field trial at M/s. Bannari Amman Sugars Pvt. Ltd. farm. Application of customized fertilizer @ 125% of the recommended dose (T3) gave significantly higher cane yield (148.13 t/ha) than that of all other treatments in the field trial at M/s. Ponni Sugars (E) Ltd. farm. Juice quality under different treatments did not vary significantly in both the trials. Study on nutrient uptake by biomass reflected no significant difference. Similarly, no significant difference among the treatments was observed with respect to soil quality after the harvest of the crop in both the field trials.

5.3 CROP PROTECTION

5.3.1 PLANT PATHOLOGY

Screening for red rot resistance under controlled conditions

(R. Viswanathan, P. Malathi, A. Ramesh Sundar, R. Selvakumar, V. Jayakumar and *K. Nithya)*

A total of 3147 clones from crop improvement projects and SBI-RC, Kannur comprising clonal trials, PZVT 2016 series, parental clones, GUK/ WL clones, GU clones, germplasm, climate resilient clones and high biomass hybrids were evaluated for red rot resistance under controlled conditions. Among them, about 1131 clones were identified as resistant and moderately resistant to red rot.

Sixteen 'Co' varieties included in SISMA trials were evaluated for red rot resistance under field conditions by plug and nodal methods of inoculation against Cf671 (CF06) and Cf94012 (CF12) pathotypes. In plug method, 12 were found to be R/MR and 3 were MS to red rot pathotype CF06, whereas for CF12 pathotype, four each were R/MR and MS and seven were S/HS. In nodal method, 13 and 8 were resistant to the pathotypes CF06 and CF12, respectively. The varieties Co 0240, Co 09004, Co 13003 and Co 15007 behaved as R/MR to both the pathotypes.

Field tolerance to red rot: Behavior of a set of varieties varying in red rot resistance was tested for their field tolerance against 10 isolates of *C. falcatum*. Among the varieties tested with all the 10 isolates, CoC 671 and Co 94012 succumbed to all the pathogenic isolates. The isolates Cf671, CfV09356-Elanganur, Cf92012-Kanjanur, CfC24-Puluthikudi, *Cf*0323-Petta, CfG93076-Kanjanur and Cf94012 have infected either the cane population completely or more than 50% of the canes. However, the isolates Cf671-Tuhili, Cf99006-MPM and CfPI1110-Kothangudi did not cause severe disease manifestations, indicating less pathogenicity of the pathogen inoculum applied in the soil. The popular variety Co 86032 showed traces of red rot in young tillers till 60 DAP for most of the isolates, but maintained its field tolerance. The other popular variety CoV 09356 tested against all the 10 isolates, picked up the disease to a severe extent in case of Cf671, CfV09356-Elanganur, *Cf*0323-Petta and CfG93076- Kanjanur. The variety remained free from the disease in case of Cf94012, traces in case of Cf92012-Kanjanur, Cf671-Tuhili and Cf99006-MPM and moderate in CfPI1110 Kothangudi and CfC24 Puluthikudi. Similarly, CoA 92081 also exhibited differential reaction to the 10 isolates. The

variety Co 0212 exhibited field tolerance to the isolates Cf671, CfV09356-Elanganur and Cf92012-Kanjanur. Similarly, the variety Co 11015 exhibited field tolerance to the isolates Cf94012 and Cf99006-MPM. Field tolerance in the respective varieties to the isolates CfC24-Puluthikudi and Cf671-Tuhili have to be confirmed. The varieties Co 06022, Co 06027, Co 06030 and Co 99006 succumbed to the three test isolates and exhibited disease of moderate to severe levels (Fig. 55).

Fig. 55. The varieties Co 06022 and Co 06030 picked up red rot to the inoculum applied in the soil

Further comparison of disease development through soil borne inoculum and plug method of inoculation revealed a clear variation among the two methods for disease development and severity in the varieties other than CoC 671 and Co 94012, which are highly susceptible to the disease. In cases of susceptible reactions of plug method, the variety Co 86032 exhibited field tolerance. Similarly, the variety Co 0212 exhibited field tolerance to the isolates *Cf*V09356-Ellanganur and *Cf*C24-Puluthkudi although it recorded susceptible reaction in plug method. On the other hand, the variety CoV 09356 picked up severe disease in case of resistant reactions in plug method (Table 23). The varieties Co 99006 and Co 06022 did not exhibit field tolerance as like Co 86032 and Co 0212.

Table 23. Comparison of sugarcane varietal reaction to C. falcatum isolates inoculatied by two methods: Plug and debris inoculation

Variety	*Cf*671		*Cf*99006-MPM		*Cf*V09356-Elanganur		*Cf*94012-O		*Cf*PI1110-Kothangudi		*Cf*C24-Puluthikudi	
	Plug reaction	Red rot incidence	Plug reaction	Red rot incidence	Plug reaction	Red rot incidence	Plug reaction	Red rot incidence	Plug reaction	Red rot incidence	Plug reaction	Red rot incidence
Co 86032	MR		S		MS		S		MS		MS	
CoV 09356	MR		MR		MR		MR		MR		MS	
Co 94012	HS		HS		HS		HS		HS		S	
CoC 671	HS		S		HS		HS		HS		S	
Disease incidence %		0		<10		10-25		25-50		>50		100

Yellow leaf disease (YLD)

(R. Viswanathan and *K. Nithya)*

Epidemiology: YLD severity and incidence on various germplasm and parental lines maintained at Coimbatore and Agali Centre were assessed periodically during the season. The results revealed that, out of 210, 280 and 189 clones in 'Co' canes, 'Co' allied canes and DUS, 185, 107 and 91 expressed YLD severity grades of 1, 2 and 3, respectively. Sixteen clones in Co canes and 12 in Co-allied had shown severity grades of more than 3. About 109 Co canes, 161 Co-allied canes and 98 clones in DUS were found to be apparently disease free. The species clones viz. *S. barberi*, *S. sinense*, *S. robustum*, *S. edule* and *S. officinarum* were also found affected with YLD with maximum disease severity grades of 2-3. Observation at NHG, Coimbatore had shown

that 48 clones were observed with YLD severity grade of 3, during the grand growth phase of the crop and 62 clones were with severity grade of 1-2.

Impact of YLD on cane growth and yield: Impact of YLD on cane growth and yield was assessed by comparing the virus-infected and virus-free planting materials in the field. It was found that the disease has significantly affected germination, plant growth/yield parameters such as number of stalks, cane diameter, cane length, number of internodes, cane weight, juice yield etc. in the popular variety Co 86032. It was found that due to the virus infection, cane and juice yield are reduced by ~20 and 10 per cent, respectively in the variety in the plant crop (Table 24).

Table 24. Impact of YLD on cane yield parameters

Growth/ yield parameters	Healthy	Diseased	% reduction
Germination per cent	87.5	72.5	17.14
No of stalks (3 m row)	37.0	31.0	16.21
No of internodes	28.6	23.6	17.48
Internode length (cm)	12.7	9.82	22.43
Cane length (cm)	253	194	24.11
Single cane weight (kg)	1.56	1.13	27.30
Estimated cane yield (t/ha)	142	114	19.71
Juice weight per kg of cane	0.56	0.50	10.79
Brix	20.0	20.5	-
Sucrose (%)	18.5	18.9	-
CCS (%)	13.1	13.3	-
No. of arrows (plot)	17	7	-

Dynamics in aphid population: Monitoring of sugarcane aphid population in the field revealed that all the 13 varieties subjected for the periodical surveys exhibited severe aphid infestation. Most of the varieties exhibited the highest population during July-August months and later the insect population showed a gradual decline. Incidentally, YLD affected plants of the cvs Co 86032, CoC 671 and CoPant 84211 showed 2 to 3 fold higher aphid population during the peak infestation of aphids.

Fig. 56. Differential interaction exhibited by Co 2001-13 to different C. falcatum pathotypes

Characterization of red rot pathotypes

(R. Viswanathan and *R. Selvakumar)*

About 34 isolates of *C. falcatum* were tested for their behavior on 32 old and new sugarcane varieties by plug method under field conditions. Among them, the isolates Cf671-G, Cf95020-G, Cf86032-Srikandapuram, CfV09356-Paripalli, CfPI1401-Kadaganur and CfV09356-Elanganur were highly virulent on the 32 varieties. The isolates Cf7805C-AP, Cf997, Cf62175-AP, Cf671, Cf86002-Polur, Cf86032-Kallakuruchi, Cf92012-Naga and Cf06022-Kuttalam were found to be less virulent. The varieties CoC 671 and Co 94012 exhibited universal susceptibility, whereas CoS 8436 and CoSe 95422 exhibited resistance. Although the resistant variety BO 91 did not exhibit susceptible reaction, it exhibited MS reaction to 18 isolates. The varieties Co 419, Co 658, Co 6304, Co 7805, Co 95020, Co 99006 and CoS 96268 mostly behaved as susceptible except for a few swings to MS or MR. Conversely

Co 94008, Co 2001-13 and Co 0238 behaved as resistant except for few MS reactions. The varieties Co 86002, Co 86032, Co 2001-13, CoV 92102, CoV 09356 and PI 1110 exhibited differential reaction to the isolates (Fig. 56).

Mapping pathogenic and molecular variability of sugarcane smut in India.

(A. Ramesh Sundar, R. Viswanathan and *P. Malathi)*

Pathogen variability: Smut pathogen (*Sporisorium scitamineum*) variability on distinct host genotypes were identified, which could be possibly used as new host differentials. The experiment is repeated for checking the consistency. Distinct mating type cultures (+ and -) of phenotyped smut pathogen isolates (isolates varying in virulence pattern) were established to utilise them for understanding variability using molecular markers. Pri mers were designed targeting mating type specific genes, so as to discriminate between opposite mating types (+ and -). The individual mating type cultures representing different smut pathogen isolates will be used for studying variability at molecular level.

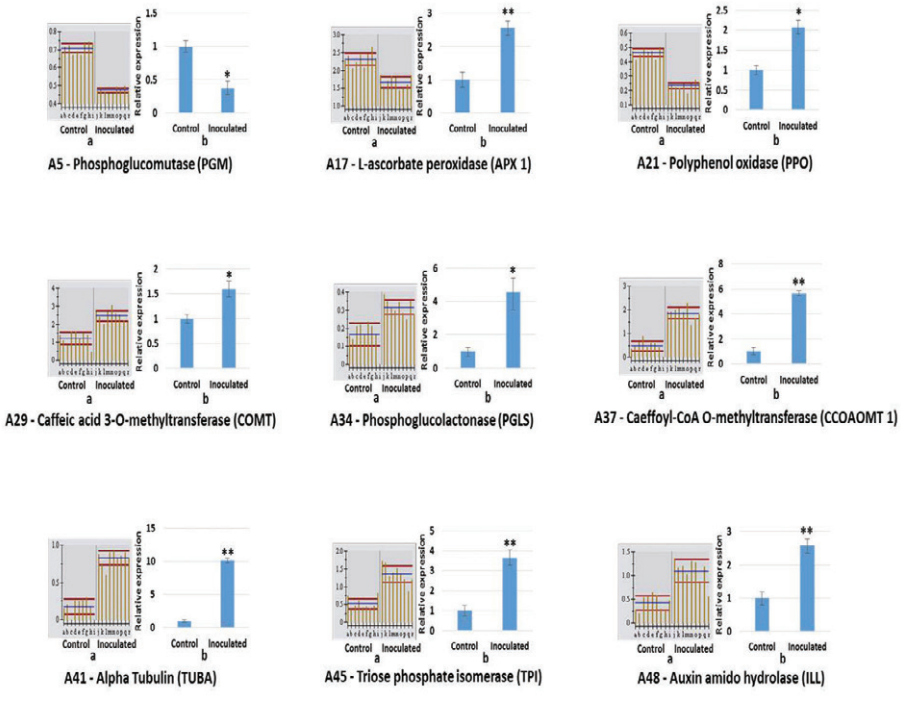


Fig. 57. Comparison of 2D gel spot intensities (a) with their corresponding transcript abundance (b) of candidate sugarcane genes with functional significance

Transcript profiling of the differentially expressed smut-pathogen responsive proteins: Proteome profiling of a smut pathogen responsive sugarcane Co 96007 established 53 differentially expressed proteins. In continuation of functional annotation of these proteins, analysis of the relative expression of these proteins at the transcript level was undertaken. Transcript expression *vis-a-vis* the activity of phenylalanine ammonia lyase was relatively higher in the infected meristem. Abundance of seven candidate proteins in 2D gel profiles was in correlation with its corresponding transcript expression levels as validated by qRT-PCR. Furthermore, this study has opened up new perspectives on the interaction between sugarcane and *S. scitamineum*.

The results indicated that there are subtle modulations and complex interplay between proteins representing phenylpropanoid pathway, oxidative stress response, and various other metabolic and cellular processes in infected sugarcane meristem cells. We postulate that *S. scitamineum* is likely to establish a compatible interaction with sugarcane by predominantly modulating the Salicylic Acid and phenylpropanoid pathways. In congruence with the abundance of these proteins spots in 2D gel profiles, relative expression levels of stress-related genes viz. APX1, PPO, *COMT*, *PGLS*, *CCOAOMT 1*, *TUBA*, *TPI* and *ILL* were significantly higher in response to *S. scitamineum* (Fig. 57). Transcript expression of *PGM* (associated with carbohydrate metabolism) was lower in pathogen-challenged samples compared to mock inoculated control. Interestingly, though the transcript abundance of *APX 1* and *PPO* genes was higher in the inoculated samples, these protein spots were down-regulated in response to *S. scitamineum* infection.

Sporisorium scitaminuem effectors: Putative orthologs of *Ustilago maydis* effectors *viz*., Pep1, Cmu1, Tin2, Srt1, Stp1 and Pit1 in *S. scitamineum* genome were identified. *In silico* analysis revealed that the identified candidate *S. scitamineum* orthologs shared higher sequence identity with *Sporisorium reilianum* than *U. maydis* sequences. Signal peptides, transmembrane and other conserved domains identified putative *S. scitamineum* effector orthologs were consistent with reported *U. maydis* effectors. Transcripts of all the six putative *S. scitamineum* effector orthologs were expressed several folds higher with distinct patterns throughout the profiled time points (1, 3, 6, 12, 18, 36 dpi) compared to dikaryotic mycelium grown under axenic condition. No expression was detected *in vitro* in both distinct (+) and co-culture (+ -) haploid sporidial samples (Fig. 58). Transcript expression of putative *S. scitamineum* Pep1 was highest at 3dpi and was consistently expressed throughout all the other time intervals, while expression of putative *S. scitamineum* Cmu1, Tin2 and Srt1 transcripts was comparably higher during the later stages of infection (12,

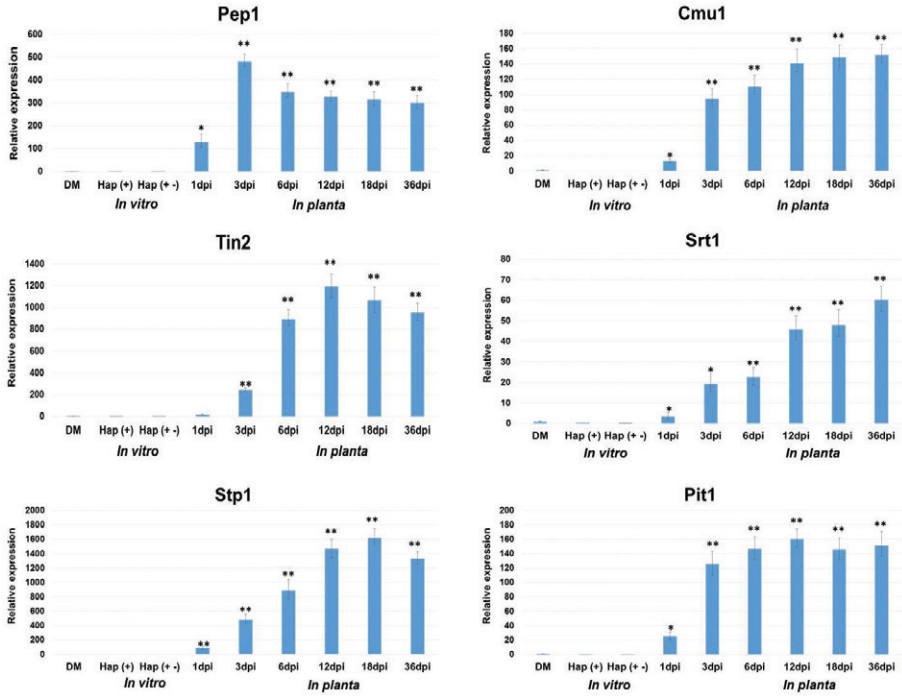


Fig. 58. In vitro and in planta transcript expression analyses of the identified putative Sporisorium scitamineum effector orthologs

18 and 36 dpi) than the initial phase (1, 3 and 6 dpi). The highest expression of Cmu1 and Srt1 was at 36 dpi and highest expression of Tin2 was at 12 dpi. Expression of putative *S. scitamineum* Stp1 increased gradually after 3 dpi with the highest expression recorded at 18 dpi, while putative *S. scitamineum* Pit1 was expressed consistently in all the time intervals after 1 dpi and highest expression was at 12 dpi. The study has identified putative *S. scitamineum* orthologs corresponding to *U. maydis* effectors, profiled its transcript expression during the entire course of sugarcane smut infection and the results indicated that these candidate effectors could also be conserved among other closely - related smut fungi and codon sites with an evidence of positive selection and episodic diversifying selection were detected in a few sequences.

Identification and characterization of genes / proteins related to Colletotrichum falcatum pathogenicity

(P. Malathi, R. Viswanathan and *A. Ramesh Sundar)*

Characterization of pathogenicity related genes of C. falcatum by genomic approach: In order to characterize the genes related to pathogenicity, differentially expressed genes from Suppressive Subtraction Hybridization (SSH) analysis carried out between the virulent isolate Cf671 and the least virulent isolate Cf92020 grown under *in vitro* conditions. *In vitro* analysis of virulent (Cf671 - tester) and least virulent (Cf92020 - driver) isolates by SSH yielded a total of 4228 differentially expressed transcripts including 3736 Unigenes belonging to Cf671. Of which 2266 had no significant hits and in the remaining transcripts, maximum similarity hit was distributed with *Colletotrichum graminicola* (around 410), *Colletotrichum sublineola* (around 385) followed by other species (Fig. 59). Gene ontology annotation was performed using BLAST2GO tool and found that the Unigenes were

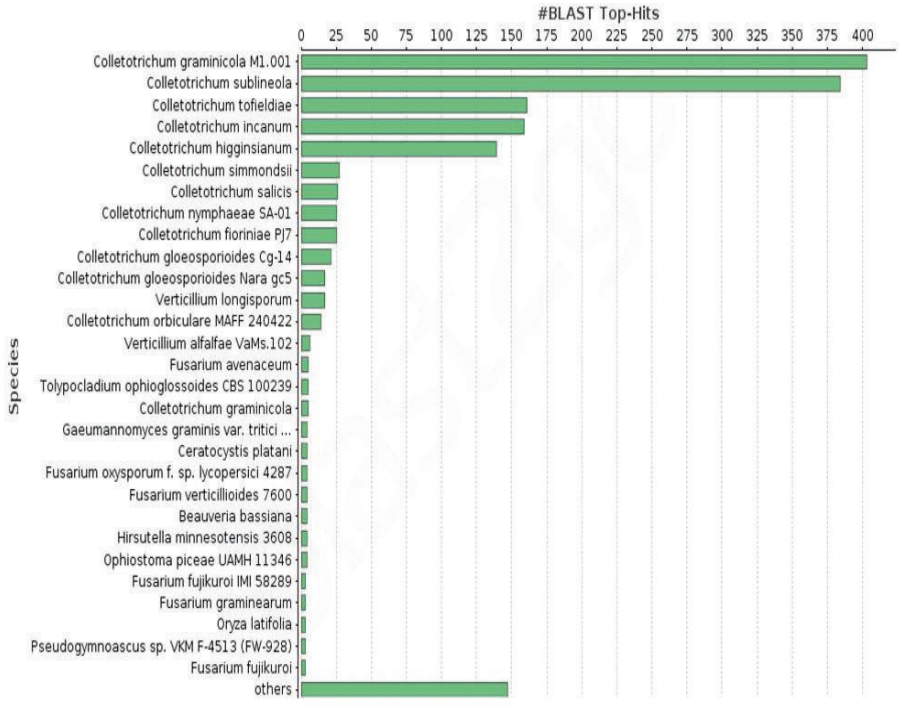


Fig. 59. Top-hit species distribution of unigenes annotated by BLASTx

distributed in different categories viz., Biological process – 540, Molecular functions – 546 and Cellular components – 502 (Fig. 60).

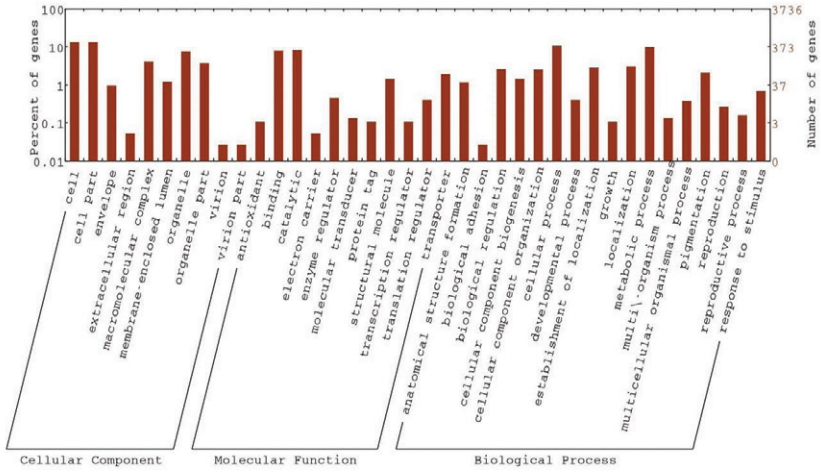


Fig. 60. GO distribution of unigenes annotated by BLAST2GO.

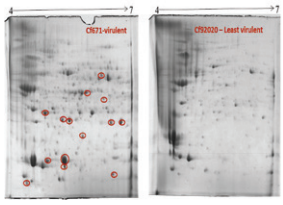


Fig. 61. In vitro Secretome analysis of C. falcatum isolates varying in virulence

Characterization of pathogenicity related proteins of C. falcatum by proteomic approach: In addition to host-pathogen interaction, attempts were made to characterize differentially expressed proteins of *C. falcatum* with respect to its virulence under culture conditions. For which, protein profiles based on 2-DE were developed for mycelial and extracellular proteins of virulent isolate Cf671 and the least virulent isolate Cf92020. The secreted proteins of the virulent (Cf671) and least virulent (Cf92020) isolates were analyzed by 2-DE (Fig. 61). A total of 543 spots from Cf671 and 475 from Cf92020 were obtained of which 398 were common spots. From that 88 unique/differentially expressed spots were sequenced by MALDI-TOF. Upon analysis of the sequenced spots by MASCOT search, it was found that hits of 65% of the obtained proteins matched with *Colletotrichum* spp. The major secreted proteins obtained related to pathogenicity were peptidyl prolyl cis/trans isomerase, fungal specific transcription factor, ubiquitin carboxyl terminal hydrolase, ABC transporters, etc.

Standardization on functional analysis of pathogenicity related genes by RNAi approach: In this study, we have utilized RNA interference (RNAi) approach using pSilent1 vector, which facilitates the generation of hair pin constructs that suppress the expression of target gene through *Agrobacterium* mediated transformation (ATMT) to functionally analyze the major gene PKS1 gene involved in the production of DHN melanin to determine its role in virulence. Functionally active sites of the PKS1 gene i.e., acyl transferase (AT) domain and the region responsible for conidial pigment (CP) were chosen for knockdown (Fig. 62). The results indicated that knockdown AT mutant failed to produce spores, whereas the CP mutants produced spores as that of the parental strains. However disease symptoms of both AT and CP mutants were restricted within the inoculated internode as compared to 3rd node in control on 15 dpi. Molecular confirmation of the knockdown mutants with the expression of hygromycin gene and absence of functional domains in

PCR clearly indicated that the PKS1 gene has a putative role in *C. falcatum* pathogenesis.

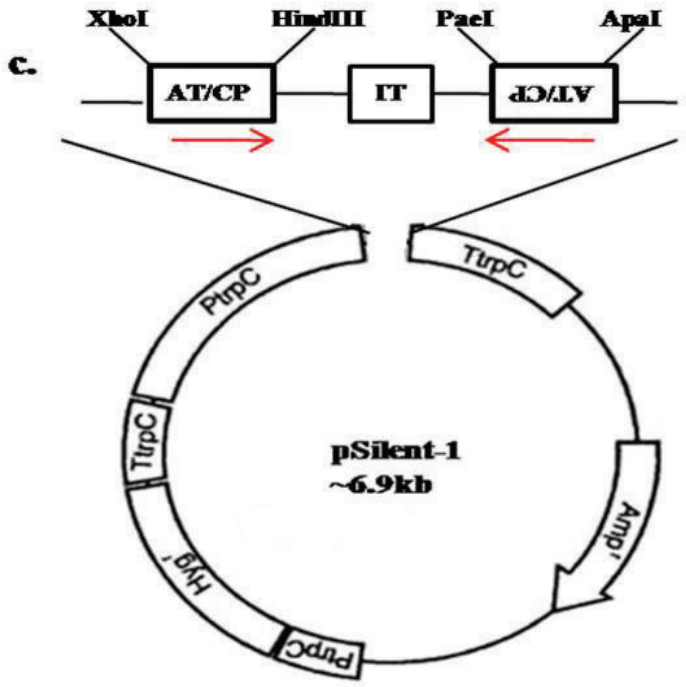


Fig. 62. Schematic representation of pSilent-1 vector containing sense and antisense construct of acyl transferase /conidial pigment domains

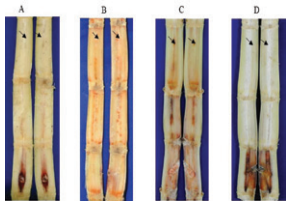


Fig. 63. Two way and three way interaction of C. falcatum and T. harzianum in sugarcane stalk

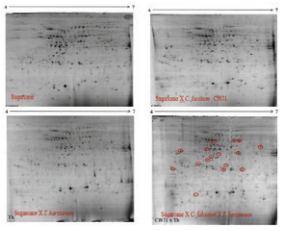


Fig. 64. Differential expression of proteins during tritrophic interaction of C. falcatum and T. harzianum on sugarcane

Identification of anti-fungal genes and sugarcane phytoalexins as marker for red rot resistance

(R. Viswanathan, P. Malathi and *A. Ramesh Sundar)*

Identification of differentially expressed proteins during tritrophic interaction: During tritrophic interaction with *C. falcatum* and *T. harzianum* in sugarcane, the results confirmed reduction in symptom production (Fig. 63), During interaction, protein samples were extracted from both *in vitro* and *in vivo,* subjected to 2-DE and differentially expressed spots were sequenced by MALDI-TOF. Analysis by Mascot search results showed that, most of the assigned proteins from *in vitro* interaction were defense and stress responsive proteins *viz*., disulfide isomerase, pyruvate decarboxylase, peroxidase, Hex1, Cu/zn superoxide dismutase etc., from *Trichoderma* spp., and few hypothetical proteins were expressed from *Colletotrichum* spp.

In vivo proteomics (Fig. 64) results showed that, s-adenosyl methionine synthetase, translation initiation factor FA, ascorbate peroxidase, caffeic acid 3-o-methyltransferase (stress responsive proteins) glutamine synthetase (nitrogen metabolism), nucleoside diphosphate kinase-1-like protein (signaling protein) and hypothetical proteins etc., were highly expressed as defense, related proteins from sugarcane against the red rot pathigen by the induction of *T. harzianum*. Simultaneously the pathogenicity / virulence related proteins *viz*., cytochrome p450, putative phosphopyruvate hydratase, Hsp20-like protein, copper / zinc superoxide dismutase, hypothetical proteins reported from *Colletotrichum* spp were also obtained during the three-way interaction.

Further, the qRT-PCR studies confirmed that the up-regulation of defense and stress related proteins were mediated by *T. harzianum* in sugarcane. Interestingly, the pathogenicity / virulence related proteins *viz*., cytochrome p450 and hsp20-like proteins, hypothetical proteins of *C. falcatum* were down regulated during the interaction both under *in vitro* and *in vivo* conditions.

Red rot resistance mechanism: The novel miRNA prediction was carried out with unaligned reads of precursor miRNAs to the reference genomes of *Oryza japonica, Sorghum bicolor, Triticum aestivum and Zea mays* using miRDeep2 tool in sugarcane after *C. falcatum* challenge. Further, target prediction was carried out for known and novel miRNA sequences using miRanda tool with *O. japonica, S. bicolor, T. aestivum* and *Z. mays* genomes, resulted in different gene targets belonging to various functions. Gene ontology (GO) functional classification analysis was performed to classify the functions of the identified miRNAs target genes and all the target genes were categorized into different functional groups. Differentially expressed miRNA among the resistant and susceptible cultivar were identified. Differentially expressed miRNA families among the resistant and susceptible cultivars viz. MIR319, MIR530, MIR399, MIR166, MIR172, MIR167, MIR397, MIR6234, MIR166, MIR6227, MIR1878, MIR408, MIR444, MIR6253, MIR319, MIR5505 and MIR164 were up regulated, while miRNA families of MIR6218, MIR6234, MIR171, MIR6227, MIR5538, MIR444, MIR319, MIR396, MIR818, MIR156, MIR166, MIR6232 and MIR821 were down regulated (Fig. 65).

Fig. 65. Identification of miRNA families during the sugarcane - C. falcatum interaction.

Developing chitosan based nano-delivery systems for disease management and enhancing nutrient use efficiency in sugarcane

(a) Inducer nano-particles as smart delivery system for harnessing red rot resistance in sugarcane

(V. Jayakumar, A. Ramesh Sundar, R. Viswanathan and *A. Bhaskaran)*

Assessing antifungal activity of chitosan: The *in vitro* antifungal activity of chitosan (3% w/v) was assessed against *C. falcatum*, *F. sacchari* and *S. scitamineum* in Petri plate and also by spore germination assay in cavity slide. Chitosan inhibited more than 50% mycelial growth (Table 25, Fig 66**)** and 100% spore germination of *C. falcatum, F. sacchari* and *S. scitamineum*. The chitosan not only prevented germination of spores but also degraded the spores of all three fungi in 24 h, which is evidenced by microscopic observation of spores in chitosan inoculated spore solution at various intervals. The results showed that chitosan has strong direct antifungal activity on all three tested pathogens and it will be very much useful in developing formulation for field application, i.e., when it is released into the sett, it will directly inhibit the pathogen propagules present in plant parts apart from its another role as coating material for SAR inducer molecules.

Table 25. In vitro antagonistic potential of chitosan against major fungal pathogens of sugarcane

Pathogen	Mycelial growth inhibition (%)	Inhibition of spore germination (%)
C. falcatum	42.5- 56.6	100
F. sacchari	43.3- 76.6	100
S. scitamineum	44.0- 60.0	100

Synthesis and characterization of chitosan coated SAR inducer nanoparticles: The protocol for synthesis of nanoparticles was modified to obtain uniform size particles with good zeta potential and the synthesized nanoparticles were characterized by assessing size, colloidal property, surface morphology and chemical properties. The chitosan coated salicylic acid (SA) nanoparticles had average particle size of 332nm in 5:1 ratio of CS: SA and had zeta potential of 32.2 mV and the benzothiadiazole (BTH) nanoparticles had average particle size of 367nm in 6:1 ratio of CS: BTH and had zeta potential of 31.0 mV. In comparison to previously developed methodology the present modified method showed reduced particle size with less particle dispersity index and higher zeta potential. The nanoparticles had very good colloidal property, i.e., particles did not settle down till 15 days after synthesis and when lyophilized particles were re-suspended in water still it maintained its stability and size. Analysis of surface morphology of particles with scanning electron microscopy showed presence of thin layered flake like structures. The encapsulation efficiency (EE), i.e., the drug content (SAR inducer molecules) that is entrapped into polymeric matrix (chitosan) were assessed by measuring the entrapped and remaining SAR inducer molecules in supernatant with colorimetric (for SA) and HPLC (for BTH) methods. The chitosan coated SAR inducer nanoparticles had EE of 83.43 % for SA and 68.52% for BTH, indicating the suitability of particles for release studies.

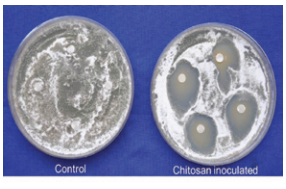


Fig. 66. In vitro mycelial growth inhibition of S. scitamineum by chitosan- paper disc assay

Characterization of rust resistance in sugarcane and dynamics of rust pathogens under changing climate in India

(R. Selvakumar)

Rust resistance status of donor parents used in Indian breeding programme was assessed under natural condition in National Hybridization Garden (NHG) and Arrowing plot. Frequent surveys revealed that the expression of rust disease was highly influenced by the prevailing weather conditions. Though sugarcane rust was noticed at Coimbatore, many of the well-known susceptible varieties did not show the expected rust severity during 2016-17 under natural conditions. The clones which did not show the rust might have escaped and their true nature of rust resistance need to be tested under artificial conditions. It was found that rust appeared twice in a year in sugarcane, once during January and second during July when the optimum temperature is prevalent. During 2016-17, more than 6% of clones in arrowing plot and less than 4% clones in NHG and 'Co' cane maintenance plots exhibited rust symptoms. Among the different entries of Sweet Bloom Project, only Co 14008 showed rust susceptibility and other entries were apparently free from infection at Coimbatore conditions during the season.

Molecular characterization of phytoplasmas associated with sugarcane

(K. Nithya and *R. Viswanathan)*

Thirty-seven sugarcane grassy shoot disease samples were collected from different places, viz. Uttar Pradesh, Haryana and Tamil Nadu. Total DNA

was extracted using CTAB method and SCGS phytoplasma was confirmed through nested PCR assay using P1/P7 and R16F2n/R16R2 primers, which amplifies the 16S-23S spacer ribosomal rRNA regions. Out of the 37 samples, 33 showed positive amplification of 1.2kb in size; in which 29 samples were sent for sequencing. The sequencing results revealed that the isolates from the cvs Co 8353, Co 86032, CoLk 8102, CoS 8436, CoTl 1153 and CoV 92101 had shown 99-100% similarity with the previously submitted SCGS phytoplasma isolates in the NCBI database. The matches were belonged to the *Candidatus* Phytoplasma oryzae - 16SrXI group, and 98% identity with the Bermuda grass white leaf phytoplasma and Brachiaria grass white leaf phytoplasma, which belonged to the *Ca*. Phytoplasma cynodontis, 16SrXIV

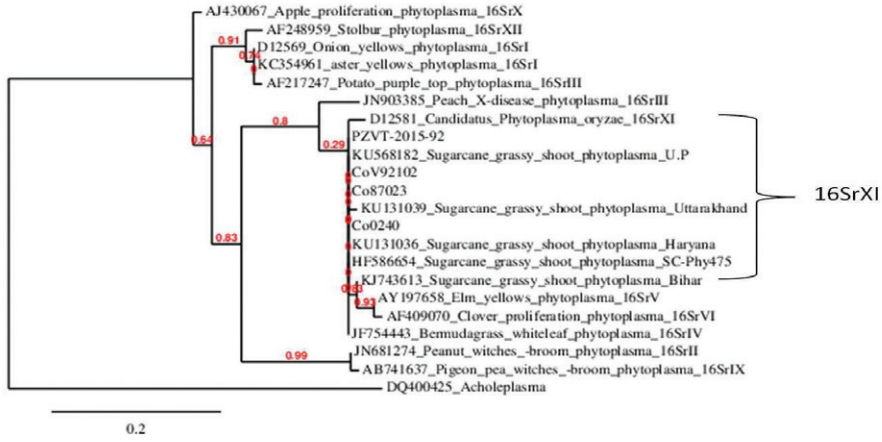


Fig. 67. Phylogenetic tree constructed by maximum likelihood estimation through PhyML program with SCGS phytoplasma 16SrRNA sequences along with other related Phytoplasma groups. Numbers on the branches indicate the cut off value of over 50 % (1,000 bootstraps). Acholeplasma sp. was used as the out group.

group (Fig. 67). Regarding association of phytoplasma in yellow leaf disease, several suspected YLD samples viz. Co 449, Co 6304, Co 86010, Co 87269, Co 10031, CoC 671, CoC 99061, CoS 8436 and 57NG56 were collected from Coimbatore and Agali Centre and subjected to nested PCR using universal phytoplasma primers as well as from newly designed primes from yellow leaf phytoplasma regions. SCGS phytoplasma association was found from the sequencing results of phytoplasma positive YLD samples from Co 6304, Co 10031, CoPant 84211 and Co 86010. However, further confirmation is needed for the possibilities of other phytoplasma associations.

Mechanized means of sett treatment to deliver different agro-inputs for the management of biotic and abiotic stress in sugarcane

(P. Malathi, R. Viswanathan, A. Ramesh Sundar, T. Ramasubramanian, A. Vennila, Ravinder Kumar, M.L. Chhabra and *B. Parameswari)*

Efficacy of mechanized sett treatment for pest and disease management: In order to find out the possibility of combining a fungicide and insecticide for the combined delivery to setts through sett treatment device (STD), a fungicide (thiophanate methyl/ propiconazole) and an insecticide (fipronil) were combined and treated the setts before planting for the management of pest (early shoot borer – ESB) and diseases (red rot/ smut) in early stages of crop growth. Results showed that the combinations were not deleterious to germination/ plant survival and were effective in reducing the disease

and early shoot borer incidence with less than 10% variation as compared to individual treatment.

Efficacy of mechanized sett treatment for the delivery of nutrients to setts: Like single bud setts treatment in STD for nursery programme, efforts were made to standardize delivery of nutrients through setts before planting in the main field. For which we have optimized the dose and vacuum level for different combinations of nutrients and plant protection chemicals. Results showed that the combination of 0.1% of urea, $ZnSO_4$ and $FeSO_4$, each at a vacuum level of 250 and 200 Hg/mm was found to give maximum benefit. The treatments were very much beneficial giving rise to increased tillers, healthy cane stalks and there was a significant yield improvement of 17 to 28% at the time of harvest in various treatment combinations

Fig. 68. Release of mechanized sett treatment technology

Commercialization of the technology: From the institute and factory trials conducted for more than 10 years with prototype/ newly fabricated units of STD, it was confirmed that this device is highly effective in treating sugarcane planting materials. The technology has been released during Kisan Mela-2016 of the Institute (Fig. 68). The technology was commercialized and licensed to an entrepreneur M/s. CLEANTEK, Coimbatore.

Characterization of virus suppressor proteins in RNA viruses infecting sugarcane and developing transgenic sugarcane lines resistance to SCSMV and SCYLV through RNAi approach

(R. Viswanathan, P. Malathi, K. Lakshmi and *B. Parameswari)*

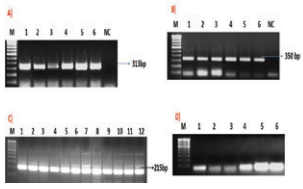


Fig. 69. RT-PCR assay to confirm the presence of chimeric and kanamycin (nptII) genes from the co-cultivated and wild (NC) regenerated shoots. A) RT-PCR amplification of SCSMV chimeric P1 gene of 313bp, B) RT-PCR amplification of SCYLV chimeric P0 gene of 350bp, C) RT-PCR amplification of nptII gene of 215bp, D) No amplification of nptII gene from wild regenerated shoots by RT-PCR.

A one month old callus derived from the sugarcane cvs Co 86032 and CoC 671 were co-cultivated with recombinant *Agrobacterium* suspension harbouring the suppressor genes of *Sugarcane streak mosaic virus* (SCSMV) P1 and *Sugarcane yellow leaf virus* (SCYLV) P0 supplemented with 200 µM acetosyringone. The presence of the transgenes in kanamycin resistant regenerated shoots was verified through RNA extraction followed by RT-PCR assay to confirm the presence of the nptII and the chimeric SCSMV-P1 and SCYLV-P0 genes. The assay confirmed the presence of nptII gene amplified by 215bp amplicon, P1 by 313bp and P0 by 350bp, respectively (Fig.69).

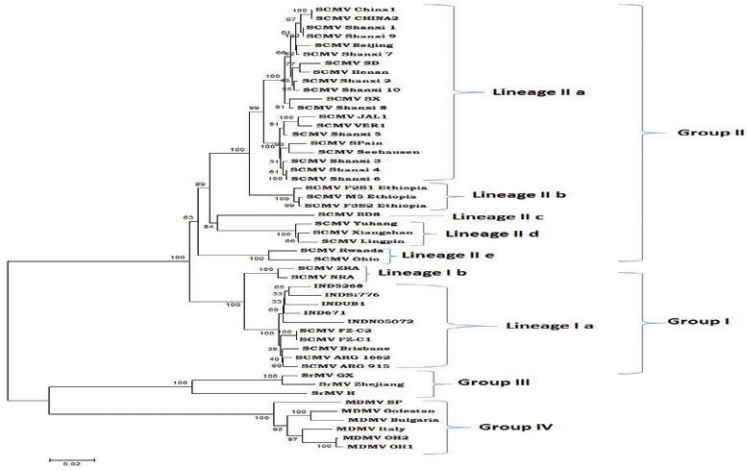


Fig.70. Maximum-likelihood tree based on the complete genome protein sequences of five SCMV Indian and other country isolates evaluated using the interior branch test method with Mega 5 software. The scale bar represents a genetic distance of 0.02. The Indian isolates were clustered in lineage I along with closely related sugarcane infecting isolates from Australia, Argentinian and China. Rest of the maize infecting SCMV isolates were clustered in lineage II.

Genome characterization of SCMV: Sugarcane mosaic virus (SCMV) another causative virus of mosaic disease was characterized based on its complete genome. Comparative genome analyses of five new isolates were performed with previously reported 36 SCMV full genome sequences of isolates infecting maize and sugarcane. Sequence identity matrix and phylogenetic analyses clearly represented that Indian isolates are closely related to sugarcane infecting isolates from Australia followed by China and Argentina and they are divergnt as a separate lineage from other reported maize infecting isolates of Mexico, China, Spain, Germany, Iran and Ethiopia (Fig. 70). Selection pressure analysis clearly depicted the predomination of strong purifying selection throughout the viral genome, and strongest in CI and HC-Pro gene. Evidence for few positively selected sites was identified in all the cistrons except in 6K1 and Nib rep. Among the genomic region, CI gene has exhibited comparatively more recombination hotspots followed by HC-Pro unlike other reported isolates. As the cultivation of sugarcane was first originated in India, our results from the recombination events strongly suggest that Indian SCMV populations contribute for the emergence of upcoming new recombinant SCMV isolates in other countries irrespective of geographic origin and host type.

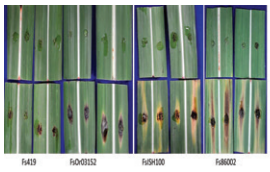


Fig. 71. Pathogenicity of F. sacchari isolates in detached leaf assay.

Top: Mock inoculated control, Bottom: Pathogen inoculated leaf bits showing lesions of different sizes

Outreach project on Phytophthora, Fusarium and Ralstonia diseases of horticultural and field crops – Fusariums infecting sugarcane

(R. Viswanathan, P. Malathi, A. Ramesh Sundar, R. Selvakumar, M.L.Chhabra and *B. Parameswari)*

Simulation of Fusarium pathogenicity

Detached leaf assay: An *in vitro* detached leaf assay was developed to screen the *F. sacchari* isolates for studing variation in their pathogenicity. Fifty three isolates were screened for their pathogenicity on CoC 671 leaf bits. Based on the necrotic lesion size and presence and absence of yellow halo, the pathogenic reactions were graded as virulent, moderately virulent and less virulent (Fig. 71). Highly virulent isolates from wilt and pokkah boeng (PB) groups were identified.

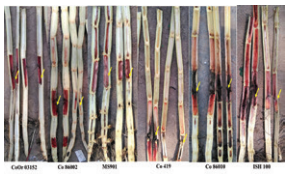


Fig. 72. Different sugarcane varieties exhibiting variation in pathogenicity to F. sacchari isolate FsMS901

Plug method of inoculation: Disease development in the stalk of six varieties to five wilt isolates was studied in detail under field conditions at Coimbatore. Half of the plot was subjected to drought conditions without irrigation after pathogen inoculation to assess the impact of moisture stress on wilt severity. The study revealed that the cane varieties exhibited a differential wilt severity with different isolates (Fig. 72). FsCPb00Q82 isolate was found to be weak in pathogenicity. The cvs Co 86010 and MS 901 were susceptible to all the six isolates in both normal irrigation and drought plots indicating their innate susceptibility (Fig. 73). However, in other varieties a clear impact of drought on wilt severity was noticed.

Comparative virulence of F. sacchari isolates at Karnal: About 23 isolates were inoculated on six sugarcane varieties and subjected to water limiting stress as in Coimbatore. Among the isolates, FsCoSe 98231 exhibited more virulence followed by FsCoS97264, FsWV11, FsWV14, FsWV13 and other isolates under water stress than normal field conditions. The cv Co 419 succumbed to 21 isolates followed by the cv Co 89003 (18 isolates), CoC 671 (13 isolates) and CoS 8436 (9 isolates). Two varieties namely Co 05011 and Co 975 exhibited limited infection probably due to lack of matching isolates.

Fig. 73. Simulation of wilt by plug method of inoculation: Severe expression of wilt in sugarcane cv MS 901. Left - external symptoms with rind discolouration and shrinkage of internode s. Right – typical wilt with pith cavities and desiccation of internodal tissue

Fig. 74. Field view of wilt affected canes at Karnal

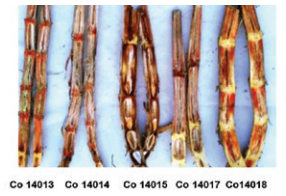


Fig. 75. Severe wilt symptoms of the affected canes at Karnal

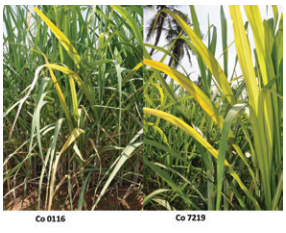


Fig. 76. Pre-wilt symptoms expressed in sugarcane varieties under Coimbatore conditions

Disease development from wilt affected setts: It was found that the sett-borne inoculum resulted in either reduction of germination or post germination death / drying of settlings during tillering phase, as well as grand growth phase in case of the cvs CoOr 03152, MS 901, Co 98010, C79128, Co 86002, CoM 88121, CoT 8201, MS 68/47 and CoJ 83. As days progressed, most of the cases in diseased plots exhibited gradual yellowing of leaves and wilting than that of the healthy plots.

Disease management

Management of pokkah boeng (PB) and wilt in sugarcane: Field experiments to manage PB in sugarcane with systemic fungicides, carbendazim and propiconazole by soil drench and foliar application revealed a reduction of PB incidence in the cvs Co 775 and Co 419. However, in case of cvs MS 901, Co 86010 and CoJ 83 the disease recovered significantly after foliar application of propiconazole. The same set of cultivars showed only partial PB recovery, when carbendazim was applied by both foliar spray and soil drench. The results clearly indicated that repeated foliar application of propiconazole is effective to manage PB incidence in sugarcane.

To manage PB in NHG, a fungicide spray schedule of Carbedazim 12% + Mancozeb 63% (Companion @ 1g/l) or propiconazole 25EC (Tilt @ 0.5ml/l) alternatively at 10 days intervals was developed. The spray schedule effectively reduced PB severity under field conditions. Although soil drenching of fungicides only showed partial recovery from wilt, it was effective to prevent further spread of wilt to adjacent clones in the field.

Fungicide treatment of wilt affected setts showed a distinct variation in germination, cane height and cane population than the untreated setts. Although fungicide treatment improved germination in the disease-affected setts, the germinated shoots exhibited wilt during grand growth phase of the crop, indicating that that sett treatment alone is insufficient to manage the sett borne inoculum. During the course of disease development at different growth phases of the cane, samples were collected and subjected to cultural and histological studies to confirm *F. sacchari* infections.

Epidemiology

Natural wilt incidence was recorded in 'Co' canes planted during the season at Karnal. Among the 48 Co canes evaluated, 39 were found to be affected by wilt, among them 23 exhibited highly susceptible, six susceptible and 10 moderately susceptible reactions to *F. sacchari* (Fig. 74 & 75). The wilt affected cane samples were subjected to pathogen isolation, in which 16 isolates were recovered from different varieties. These isolates were sub-cultured and maintained along with the existing *Fusarium* culture collections for further studies at Karnal.

Detailed studies carried out under field conditions at Coimbatore gave new information on wilt and PB epidemiology for the first time. Possibility of same *Fusarium* sp causing wilt and PB diseases has been established. Similarly, how the foliar infections of PB phase turn to systemic wilt has been discovered. Early phases of wilt symptoms have been identified for the first time (Fig. 76). During the 2016-17 season, observations were made on the status of PB in NHG which had 629 clones. Three different phases of PB incidences were recorded up to grand growth stages of the canes. About 84 clones showed wilting of canes from the 169 PB affected clones.

Identification of wilt resistant sources in parents in NHG: Detailed investigations were carried out to assess wilt resistance in 687 parental clones maintained in NHG by grouping them under as resistant, moderately resistant, moderately susceptible and susceptible to wilt based on varying yellowing or pre wilting symptom expression. About 172 clones were identified as R and MR to wilt. When the resistant clones were analyzed for the source of their origin, it was found that these clones originated from the subtropical region contributed more for wilt resistance among the parents.

Molecular diagnostics

Molecular diagnosis for Fusariums causing wilt and pokkah boeng: Primers were designed from the conserved region of termination elongation factor (TEF1) gene of *Fusarium* spp and PCR reactions were optimized (Fig. 77). Amplicons of 495 bp from 48 isolates were sequenced and compared with GenBank database. TEF1-α gene sequencing of 48 *Fusarium* isolates revealed that 44 were of *F. sacchari* and the remaining four belonged to *F. proliferatum*. Of the four *F. proliferatum,* three were associated with PB and one with wilt. Almost all the 41 wilt associated isolates belonged to *F. sacchari.* Investigation carried out to identify *Fusarium* isolates from plants exhibiting both wilt and PB in two varieties Co 0238 and MS 901 revealed that in both the varieties only *F. sacchari* caused wilt and PB symptoms. The results clearly established for the first time that the same fungal pathogen systematically infects sugarcane and exhibits both the diseases.

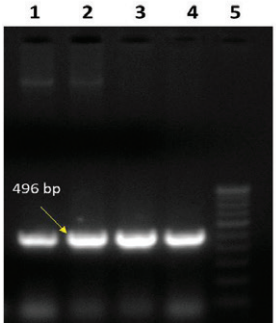


Fig. 77. Amplification of 496 bp TEF-1 gene fragment of F. sacchari isolates from of sugarcane cv MS 901. 1, 2 - Isolates form wilt affected canes, 3, 4 - Isolates from pokkah boeng affected leaves; 5 - DNA ladder

Virus indexing service

(R. Viswanathan)

During the year, about 330 tissue culture batch samples received from different tissue culture labs from Tamil Nadu, Andhra Pradesh and Gujarat were tested for sugarcane viruses and phytoplasma. Of 330 samples tested for SCYLV, 242 were negative to the virus. Of 61 tested for SCMV and SCSMV 59 and 45 were negative, respectively. Of the 224 samples tested for GSD phytoplasma, 254 were negative. Test reports were prepared and sent to the respective labs.

Sugarcane quarantine

(R. Viswanathan)

The following clones BO 154, BO 155, CoP 11436, CoP 13438 (Pusa), CoC 22, CoC [Sc] 24, CoC 08336 (Cuddalore), CoH 160, CoH 167 (Uchani), CoLk 09202, CoLk 09204, CoLk 11201, CoLk 13201, LG 05464, LG 07443, LG 07503, LG 07518, LG 07590, LG 09810, LG 09814 (Lucknow), CoPant 10221 (Pantnagar), CoPb 08212 (Kapurthala), CoOr 10346, CoOr 12346 (Orissa), CoS 767 and CoS 8436 (Shahjahanpur) were handed over to NHG after quarantine. Similarly, the following clones BO 146, CoP 09437 (Pusa), CoH 160, CoH 167 (Uchani), CoPb 08212 (Kapurthala), CoOr 10346, CoOr 12346 (Orissa) and LG 01118 (Lucknow) were handed over to NAG after quarantine.

The following clones LG 08443, LG 09487, LG 11001 (Lucknow), CoS 767, CoS 8436, CoS 03251, CoSe 03234 (Shahjahanpur), CoT 8201 (Tirupati), BO156, CoP 16436, CoP 16437, CoP 16438, CoP 16439, CoP 16440 (Pusa), 97 R 129, 2009 R 74, 2010 R 854 (Rudrur), CoH 10262 (Uchani), CoC 08336 and CoC 13339 (Cuddalore) were received for NHG and are in quarantine. The following clones VCF 0517 (Mandya), CoH 10262 (Uchani),

CoN 09072 (Navsari), Co 09004 (Coimbatore), CoA 11321 [2005A128], CoA 11323 [2000A240], CoA 11326 [2005A122], CoA 12321 [2006A64], CoA 12322 [2006A102], CoA 12323 [2006A223], CoA 12324 [2007A177] (Anakapalle), Co 09022 (Karnal) and CoLk 09204 (Ikshu-3) (Lucknow) were received for NAG and are in quarantine.

5.3.2 ENTOMOLOGY

Studies on sugarcane pests and their management

Host plant factors influencing genotypic reaction to shoot borer Chilo infuscatellus

(M. Punithavalli, R. Jayanthi and *K.P. Salin)*

Laboratory screening of *Erianthus arundinaceous* genotypes against shoot borer, *Chilo infuscatellus*

Erianthus arundinaceous genotypes such as IK 76 78, IJ 76 400, IK 76 84, IK 76 88, IJ 76 370, ERI 2798, Fiji 55 and IJ 76 364 were identified as resistant(R) to shoot borer in field screening. To confirm the resistance, the identified R genotypes were further screened under laboratory. The results revealed that shoot borer larval period differed significantly among the selected genotypes and ranged from 16.0 ± 0.71 to 26.1 ± 0.96 days. Prolonged larval durations were recorded in the genotypes IJ 76 370 and IJ 76 364 with 26.1 ± 0.96 and 24.88 ± 1.98 days, respectively. However, it was shorter in the genotypes IK 76 84 (16.0 ± 0.71 days), ERI 2798 (16.2 ± 0.49 days) and Co 86032 (16.5 ± 1.48 days). Similarly, pupal period varied from 4.71 ± 0.22 to 7.22 ± 0.49 days. Maximum pupal period was recorded in the genotype IJ 76 370 while, it was minimum in the genotypes IK 76 88, Fiji 55 and IK 76 84; male adult longevity was shorter than female. Total egg laying capacity ranged from 142 ± 10 to 315 ± 26 eggs / female on selected *Erianthus* genotypes. Maximum fecundity was recorded in the genotypes Co 86032 (315 ± 26 eggs / female) and ERI 2798 (264 ± 27 eggs / female). The growth index of shoot borer varied from 2.05 to 4.20. Minimum growth index was recorded in both genotypes IJ 76 370 and IK 76 88. There was a significant difference observed in the larval and pupal survivability of shoot borer and ranged from 44 to 82% and 28 to 56% among the selected genotypes. The lowest larval and pupal survival were recorded in the genotypes IJ 76 370, IK 76 78 and IJ 76 364 with 44 & 32%, 56 & 36% and 60 & 28%, respectively. However, it was the highest in the genotypes IJ 76 400 (82 & 48 %) and Co 86032 (69 & 48%).

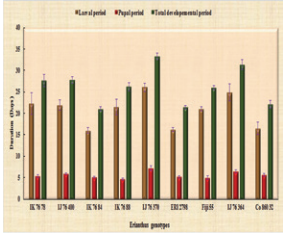


Fig. 78. Developmental characteristics of shoot borer on Erianthus arundinaceous genotypes

There were no significant differences in the larval weight at 10 days after growth of the larvae reared on the chosen genotypes. But, it differed at 15 days after the larval growth which varied from 40.28 ± 2.12 to 84.42 ± 6.5/ mg/larva. The genotypes IJ 76 370, IK 76 78 and IJ 76 364 larval reduced their weight significantly compared to other selected genotypes, Similarly, shoot borer male pupal weight was not differed due to the genotypes. however, female pupal weight varied from 46.5 ± 2.28 to 74.67 ± 2.78 mg. The lowest female pupal weight was recorded in the genotypes IJ 76 370, IK 76 88 and IJ 76 364 (Fig. 78).

Nutrient profiling of shoot borer on the selected Erianthus arundinaceous genotypes: Shoot borer larvae were reared on the selected *E. arundinaceous* genotypes *viz*., IK 76 78, IJ 76 400, IK 76 84, IK 76 88, IJ 76 370, ERI 2798,

Fiji 55, IJ 76 364 and Co 86032. Fifth instar larvae were selected for extraction of total proteins and total carbohydrates. The results revealed that the shoot borer larval protein content varied from 49.20 ± 2.94 to 65.60 ± 2.79 mg/g of larvae due to *Erianthus* genotypes. The genotypes IK 76 88, IK 76 84 and IK 76 78 fed-shoot borer larvae recorded lowest protein content with 49.20 ± 2.94, 50.71 ± 4.97 and 54.09 ± 6.61 mg/g of larvae, respectively. Similarly, total carbohydrate content of shoot borer differed significantly among the chosen genotypes which ranged from 1.71 to 7.13 mg/g of larvae. The carbohydrate content of shoot borer was the lowest recorded in the accessions IJ 76 364, IK 76 84 and IK 76 78 resulting with 1.71 ± 0.47, 2.45 ± 0.47 and 2.88 ± 0.23 mg/g of larvae, respectively (Fig. 79).

Screening of Indian hybrid genotypes against internode borer

(P. Mahesh and *B. Singaravelu)*

Four INB resistant Indian hybrid genotypes along with two standard check varieties were planted in a replicated trial in the borer endemic area in M/s Rajshree Sugars, Mundiampakkam to assess final field reaction. Of the four genotypes, only the genotype Co 293 was found to be moderately tolerant (MR) in the field with less than 30% incidence. While the other 3 genotypes and 2 standard checks were highly susceptible (HS) with an incidence of 50-82.0%. Intensity of INB was also recorded in the trial. The lowest intensity was recorded in Co 293 (8.22%) while the highest was recorded in Co 62019 (16.87%). A maximum of 10 internodes per cane showed bore-hole symptoms in Co 62019.

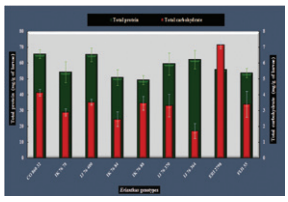


Fig. 79. Nutrient profiling of shoot borer on the selected Erianthus arundinaceous genotypes

Artificial infestation: In the confirmatory screening studies, 4 genotypes showing resistance from the previous year along with 2 standard check varieties were screened in a replicated trial under pot culture for artificial infestation. In this studies all the four test genotypes were found to be HS with an incidence of 37 - 89%. The lowest incidence was recorded in Co 293 (37.0%) while the highest was recorded in Co 62019 (89.00%).

Agro-morphological trait: Selected morphological traits such leaf length, leaf width, sheath hair and nature of leaf sheath clasping were recorded at ninth month as per the descriptor classes and yield traits like cane thickness, cane length and sucrose percentage and fiber in healthy canes were recorded at 12th month. Simple correlation coefficients applied to plant morphological characters in relation to infestation parameters were found not significant.

Prospective determinants of virulence and rhizosphere competency in Metarhizium anisopliae

(N. Geetha, M. Punithavalli and *K.P. Salin)*

Collection and isolation of M. anisopliae *isolates:* Trichy isolate showed high rate of colony growth, sporulation but the efficacy against *G. mellonella* was significantly lesser than the existing MTCC, MCC, ITCC and local isolates. MCC 1189 proved to be on par with ITCC 5489 and MTCC 6060 in colony growth, sporulation and efficacy against *Galleria* and termite.

*Virulence of M. anisopliae isolates***:** Three new isolates of *M. anisopliae* collected locally and two MCC isolates namely MCC 1130 and MCC 1189 were assessed for colony growth and sporulation. Of these isolates tested for the spore production in liquid YPSS medium, MCC 1130 and Ma local 2 were on par with the earlier tested high sporulating isolates. Colony growth was significantly higher in Ma local 1 and MCC 1130.

To develop a consortium, bioassays with MTCC, MCC, ITCC cultures on *G. mellonella*, termites and white grubs were conducted. The bioassays indicated high virulence of ITCC 5489, MTCC 3943, MTCC 6060, MCC 1129, MCC 1130, NAIMCC-F-1296 and NAIMCC-02108 when assessed across the hosts in the laboratory. Against the target host *Holotrichia serrata,* ITCC 5489, ITCC 6322, MTCC 6060, MTCC 3943, MCC 1130, MCC 1189, SBMa NAIMCC-F-01295, NAIMCC-F-01296 and NAIMCC F- 02108 showed 90% or more mortality at I instar stage, tested at 10^6/ml. However the mortality reduced to 80% or lower even at 10 times the dose for the second instar. The isolates were ineffective against third instar grubs, at 10^9/ ml with ITCC 5489 recording the maximum of 33.33 % mortality and most cultures resulting in less than 10% mortality. Pot culture studies indicated differential mortality efficacies when the grubs (I instar) were inoculated one week after fungus inoculation but recovered after different incubation times. Exposure of II instar grubs to *M. anisopliae* isolates in pot culture studies showed significantly lesser efficiency. Based on the bioassay studies and the enzyme studies (described below) a consortium of MTCC 6060, ITCC 5489 and SBMa may be used for field evaluation.

Root exudates and rhizosphere competence: Studies indicated that of the 30 isolates tested, ITCC 5489, MTCC 3210, MTCC 3943, MTCC 6060, MCC 1027, MCC1029, MCC 1130, MCC 1189, Ma Sb, NAIMCC- F-01295, NAIMCC –F- 01296 and NAIMCC-F- 2108 showed good survival of spores (> 70% mortality) in *Galleria* trap studies. CFU recovery from plating of soil suspensions from rhizosphere area showed that the isolates ITCC 5489, MTCC 6060, NAIMCC-F-1296 were significantly superior to all other isolates.

Enzymes involved as virulence factors: Following the standardization of protocols for the three enzymes namely, Chitinases, Lipases and proteases were studied for their activity. The estimation of protease activity of different isolates of *M. anisopliae, B. bassiana , B. brongniartii* and *P. ilacinus* were observed and wide variation due to pH was not observed in minimal media at different pH at 28^0C after incubation for four days at 180 rpm. Only at pH 4 high variation among isolates and the pH was observed in protease activity. Protease activity ranged from 0.428 mU/ml to 0.659 mU/ml among the different isolates at pH 6. In general the protease activity was very low at pH 7 with no variation in the protease activity among tested organisms. The alkaline pH 8.0 increased the production of proteinase enzyme in some isolates and fungi while it did not favour some other isolates. The fungi *P. lilacinus, B. bassiana* had a very good activity of proteinase activity unlike at lower pH. The only two isolates that had lower production of protease were NAIMCC-F-1300 and ITCC 6322 at pH 8. pH 9 too favoured the isolates and species of fungi which had lower production of proteases in minimal media at pH 6, 7 and 10, thus nullifying the differences among the different species and isolates in their proteinase production. At pH 10, activity of proteinase varied from 0.428 mU/ml to 0.665 mU/ml among the different fungi as well as the isolates of *M. anisopliae*. Isolates ITCC 5489, MTCC 3943, NAIMCC-F-1296 had high proteinase activity. However, it could be concluded that alkaline pH was not detrimental to the production of proteases while it also enhanced isolates which had inherently low potential of protease activity.

For the lipase assays in four different media i.e., SD, YPSS, Minimal media 1 and 2 were assessed and minimal media 2 was found to be ideal for the estimation of lipase activity among different isolates of *M. anisopliae, B.*

bassiana, B. brongniartii and *P. lilacinus*. In castor oil, the activity of lipase was found to be the highest in MTCC 3943 and on par in all other isolates. Different oils were used as sources in the medium for enzyme assay. In coconut oil the activity was the highest in *B.bassiana* and the lowest *P. lilacinus* and NAIMCC-F-02108 among the rest. Among all oils Olive oil medium showed highest activity. *B. brongniartii* showed highest activity and ITCC 6322 showed the lowest activity. In Gingelly oil the lipase activity among the isolates of *M. anisopliae* or other species was high. In sunflower oil additive medium, the activity was the lowest in MTCC 6060 and highest in Ma local.

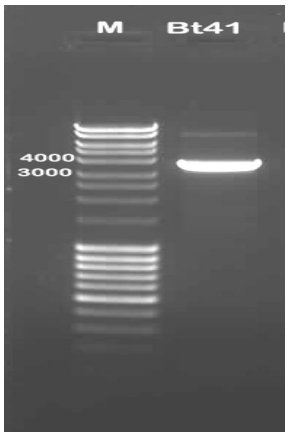


Fig. 80. Full gene amplification of Bt 41

For chitinases assay, three different chitins namely, chitin as such, chitosan and colloidal chitin were used. Colloidal chitin induced best chitinolytic activity of the isolates of *M. anisopliae* and other fungi. The lowest activity was in *P. lilacinus* and highest in MCC 1129. The other isolates more or less showed equal activity showing all of them to be virulent in breaking down the chitin.

Evlauation of M. anisopliae against white grub in the field: A field trial was laid out at Thalavady area of M/S Bannari Amman Sugars to assess the efficacy of *M. anisopliae* with *B. brongniartii* as microbial check and Phorate as insecticidal check. However, grubs could not be retrieved during sampling after application of fungus due to very low incidence. Soil samples from other areas from M/S Bannari Amman Sugars yielded *B. brongniartii* and *M. anisopliae* through *Galleria* trap studies.

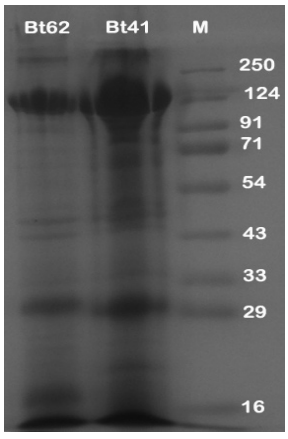


Fig. 81. Crystal protein profile of Bt 41

Screening of indigenous isolates of *Bacillus thuringiensis* isolated from sugarcane ecosystem for various crystal toxin genes

(B. Singaravelu, J. Srikanth, C. Sankaranarayanan, P. Mahesh and *C. Appunu)*

Bacillus thuringiensis was isolated from soils collected from Haryana, Punjab, Uttar Pradesh, Tamil Nadu. Twenty six putative Bt isolate was identified from these soils and would be screened for *cry*1, *cry6*, *cry8*, and *cry9* genes. Out of these 26 isolate, four Bt isolates were showing bipyramidal crystal morphology under phase contrast microscope and hence were considered positive for *cry1* gene.

Sequencing of the complete coding region of *cry8* gene amplicon from the positive 41 Bt isolate revealed the presence of a novel *cry8* gene holotype (Fig. 80.) which shares a protein homology of 67% with *cry8Ab1*. The size of the crystal toxin was found to be approximately 130kDa protein (Fig. 81)

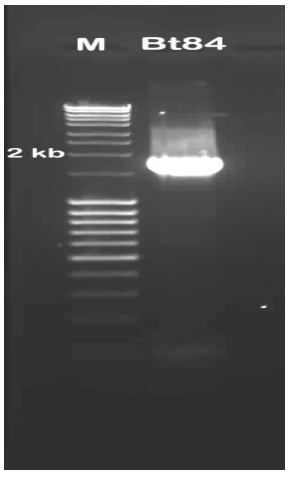


Fig. 82. cry1n full gene

Bt isolates containing various subfamily *cry*1 genes viz., *cry1A*, *cry1C*, *cry1*D, *cry*1I, and *cry1N* were detected in our indigenous isolates through PCR screening. Bt isolate 8 and 84 were found to harbour *cry9Da* and *Cry1Na* genes (Fig. 82.).

Bt isolates containing *cry* genes viz., *cry1*, *cry8*, *cry9D* were bioassayed against 1st instar larvae of Early shoot borer. *cry8* genes containing Bt isolates was not effective against the early shoot borer larvae. *cry1* and *cry9* isolates caused mortality of upto 80 % of first inastar early shoot borer.

The holotype *cry8* gene containing Bt 41 when bioassayed against *Holotrichia serrata* did not cause any mortality. However when tested against *Oryctes rhinoceros* larvae, they were found susceptible. Since *cry8* genes are scarabid specific, efficacy of Bt 41 isolate have to be tested against *H. consanguinea*, the subtropical white grub species and also including other white grub species.

Pesticide dynamics in sugarcane and its ecosystem

(T. Ramasubramanian, S. Chandrasekaran (TNAU) and *R. Jayanthi)*

Development and validation of method for determination of carbofuran and its metabolites in GC-MS and studies on its metabolism in the soil and sugarcane plant: A simple and sensitive method has been developed and validated for determination of carbofuran and its metabolites *viz.,* 3-keto carbofuran and 3-hydroxy carbofuran in Gas Chromatography-Mass Spectrometry. The metabolism of carbofuran was also studied in the soil and sugarcane plant by employing the method standardized in the present study.

Method validation: The recoveries of carbofuran were in the range of 94.15-100.25, 88.75-95.78 and 95.34-98.28% from soil, sugarcane leaf and juice respectively. The recoveries of 3-keto carbofuran were in the range of 93.68-98.24, 90.38-96.18 and 95.48-97.26% from soil, sugarcane leaf and juice, respectively. The metabolite 3-hydroxy carbofuran was recovered to the extent of 95.46-98.10, 89.25-97.12 and 94.14-94.26% from soil, sugarcane leaf and juice, respectively when the matrices involved in the study were contaminated at three levels of fortification ranged between 0.01 and 0.1 µg/g. The RSDs of recoveries were less than 5% across the three levels of fortification for all the three metabolites involved in the study. As per the European Commission's Regulation for Trace Residue Analysis, the recoveries of target analytes should be within the range of 70-120% with the RSD of less than 20%. Thus, the method standardized in the present study to quantify the residues of carbofuran and its metabolites from soil, sugarcane leaf and juice are in compliance with European Commission's Regulation for Trace Residue Analysis. Hence, the method may be adopted by the researchers worldwide to determine the residues of carbofuran in sugarcane without any further modifications. Linearity for all the target analytes involved in the study (carbofuran, 3-hydroxy carbofuran and 3-keto carbofuran) was observed to be excellent as the values of co-efficient of determination were in the range of 0.9987–0.9993. In the earlier studies, residues of carbofuran and its metabolites present in the soil and sugarcane plant were detected and quantified after derivatizing the samples with 1-fluoro-2,4-dinitrobenzene. The derivatization step involved in the conventional method was reported to be relatively complicated. Hence, in the present study, a simple and sensitive method has been developed after necessary modifications in the QuEChERS (quick, easy, cheap, effective, rugged and safe) method, which has no derivatization step.

Persistence and metabolism of carbofuran in soil: At the recommended dose (2 kg a.i./ha), the initial deposits of parent compound and its metabolite, 3-hydroxy carbofuran were 14.390 and 0.084 µg/g, respectively. The metabolite, 3-hydroxy carbofuran was detected from zero-day till 30 DAT. The residues of carbofuran were detected up to 105 DAT and reached below the detectable level (BDL) on 135 DAT. The total residues comprising carbofuran and 3-hydroxy carbofuran were also detected up to 105 DAT and more than 70% of the residues got dissipated within a week period. The half-life of carbofuran in the soil of tropical sugarcane ecosystem was 10.83 days. The metabolite 3-keto carbofuran was not detected in the soil throughout the study period.

Residues of carbofuran and its metabolite in sugarcane plant: It was observed that the residues of carbofuran and 3-hydroxy carbofuran moved from the soil

to plant. At recommended dose, the residues of carbofuran and its metabolites were not detected up to 10 DAT in sugarcane leaves. The residues of carbofuran and 3-hydroxy carbofuran were detected and quantified from 14 DAT to 75 DAT. The residues of both parent compound and metabolite reached their maximum level on 45 DAT. The total residues were 0.212 and 0.120 µg/g on 14 and 75 DAT, respectively. The residues of 3-hydroxy carbofuran was found to be higher than that of the residues of carbofuran from 30 DAT till 75 DAT. Apart from leaves, sugarcane juice extracted from the stem was also analysed for the presence of carbofuran and its metabolites. At recommended dose, the residues of carbofuran and 3-hydroxy carbofuran were detected and quantified from 14 DAT. The residues of both were detected only up to 30 and 21 DAT, respectively.

Development and validation of method for determination of bifenthrin in GC-ECD and studies on its dissipation in the soil and sugarcane plant: A simple and sensitive method has been developed and validated for determination of bifenthrin in gas chromatography equipped with electron capture detector (GC-ECD). Further, dissipation kinetics of the insecticide was also studied in the soil and sugarcane plant by employing the method standardized in the present study.

Method validation: The recoveries of bifenthrin were in the range of 95.86-97.67, 94.64-98.19, 94.57-97.15 and 92.78-94.39% from soil, sugarcane setts, stem and leaf, respectively at three levels of fortification ranged between 0.01 and 0.1 µg/g. The RSDs of recoveries were less than 5% across the three levels of fortification (0.01, 0.05 and 0.1 µg/g). The limit of quantification of the method was 0.01 µg/g. The method standardized in the present study to quantify the residues of bifenthrin in soil and sugarcane plant are in compliance with European Commission's Regulation for Trace Residue Analysis. Hence, the method may be adopted by the researchers worldwide to determine the residues of bifenthrin in sugarcane without any further modifications.

Dissipation of bifenthrin in soil and sugarcane setts: The initial deposits of bifenthrin were 1.49 and 2.23 µg/g when the insecticide was applied at the recommended (RD: 100 g a.i./ha) and double the recommended doses (2RD), respectively. Bifenthrin residues were detected and quantified up to 60 and 75 DAT, respectively at RD and 2RD, respectively. The half-life of bifenthrin in the soil was 10.5 and 12.6 days, respectively at RD and 2RD, respectively. In cane setts, the initial deposits of bifenthrin were 0.93 and 2.16 µg/g at RD and 2RD, respectively. The residues were detected up to 75 DAT in cane setts and they reached BDL on 90 DAT. The half-life of bifenthrin was 14.14 and 15.01 days at RD and 2RD, respectively. More than 80% of the residues got dissipated after three weeks of applying the insecticide in the tropical cane belt. No residues were detected in sugarcane leaf and stem throughout the study period. Bifenthrin is expected to protect the sugarcane crop from termites for quite a long period as it persists in the soil and sugarcane setts for more than two months.

Impact of organic amendments on the persistence of chlorpyrifos in the soil of tropical sugarcane belt: Impact of organic amendments *viz.,* coir pith, farm yard manure (FYM), pressmud and sugarcane trash on persistence of chlorpyrifos in the soil was studied. The initial deposits were 0.480, 0.475, 0.524, 0.452 and 0.501 µg/g in coir pith, FYM, press mud, sugarcane trash and

control soil, respectively. The residues were detected up to 60 DAT in FYM and pressmud applied soil as against 75 days in coir pith, sugarcane trash and control soil. The half-life of chlorpyrifos was 17.17 and 16.11 days in coir pith and sugarcane trash as against 15.40 days in the control soil. The half-life was lesser in FYM (11.18 days) and pressmud (14.14 days) applied plots as compared to the control soil (15.40 days). Thus, dissipation of chlorpyrifos was observed to be faster in FYM and pressmud applied soil as compared to the soils amended with coir pith and sugarcane trash.

Development of DNA barcodes and species-specific markers for insects in sugarcane ecosystem

(T. Ramasubramanian, K. Ramaraju (TNAU) and *S.K. Pandey)*

Development of DNA barcodes for insects in sugarcane ecosystem: DNA barcodes were developed for seven insects during the period under report. Ideal DNA barcodes were developed for woolly aphid (*Ceratovacuna lanigera)*, eriophyid mite (*Aceria sacchari)*, hispa (*Asamangulia cuspidata)*, black bug (*Cavelerius sweeti)*, leaf folder (*Cnaphalocrocis ruralis)*, cut worm (*Spodoptera litura)* and the braconid parasitoid (*Cotesia flavipes)*. Insects/mites involved in this study were collected from sugarcane fields in Tamil Nadu. The black bug *Cavelerius sweeti* was collected from Karnal. The black bug samples were preserved in 70% ethanol until used for DNA isolation. Genomic DNA was isolated by adopting the conventional CTAB method with necessary modifications. LCO1490 (5'-GGTCAACAAATCATAAAGATATTGG-3') and HCO2198 (5'-TAAACTTCAGGGTGACCAAAAAATCA-3') were the forward and reverse primers used to amplify the target fragment from the mitochondrial *cytochrome c oxidase-I (COI)* gene. The PCR product was gel purified using GenElute gel extraction kit (Sigma-Aldrich India Private Ltd., Bengaluru) and the target fragment was cloned by using the InsTAclone PCR cloning kit as per the manufacturer's instructions (Thermo Scientific Inc., USA). Screening of recombinants was done by both colony PCR and restriction digestion. This was followed by plasmid isolation by conventional method. The purified plasmids were sequenced through outsourcing and the resultant sequences were edited by using BioEdit software. Sequencing was performed in both the directions to identify mismatches, if any, in the sequences. The edited nucleotide sequences were translated into amino acid sequences using the ExPASy Translate tool of the Swiss Institute of Bioinformatics. The nucleotide sequences were compared with already submitted sequences retrieved from the National Center for Biotechnology Information by BLAST algorithm. Further, the *COI* sequences cloned in the present study were aligned together by employing the *Clustal Omega* programme of the European Bioinformatics Institute and the extent of identity among the sequences were deduced. The DNA barcodes of all the seven insects are ideal ones for the respective species as they are all 658 bp in size. The protein sequences of all the seven barcodes do not have any stop codon and thus, indicating the flawlessness of the *COI* gene sequences cloned in this study. The DNA barcodes developed for *Asamangulia cuspidata* and *Cavelerius sweeti* are the first.

The extent of identity at nucleotide level among the COI sequences of seven species varied from 65.5% (between *Aceria sacchari* and *Asamangulia cuspidata*) to 88.91% (between *Cnaphalocrocis ruralis* and *Spodoptera litura*). The minimum threshold variation between two COI sequences should be 3%

to delineate different species of the class Insecta. Since the variation between the COI sequences of two species varied from 11.09 to 34.5%, the barcodes developed in the study will certainly serve as ideal molecular diagnostic kits and help in the identification of cryptic species among the diverse populations that exist in the tropical and subtropical sugarcane ecosystems of the country. *A. sacchari,* being a member of the class Arachnida (sub-class: Acari), that is different from the class Insecta, exhibited significant difference at nucleotide level. The COI sequence of *A. sacchari* showed only 65.5-72.04% identity with other six COI sequences cloned in this study. The lepidopteran species *Spodoptera litura* and *Cnaphalocrocis ruralis* showed 88.91% identity between their COI sequences. At protein level the extent of identity among the barcode sequences varied from 62.56% (between *Aceria sacchari* and *Asamangulia cuspidata*) to 97.62% (between *Cnaphalocrocis ruralis* and *Spodoptera litura*). The Arachnid, *A. sacchari* showed only 62.56-69.41% identity with species belonging to the class Insecta. The extent of identity at protein level between the closely related lepidopteran species, *C. ruralis* and *S. litura* was 97.62%.

Studies on the prospects of *Telenomus* sp. as a candidate biocontrol agent of internode borer

(J. Srikanth, P. Mahesh and *K.P. Salin)*

Seasonal dynamics: Seasonal dynamics of egg parasitoids of internode borer were monitored through fortnightly collection of egg masses from sugarcane ecosystem at Coimbatore. The parasitoid *Telenomus dignus* was active throughout the year, except in the first fortnight of April. Parasitism rates ranged 8.3-100.0% on egg mass basis, the lowest being in April 2016 and the highest in August 2016 and February 2017. Within the egg masses parasitism rates were 100.0% in all observations though adult emergence from individual egg masses ranged 27-100%. One egg mass parasitized by *Telenomus* showed partial hatching of borer larvae which indicated that the parasitoid failed to attack all the eggs. On the other hand, one egg mass was parasitized by both *Telenomus* and *Trichogramma* which indicated that one of them failed not only to parasitize the entire complement of eggs but also deter the other from parasitizing the egg mass.

Parasitization behavior: In laboratory studies on parasitization, adults of *Telenomus* sp. were exposed to variable number of freshly laid lab-reared egg masses of internode borer to give different host egg: parasitoid ratios (0.88 – 11.8). Regardless of the variation in the ratio, parasitization within individual egg masses was 100% in all batches. However, parasitoid emergence ranged 14.3-100.0%. Correlation analysis indicated that parasitoid emergence rates were not influenced by host: parasitoid ratio.

In another laboratory study, when a range of borer eggs was exposed to a single female parasitoid, 100% parasitism was observed which indicated that a single parasitoid was able to parasitize 10-22 eggs. However, here too, adult parasitoids failed to emerge from a few parasitized eggs. In one case, both parasitoid and borer larvae emerged from the egg mass exposed to the parasitoid.

Suitability of alternative hosts: When five batches of early shoot borer and three batches of sorghum borer were exposed to a variable number of *Telenomus* adults, parasitoid emergence was not observed in about 15 days, the normal developmental period of the parasitoid in internode borer eggs, but

neonate larvae hatched from all the egg masses. However, when five batches of *Spodoptera litura* eggs were exposed to *Telenomus*, neither parasitoid emergence nor neonate larval hatching was observed.

Parasitoid age vs parasitization: In another study, different batches of *Telenomus* were allowed to parasitize internode borer eggs at variable age of the parasitoid. In batch-1 with nine parasitoids, when variable number of eggs was exposed within 24, 48, and 72 h of age of the parasitoid, 100% parasitism was observed with 8.33-34.78% adult emergence. In batch-2, when 12 eggs were exposed to six parasitoids at 96 h age, 100% parasitism and adult emergence were noticed. In batch-3, 60 eggs exposed to nine parasitoids at 120 h age also produced similar results. In the fourth batch, five parasitoids of 144 h age exposed to 59 eggs produced 100% parasitism but 47.5% adult emergence. The results indicated that *Telenomus* was able to parasitize internode borer eggs up to 144 h of age and adult emergence was not influenced by parasitoid age.

Adult longevity: The longevity of freshly-emerged adults maintained in the laboratory without honey ranged 1-2 days. In contrast, adults provided with 50% honey water solution in cotton swab survived for 5- 39 days. This indicated the possibility that adult food resources such as nectar available in the habitat might prolong the longevity of adults of the parasitoid and enhance its efficacy in the field.

Activity of egg parasitoids in Trichogramma *release areas:* Activity of egg parasitoids was monitored in selected sugar factories which are known to be *Trichogramma* release areas. In M/s Bannari Sugar Mills area, *Telenomus* emerged from the egg masses collected in all three months whereas *Trichogramma* was noticed in one of the months. Parasitism rates due to *Telenomus* ranged 25.0-90.5% among egg masses and 100.0% within egg masses. Adult emergence ranged 50.0-100.0%. *Trichogramma* parasitism was noted in only one egg mass which constituted 8.33% of the egg masses collected. Superparasitism was observed in this egg mass with 38 adults emerging from 13 eggs. In M/s Rajshree Sugars and Chemicala Ltd., parasitism due to *Telenomus* was 54.5% among the egg masses collected and 100.0% within the egg masses. Adult emergence ranged 62.0-100.0%. *Trichogramma* activity was not noticed in the batch of egg masses collected.

Bio intensive management of white grub in sugarcane

(N. Geetha, K.P. Salin and *M. Punithavalli)*

To assess the efficacy of various microbials in the laboratory against target host: The cultures of *Beauveria brongniartii, B. bassiana* and *Metarhizium anisopliae* were mass cultured on liquid SD medium and maintained on solid medium. The cultures of entomopathogenic nematodes *Heterorhabditis indica* and *Steinernema glaseri* were obtained and mass cultured on *Galleria mellonella*. Cultures are maintained in the laboratory and routinely sub cultured. Bioassays have been taken up with III, IV and V instar *G. mellonella* in different combinations, i.e., *B. brongniartii, B. bassiana, M. anisopliae* at different doses. Synergistic mortalities were observed more at lower doses of fungi. Compatibility between *B.brongniartii* and *M. anisopliae* was poor. Bioassays have been taken up with the insecticides (Chlorantraniliprole, Chlorpyriphos, Imidacloprid, chlorpyriphos, carbofuran, Fipronil and Phorate), three fungi and the EPN, *H. indica* and *S. glaseri* against IV instar *Galleria* at different doses and combinations of each other. The sequence of

application influenced the survival and recovery of biocontrol agent from the cadavers.

In case of *H. indica* at higher doses of fungi tested, irrespective of the species of fungi tested, no recovery of the nematode was observed. Synergistic reactions were obtained in most of the combinations except in some combinations involving *B. brongniartii* and *M. anisopliae* as well as *B. brongniartii* and *H. indica*. Insecticides did not deter the sporulation when applied 24 hrs after the application of the fungi. However when applied simultaneously or 24 hrs before the application of fungus, mortality though was synergistic, recovery of the fungi was not obtained.

To assess the efficacy of various microbials in the pot culture: Pot culture experiments with various combinations of *B. brongniartii, B. bassiana, M. anispliae, H. indica* and the four selected insecticides have been applied at field recommended dose. Two sets of experiments with matured crop as well as young crop have been taken up. White grubs are to be assessed for infection in two different inoculation periods of 15 days as well as continuous exposure throughout larval cycle. The studies are under progress.

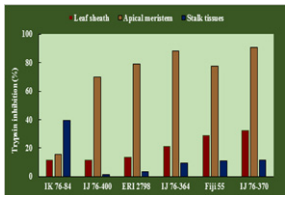


Fig. 83. Profiling of proteinase inhibitors (PIs) from different tissues of Erianthus arundinaceous genotypes

Identification and characterization of proteinase inhibitors influencing resistance against shoot borer, Chilo infuscatellus (Snellen) and internode borer, Chilo sacchariphagus indicus (Kapur) (Lepidoptera: Crambidae) in sugarcane (DST-SERB)

(M. Punithavalli)

Profiling of proteinase inhibitors (PIs) on the different plant parts of Erianthus arundinaceous genotypes: Proteinase inhibitors (PIs) extracted from leaf sheath, apical meristem and stalk tissues of six *E. arundinaceous* genotypes and their inhibitory activity evaluated against trypsin enzyme. The results showed that the amount of trypsin inhibition in leaf sheath, apical meristem and stalk tissues differed significantly among the chosen genotypes. However, it was comparatively higher in apical meristem (15.86 to 90.94%) followed by leaf sheath (11.51 to 32.26%) and stalk tissues (1.62 to 39.62%) of selected genotypes. The trypsin inhibition was highest recorded in the genotype IJ 76-370 leaf sheath and apical meristem resulting with 32.26% and 90.94%. While, it was lowest in leaf sheath (11.64%) and apical meristem (15.86%) of genotype IK 76-84 (Fig. 83). None of the selected genotypes were recorded with marked increase of trypsin inhibition in stalk tissues except the genotype IK 76-84 (39.62%).

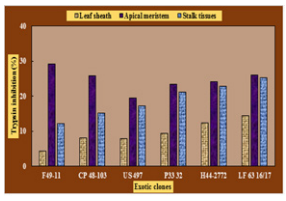


Fig. 84 Profiling of proteinase inhibitors (PIs) from different tissues of exotic clones

Profiling of proteinase inhibitors (PIs) on different parts of exotic clones: Quantification of proteinase inhibitors (PIs) on leaf sheath, apical meristem and stalk tissues of six selected exotic clones *viz*., F49-11, CP 48-103, US 497, P 3332, LF 63 16/17 and H44-2772 were studied. The percent trypsin inhibition differed significantly due to the genotypes and varied from 4.26 to 14.43%, 19.48 to 29.19% and 12.17 to 25.33% in leaf sheath, apical meristem and stalk tissues, respectively. Results evidented showed that the percent trypsin inhibition was quite high in apical meristem followed by stalk tissues and leaf sheath of selected genotypes. Among the genotypes, trypsin inhibition was highest recorded in leaf sheath (14.43 & 12.36%), apical meristem (26.05 & 24.10%) and stalk tissues (22.78 & 25.33%) of the genotypes LF 63 16/17 and H44-2772 (Fig. 84).

Standardization of protocol for purification of proteinase inhibitors: Erianthus arundinaceous genotype IJ 76 370 was taken for purification of proteinase inhibitors in sugarcane. The meristem region was powdered with liquid nitrogen. The tissue powder was further extracted with 0.01 M phosphate buffer (pH 7.0) and kept in incubator cum shaker at 4^0C for 2 h. Then, sample was centrifuged at 10,000 rpm for 30 minutes at 4^0C. Solid ammonium sulphate was added to the supernatant (crude extract) to obtain a precipitate formed at 0-30%, 30-60% and 60-90% with respect to the salt and allowed for overnight at -20^0C. All the precipitated fractions (F0-30%, F30-60% and F60-90%) were centrifuged at 10,000 rpm for 10 minutes at 4^0C to collect the pellet form of proteins. Then, ammonium sulphate fractionated protein samples were taken in a pretreated dialysis bag (0.0025 µm pore size) and dialyzed 24 hours with the same extraction buffer at 4^0C. At each concentration, the proteinase inhibitory activity and protein content were estimated. The F30-60%, which corresponds to a 30-60% saturation range, showed a high level of inhibitory activity against trypsin.

Analysis of proteinase inhibitors was carried out by sodium dodecyl sulphate-poly acrylamide gel electrophoresis (SDS-PAGE) method (5% stacking gel and 15% resolving gel). The supernatants IJ 76 370 (crude extract and ammonium sulfate 30-60 fraction) were loaded on the gel and electrophoresis was carried out at room temperature. The gel was stained for 4 h. It was then destained till the background was colourless and the bands became clearly visible. The SDS-PAGE was given a single intact band around 22-25 kDA range in both crude extract and ammonium sulfate 30-60 fraction of IJ 76370.

5.3.3 NEMATOLOGY

Studies on insecticidal molecules of symbiotic bacteria associated with entomopathogenic nematodes

(C. Sankaranarayanan, K. P. Salin, K. Hari and *B. Singaravelu)*

Isolation and molecular characterization of symbiotic bacteria: During the period under report, five *Photorhabdus* symbiotic bacteria were isolated from larvae of *Galleria mellonella* infested with EPN *Heterorhabditis indica, H. bacteriophora*. Molecular characterization of five *Photorhabdus* bacterial isolates by 16S rDNA gene sequencing revealed that four *Photorhabdus* spp. have maximum similarity with *P. luminescens* sub sp. *akhurstii* and other one *Photorhabdus* spp. has maximum similarity with *P. luminescens* sub sp. *laumondii.* Similarly seven *Xenorhabdus* bacterial isolates had maximum similarity with *X. stockiae*.

Testing insecticidal activity against 2nd instar G. mellonella : Insecticidal activity of cell and cell free culture of four *X. stockiae* strains and two *Photorhabdus* strains was studied on *G. mellonella.* Among the six bacteria tested, *P. luminescens* ssp *laumondii* (SBIPLLKSM12) as cell free culture in diet assay recorded maximum mortality of 73.3 % of *G. mellonella* larvae followed by *X. stockiae* (SBIXSRS1) as cell culture filter paper assay and cell free culture in diet assay of *X. stockiae* (SBIXSRS1) both caused 66.6 % mortality of the larvae. The mortality of larvae by other bacteria were in the range of 10 - 60%.

Testing insecticidal activity against 1st instar white grub Holotrichia serrata: Insecticidal activity of cell and cell free culture of 12 bacterial isoaltes was studied against 1st instar white grub larvae. Among the 12, cell and cell free culture of *P. luminescens* ssp *akhurstii* (SBIPLAACM) recorded maximum

mortality of 80-100% followed by *P. luminescens* ssp *akhurstii* (SBIPLARS7) which caused 80% mortality of the grubs.

Purification of insecticidal molecules: Purification of insecticidal metabolites from *P. luminescens* sub sp. *laumondii* (SBIPLKCSM26) was done and totally eight fractions were obtained. Eight purified fractions were tested against 1st instar white grub larvae. All the fractions caused mortality of white grub and it was ranged between 8 and 75%. Fraction 8 caused 75% mortality of the larvae followed by fraction 6 and 7 which caused 58.3% mortality of grubs.

Isolation and evaluation of entomopathogenic nematodes (EPN) from white grub endemic areas of subtropical sugarcane ecosystem

(C. Sankaranarayanan, S.K. Pandey and *B. Singaravelu)*

Survey and isolation of EPN: Survey for isolation of EPN from subtropical regions of India were conducted in western UP, Haryana, Punjab and Uttarakhand. Soil samples were collected from Mansurpur, Mawana, Chandanpur, Nigohi and U.P State Sugar Corporation farm in UP and Kiccha Sugar, Uttarakhand.

About 27 EPN were isolated from 304 soil samples. Among them, 16 were *Heterorhabditis* and 11 were *Steinernema* spp. The EPN were processed for pure culture, Koch postulate was confirmed and the EPN cultures are being maintained for further studies.

Morphological and molecular identification of subtropical EPNs: Among the 12 EPNs, three *Heterorhabditis* isolates SBIH1782, SBIP1809 and SBIUPDSM60 had 99% similarity with *H. indica*. Among the 9 *Steinernema* isolates, isolates SBIH1764, SBIUPTSL8 and SBIUPDSM81 had 98 to 99% similarity with *S. thermophilum;* Isolates SBIUK145, SBIUPSF171 and SBIP1838 had 97% similarity with *S. surkhetense;* Isolate SBIP1820 had 99% similarity with *S. carpocapsae*; isolate SBIH1771 had 99% similarity with *S. siamkayai*

Pathogenicity of subtropical EPNs against G. mellonella: Sixteen *Heterorhabditis* sp. were tested against *G. mellonella* under laboratory condition with dosages *viz*, 5, 10, 15, 20 and 25 IJs/grub and control. All the EPN caused mortality of *Galleria* larvae. The mortality ranged between 6 and 100%. When the dosage increased, increased mortality was observed. Maximum mortality of 100% recorded with inoculation of 25IJs/larvae. Among the isolates SBIP1816 caused 60% mortality at 5IJ/larva. SBIH1768, SBIH1782 and SBIP1834 recorded 100% mortality. All the 11 *Steinernema* spp. isolates caused mortality of *Galleria* larvae. The mortality ranged between 6 and 100%. As the dosage increased, an increased mortality of the grubs observed. Maximum mortality of 100% recorded with inoculation of 25IJs/larvae. Among the isolates SBIH1764caused 80% mortality at 5IJ/larva. SBIH1764, SBIUPTSL8 and SBIUPDSM81 recorded 100% mortality.

Pathogenicity of tropical EPN isolates against Holotrichia serrata: Among 12 EPN, seven *Heterorhabditis* spp and five *Steinernema stockiae* were tested against first instar larvae of white grub, *H. serrata* under laboratory condition. Maximum mortality of white grub (100%) recorded with *H. indica* (SBIKSM12), *H. bacteriophora* (SBIKSM26) and *S. stockiae* (SBIDSM3) at the dosage of 15 and 20 IJs/grub.

Morphological and molecular identification of EPN from tropical regions: Twenty EPN (8 *Heterorhabditis* and 12 *Steinernema*) isolates from Karnataka

and Tami Nadu were morphologically and molecularly identified by analysis of genomic rDNA sequences. Eight *Heterorhabditis* isolates SBIKCSM9, SBIKCSM12, SBIKCSM24, SBIKCSM26, SBIDSM2, SBIACS, SBIBASLS5 and SBIRS7 had 99% similarity with *H. indica* and 12 *Steinermea* isolates SBIDSM3, SBIDSM4, SBIDSM5, SBIRS1, SBIRS2, SBIRS8, SBICOSL5, SBICOSL15, SBICOSL11, SBICOSL30, SBICOSL33 and SBIBASL1 had 99% similarity with *S. siamkayai.*

Fig. 85. Sugarcane farm leaders(SFL)from Tirunelveli dist, Tamil Nadu

5.4 STATISTICS AND ECONOMICS SECTION

Innovative training module for development of sugarcane farm leaders for upscaling sugarcane production and protection technologies

(*V.Venkatasubramanian, P. Murali, D. Puthira Prathap* and *T. Rajula Shanthy*)

The objective of the project is to develop Sugarcane Farm Leaders (SFL) through need based capacity building programmes. The project helped to develop grass root level leaders who can guide fellow farmers through institutional linkages. Capacity development (CD) programmes were organised for 125 SFLs selected from five low productivity districts namely Vellore, Dharmapuri, Nagapattinam, Karur and Tirunelveli to develop them as human resources at grass root level (Fig.85-86). Capacity development module for SFLs of each district was prepared based on the CD. Training manual in Tamil on 'Improved sugarcane technologies' was published.

Fig. 86. Director giving away the participation certificate to SFL farmer

A feasibility study of recommended sugarcane production and protection technologies for promoting rural entrepreneurship

(*V.Venkatasubramanian, P. Murali, D. Puthira Prathap* and *T. Arumuganathan*)

The project aims at assessing the income generation potential of recommended technologies, preparation of technology inventory, model project and training module for capacity development of potential entrepreneurs. In the current year, methodological issues related to quantification of technology potential and implementation of project objectives have been undertaken along with literature review related to entrepreneurship behaviour.

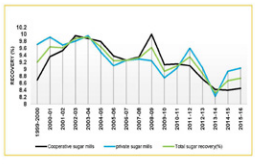


Fig. 87. Cultivation of variety Co 86032 and sugar recovery in Tamil Nadu

An economic analysis on sugar recovery in different states in India

(P. Murali, D. Puthira Pratap and *V. Venkatasubramanian)*

The project was initiated to study long-term sugar recovery in relation with varieties that are being cultivated in Tamil Nadu. Survey was conducted in Ambika sugars, Pennadam, Ambika sugars, A. Chittur, Rajshee sugars, Villupuram, Rajshee sugars Semmade, Sakthi sugars, Appakudal, Erode and Vellore Cooperative sugars to collect data on sugar recovery and varietal mix of sugarcane secondary data on sugar recovery from Dharmapuri, Perambalur and Amaravathi sugar mills were collected for study. In addition, data on different varieties that are cultivated in different sugar mill zones were also collected.

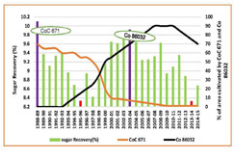


Fig. 88. Sugar recovery in relation with two predominant cane varieties cultivation in Tamil Nadu

Time series data on sugar recovery corresponding with variety Co 86032 which was cultivated in about 65% of the cane area in Tamil Nadu, sugar recovery pattern of Tamil Nadu state including recovery of cooperative, private and total sugar recovery since 1999-2000 are depicted in Fig. 87. The preliminary analysis revealed that sugar recovery had crept to 9.91 in 2003-04, then it was marginally fluctuating in downward direction up to 2011-12. Nevertheless, it has decreased significantly to 8.32% in 2013-14, thereafter it is depicting

Fig. 89. Release of compendium during R&D meeting of Tamil Nadu

Fig. 90. Release of compendium during R&D meeting of Northern Karnataka

Fig. 91. Training session in progress (30-31 August 2016)

Fig. 92. Trainees visiting experimental fields

Fig. 93. Participants of the training programme (21-22 September 2016)

peripheral improvement in sugar recovery. Traditionally, cooperative sugar mills recorded better sugar recovery than private sugar mills, however this trend was reversed for the past four years. In micro analysis, the sugar recovery was reduced more drastically in cooperative sugar mills than private sectors. Historical sugar recovery revealed that recovery is fluctuating over the period of time. With time series data, the peak sugar recovery of the two predominant sugarcane varieties was estimated (Fig.88).

The pinnacle of sugar recovery was achieved for variety CoC 671 and Co 86032 in 1988-89 and 2003-04 respectively in Tamil Nadu. Declining of sugar recovery is attributed to premature harvesting of sugarcane, varietal degeneration, poor management of crop and prolonged drought in the Tamil Nadu state. Data on sugar recovery is continuously collected to study the dynamics of sugar recovery.

5.5 EXTENSION SECTION

Transfer of Technologies

Utilization of extension methods and media for effective transfer of sugarcane technologies

(T. Rajula Shanthy, D. Puthira Prathap and *V. Venkatasubramaniam)*

Sugarcane Research and Development workers meetings

Tamil Nadu & Puducherry: The 47th meeting of Tamil Nadu and Puducherry was held at Dhanalakshmi Srinivasan Hotel, Perambalur during October 14-15 2016 (Fig. 89). The meeting was hosted by the Dhanalakshmi Srinivasan Sugars Ltd. (V.V. Sugars), Perambalur Dr. A. Ramamourti, Director of Agriculture, Govt. of Puducherry inaugurated the meeting. Dr. Bakshi Ram Director, ICAR-SBI delivered the Theme Address. About 350 delegates comprising scientists from ICAR-SBI and Tamil Nadu Agricultural University, Cane Development personnel from sugar factories, officers from the Department of Agriculture, Directorate of Sugar and other Cane Development organizations participated in the meeting. The major topics discussed were wild boar and rodent management and sugarcane mechanization including mechanical harvesting.

Northern Karnataka: The 17th meeting of Northern Karnataka was conducted at Belagavi during 16-17 September 2016 (Fig. 90). S.Nijalingappa Sugar Institute, Shri Prabulingeshwar Sugars & Chemicals Ltd. and Gem Sugars Ltd. hosted the meeting. Dr. D.P. Biradar, Vice-Chancellor of University of Agricultural Sciences, Dharwad inaugurated the meeting. Dr. Bakshi Ram Director, ICAR-SBI delivered the Theme Address. About 150 delegates comprising scientists from ICAR-SBI, MVSRI, SNSI, University of Agricultural Sciences, Bangalore, Cane development personnel from sugar factories, officers from Karnataka Sugar Institute, Department of Agriculture, Commissionerate of Sugar and other cane development organizations in Karnataka participated in the meeting. The major topics discussed include pest management in sugarcane including white grubs and managing saline-alkali soils in Northern Karnataka.

Training programs organized

National level programs organized: The following four national level training programs on 'Advances in Sugarcane Cultivation' sponsored by the Ministry of Agriculture were organized (Fig. 91-94).

- 17-18 August 2016 with 31 participants from Tamil Nadu (13), Karnataka (4), Maharashtra (4), Uttar Pradesh (2), Puducherry (2), Uttarakhand (2), Bihar (2), Punjab (1) and Gujarat (1).
- 30-31 August with 25 participants from Tamil Nadu (14), Karnataka (4), Maharashtra (2), Madhya Pradesh (1) and Uttar Pradesh (4).
- 2-3 September with 26 participants from Tamil Nadu (19), Karnataka (4) and Maharashtra (3).
- 21-22 September 2016 with 29 participants Tamil Nadu (22), Maharashtra (2), AndhraPradesh (3) and Uttar Pradesh (2).

Fig. 94. Trainees receiving their certificate of participation

Evaluation of knowledge level of the participants of the four training programs indicated an average pre-evaluation score of 73.02%, post-evaluation at 84.60 and the difference in knowledge was 11.58%.

One day training programs: Three one-day training programs on 'Sugarcane agriculture' were organized:

- 'Scientific jaggery preparation' for 20 farmers from Namakkal on 4 August 2016
- 40 farmers from KeezhBhavani Water management Club on 9 August 2016
- Twenty members of Board of Directors of Shri Someshwar Coop Sugar Factory Ltd, Baramati, Pune, Maharashtra on 17 March 2017.

Fig. 95. Exposure visit to ICAR-SBI

Exposure visits: Conducted an 'Exposure Visit' for 20 delegates from nine countries organized by Kothari Agricultural Management Centre, Coonoor on 21 January 2017 (Fig. 95 & 96).

Fig. 96. Dr. Bakshi Ram, Director, ICAR-SBI interacting with delegates

Scientists-Extension Workers-Farmers Interface Meet: Conducted a District level Scientists-Extension Workers-Farmers Interface Meet in collaboration with Avinashilingam KVK on 14 February 2017 with the participation of 22 farmers and district level officials from the departments of agriculture, horticulture, animal husbandry and sericulture (Fig. 97).

National level 'Kisan Mela': 'Kisan Mela' was organized at the institute during 26-27 August 2016 with the participation of around 1800 farmers wherein we had a display of 36 stalls, demonstration on various technologies of the institute, demo on machineries, seminars, interactive sessions and screening of video films. Fourteen progressive farmers from seven states were honoured. Three books on 'Sugarcane agriculture' were printed and released.

Fig. 97. Interface Meet at ICAR-SBI on 14 February 2017

M.Sc. (Sugarcane technology) in ODL mode: ICAR-Sugarcane Breeding Institute and Tamil Nadu Agricultural University are jointly offering the M.Sc. (Sugarcane technology) course in Open and Distance Learning mode from the academic year 2007-08. Personal contact classes were offered at Coimbatore for the following four batches:

- II Semester students during 22 April-1 May 2016 with 21 students
- IV Semester students during 27 April-1 May 2016 with 22 students
- I semester during 25 September-4 October 2016 with 26 students
- III semester students during 11-20 November 2016 with 18 students

Production of video films: Six video films on varied topics (New sugarcane varieties, Seed production in sugarcane, Integrated disease management, Integrated pest management, Integrated nutrient management, Ratoon management) were produced in trilingual.

Frontline demonstration: The following demonstrations were planted:

- Planted On Farm Trials of six sugarcane varieties viz., Co 0212, Co 92005, Co 06022, Co 06030, Co 86032 and Co 99006 in a jaggery farmers' field in Pariyamangalam village, Vellore district on 8 February 2017.
- Planted a Varietal Demonstration Farm in Avinashilingam KVK, Karamadai with six sugarcane varieties namely Co 86032, Co 0212, Co 0238, Co 06022, Co 06030 and Co 99006 on 10 February 2017.

Fig. 98. Farmers visiting ICAR-SBI stall in Agri-Intex 2016

Technology Park: A 'Technology Park' with 17 sugarcane varieties (Co 86032, Co 06027, Co 06030, Co 99004, Co 2001-13, Co 0403, Co 92005, Co 06022, Co 99006, Co 2001-15, Co 0118, Co 0212, Co 0232, Co 0233, Co 0237, Co 0238, Co 05011) & tissue culture plants were planted in the institute covering 150 rows on 23 December 2016. A 'Technology Park' with 16 sugarcane varieties and tissue culture seedlings of Co 86032 planted in the institute on 21 January 2016 was maintained.

Fig. 99. Dignitaries visiting ICAR-SBI stall

Participation in exhibitions

Participated by putting up a stall in the following four exhibitions:

- Agri-Intex 2016 organized by CODISSIA at Trade Fair Complex during 15-18 July 2016 (Fig. 98).
- Farmers Day organized at NRC for Banana, Tiruchirapalli on 21 August 2016 (Fig. 99).
- International Conference at VSI, Pune during 13-15 November 2016 (Fig. 100.)
- SugarMech 2017 exhibition organized at Bannari Amman Institute of Technology, Sathiamangalam, Erode district during 17-18 March 2017 (Fig. 101).

Fig. 100. Farmers visiting ICAR-SBI stall at VSI, Pune

Charts on package of practices for cane cultivation in tropical / subtropical states, live specimens on new sugarcane varieties, bud chip seedlings, tissue culture plants, liquid jaggery, particle boards *etc*. were exhibited and technology advisories were offered to the visitors by Scientist of ICAR-SBI.

Fig. 101. View of ICAR-SBI stall in SugarMech 2017

National Science Day: National Science Day celebration as an 'open day' on 28 February 2017. Students of schools and colleges were invited for inculcating scientific awareness for nation building. Nearly 650 students visited the institute. The students were taken around the institute's museum and Scientists and Technicians explained the exhibits with live specimens apart from video shows (Fig. 102 -103).

Interaction with Krishi Vigyan Kendras: Participated in the Scientific Advisory Committee meeting of MYRADA KVK, KVK, Dharmapuri and Shri Avinashilingam KVK and offered suggestions for implementation of programs.

Visitors program: Visitors (4081) from different states of the country comprising farmers (614), students (3221) and extension personnel & university staff (246) were explained about the activities of the institute and sugarcane cultivation aspects.

ICT diffusion and use: A feasibility analysis in the disadvantageous regions

(D. Puthira Prathap, P. Murali, V. Venkatasubramaniam and *T. Rajula Shanthy)*

Surveys were conducted in Villupuram and Cuddalore districts in Tamil Nadu. In Villupuram district, 60 farmers and 15 cane development personnel belonging to five divisions of Rajshree Sugars and Chemicals Ltd., Mundiyampakkam formed the sample for the main survey. In Cuddalore district, 60 farmers and 15 cane development personnel belonging to four divisions of Sri Ambiga Sugars Ltd., Pennadam and six divisions of Thiru Arooran Sugars Ltd., A.Chittur formed the sample.

Fig. 102. Students looking at the exhibits

Fig. 103. Dr. Bakshi Ram, Director, ICAR-SBI interacting with school students

Data pertaining to ICT resources used by the cane growers, perception on ICT availability and use, barriers in access and use and their information needs and content priorities for *CaneInfo* website were collected from them.

- ◊ Most of the farmers had preferred newspapers/farm magazines as the preferred source of information followed by television, radio and internet among the mass media. *Pasumai vikatan* magazine is commonly referred to followed by TNAU's *Valarum velaanmai*. DD *Pothigai's* farm programmes are also being preferred among Farm TV programmes.
- ◊ Most of farmers use mobile phones primarily for making calls, sending and receiving SMSs, taking photographs and accessing internet, in that order. Accessing Internet through PCs is minimum. Many browse using mobile phones. A few travel to nearby towns to browse @ Rs.20 /hour. The common problem they encounter while attempting to seek information on sugarcane is outdated information.
- ◊ Farmers would prefer finding information on sugarcane varieties in *CaneInfo* website.
- ◊ A few farmers call Pasumai Vikadan's helpline for clarifying doubts.
- ◊ Cane Development Personnel in the district obtain sugarcane related information through handouts (RSCL diary) and Internet.
- ◊ Many of them use Chrome and Firefox browsers to access the Net in PCs.
- ◊ Many share sugarcane related information through Facebook and WhatsApp. They agree that learning how to use Internet/www has been worthwhile. Many felt that there is indeed a difference between urban and rural areas in terms of e-communication.

Extent of adoption of recommended production cum protection technologies of sugarcane in Tamil Nadu and constraint analysis

(D Puthira Prathap K. Sivaraman, T. Ramasubramanian, T. Rajula Shanthy, P. Murali, V. Venkatasubramanian and *K. Mohanraj)*

Surveys were carried out in Cuddalore and Villupuram districts of Tamil Nadu for assessing the extent of adoption of cane technologies. A few observations of the survey are given hereunder.

- ◊ Sugarcane is grown in about 35000 ha in Cuddalore district producing about 45 lakh tonnes. The average cane yield obtained in the study area is about 35 t/acre. This year due to drought the average yield has come down to 28 t/acre.
- ◊ In this district (under Shree Ambika Sugars Ltd, Pennadam and Thiru Arooran Sugars Ltd., area), Co 86032 is being cultivated predominantly followed by CoV 09356, that is being preferred for its erect nature. PI 1110, Co 0212, Co 06022, CoV 92102. CoC 22 and CoC 24 varieties are also being grown in a few areas.
- ◊ Most of the farmers seek agriculture related information from fellow-farmers. Rat menace, and creeper weeds are major issues. Many farmers were found to discontinue micro irrigation and soil testing practice was not being followed. Though about 7-8 machines are available for harvesting, it is not so popular among the farmers. Cane payment arrears has also affected the maintenance of ratoon crop. Obtaining good quality seed material is a constraint in this area often resulting in varietal mixture and disease incidences. Many felt that high cost of cane production and less returns have made them switch over to alternate crops such as paddy. Information on varietal adoption and yield levels were collected from the sugarcane farmers.

Fig. 104. OFT plot on Co 09004

In Villupuram district, in general, sugarcane is grown in about 35,000 ha producing about 42 lakh tonnes. The average cane yield obtained in the study area is about 30-32 t/acre; In this district (RSCL, Mundiyampakkam & RSCL, Semmedu units), Co 86032 is being cultivated predominantly followed by SI 309 and SI 339. Co 99006, CoC 24, CoV 92102 and Co 97009 (MC 707) are also being grown in patches. The respondents had mentioned that the major factors for continuing with sugarcane crop were labour arrangement by the factory, timely technical advice offered, demonstration plots for yield improvement in each division and extension initiatives/periodical training programmes by the factory. The factory had arranged for rain guns this year to a few ryots in view of the prevailing drought situation. Major problems include drought, wild boar menace, early shoot borer and depleting water table.

In the OFT plot of Co 09004, belonging to Shri Ambigapathy, of Pallapalayam village, this variety had yielded about 79 t/ha at 9 months of age as against 75t/ha of Co 86032.

On-Farm Trial: An On-Farm Trial was laid out in Varappallam (Perumugai) village, Erode district with varieties Co 09004, a pre-release clone of ICAR-SBI and Co 86032 on 1 March 2017 (Fig. 104).

Farmer support program for sustainable sugarcane production in India

(T. Rajula Shanthy)

This project was sponsored by Solidaridad through Prakruthi with the objective to train 1000 lead farmers representing eight sugar mills of Tamil Nadu on sustainable agricultural practices to improve their knowledge base and thereby cane productivity and profitability of cane farming. The trained

lead farmers would serve as resource persons to enable fellow farmers take up sustainable farming at village levels.

A total of 16 training programs with the participation of 755 cane growers and 58 cane development personnel from eight sugar mills of Tamil Nadu state were conducted and were trained as Sugarcane Lead Farmers. During this period, three two-days training programmes with the participation of sugarcane farmers and cane staff from EID Parry (India) Ltd. and Rajshree Sugars Ltd. were organized (Fig. 105-108) as detailed below:

Fig. 105. Trainees visiting experimental fields(5-6 April 2016)

- 5-6 April 2016 with 53 farmers and four cane staff
- 12-13 April 2016 with 49 farmers and four cane staff
- 21-22 April 2016 with 52 farm women and three cane staff

The program included theory classes, practical sessions, filed visits, demonstrations and interactive sessions. The training program organized during 21-22 April 2016 was unique with the exclusive participation of farm women. The enthusiasm of the women farmers expressed in terms of their quest for learning and interactions during the interface is worth mentioning. For few of them, it was a maiden trip outside their village and it became a myth to reality.

Fig. 106. A training session in progress (12-13 April 2016)

Knowledge evaluation studies conducted pre and post training indicated that the average pre-evaluation score was 50.04, the range being 37.05 to 60.40; the average post-evaluation score was 62.12, the range being 52.70 to 72.31; the average of difference in knowledge level was 12.08% with a range of 1.42 to 24.27.

Fig. 107. Participants visiting sugarcane fields (21-22 April 2016)

Developing eganna, a mobile app on sugarcane: An initiative towards digital India

(T. Rajula Shanthy, , S. Alarmelu, C. Jayabose, P. Malathi and T. Arumuganathan)

This project was sponsored under Extramural funding from Division of Agricultural Extension, ICAR with the main objective of developing a mobile app on sugarcane.

Fig. 108. Farm women designated as ' Sugarcane Lead Farmers'(21-22 April 2016)

- Surveys were conducted to understand the information needs of cane growers through mobile app, the type of mobile phones they use, and the pattern of mobile use through focus group discussions with cane growers and millers.
- Developed a database of sugarcane farmers of over 1,50,000 covering 12 states of the country with details of mobile numbers and demographic profile to establish a network of sugarcane stakeholders through mobile usage.
- The content for the mobile app covering all aspects of sugarcane cultivation right from sett plating to harvest was digitized and arranged as sugarcane varieties, crop production technologies and crop protection technologies (~220 pages) with relevant photographs (~550 nos.). The entire matter was translated in Tamil and Hindi to make the app in trilingual.
- The storyboard of the proposed app was designed; executed the programming, integration, code review and configuration for the

module and developed an android-based mobile application software. The app includes static as well as dynamic platforms for technology delivery. The static display is on entire sugarcane agriculture including fertilizer schedule for all the cane growing states, both text matter and graphics which would serve as a digital compendium; The dynamic user-interface facets include login dialogue, downloader, tailor-made scheduler app with reminder messages for the individual registered users, query sender in text or graphic form, message sorting, facilities for short message service etc.

- ◊ The app envisaged in this endeavor targets to provide farmers, cane development personnel, line department officials and rural residents with timely access to extension services such as advancements on scientific sugarcane production, advice on appropriate technology and availability of services.
- ◊ The module development is in its final stage and facilities for mobile transmission are being explored after test verifying the entire content.

Digital inclusion of rural youth for sustainable development: A comparative assessment

(D. Puthira Prathap, P. Murali and *V.Venkatasubramanian)*

Pilot survey was conducted among rural youth in Erode district of Tamil Nadu, a non-sample area. Altogether, 26 young sugarcane farmers belonging to Gobichettipalayam West, Athani, Bhavani, Andhiyur and Kavundhapadi divisions of Sakthi Sugars Ltd., Appakudal formed the sample. Data pertaining to dynamics of ICT uptake, perception on use and availability of ICTs, enablers and barriers in accessing and using ICTs among rural youth were collected. The preliminary observations of the pilot survey are:

- ◊ Young cane farmers in the study area had used mobile phones for sharing sugarcane information. The preferred source of farm information was newspapers among mass media.
- ◊ Facebook & WhatsApp are the predominantly used networking tools. Many were part of Agriculture-based WhatsApp groups.
- ◊ Though CSCs (Common Service Centres) are available in nine blocks of the district, only a few of the respondents were aware of them. A few farmers had contacted KCC (Kisan Call Centre) to clarify doubts and had utilized the SMS alerts facility of Uzhavan FPO (Farmer Producer Organization), Erode.
- ◊ Kisan Suvidha app was being used by a few farmers.
- ◊ Rural youth farmers had confidence that can find farm information on the internet and prefer to browse from their mobile phones than at Internet Cafes.

The main survey was conducted in Villupuram district, one of the six identified backward districts of Tamil Nadu. Altogether, 42 rural youth farmers belonging to the cane divisions of Villupuram, Mundiyampakkam, Tindivanam & Koliyanur of RSCL, Mundiyampakkam and Semmedu, Ananthapuram, Vallam, Valaththi, Avalurpettai and Gingee North of RSCL, Semmedu were contacted.The preliminary observations of the main survey are:

- ◊ Majority of the young farmers used smart phones. Most of them access agriculture related information through their mobile phones compared to other devices. However, usage of mobile apps is minimal.
- ◊ Young farmers in the study area had used Reliance Foundation's helpline service to clarify doubts on agriculture. Information related to weather, crop production, horticulture and animal husbandry are being disseminated through the foundation's call centres, it was reported.
- ◊ The number of *neo* Internet users is on the rise with free Internet access offers from Telecom companies. UC Browser is commonly used in mobiles
- ◊ Many of the rural youth had reported that they have a lack of awareness about how to obtain information on modern sugarcane production technologies.
- ◊ Most of them use YouTube agricultural videos for obtaining farm – related information, machinery in particular. Majority of the farmers had reported that Internet is a rich source of agricultural information. Many of them use the internet daily or twice a week.
- ◊ Young farmers need authentic information on sugarcane varieties and drought management techniques from the Internet

5.6. ICAR-SBI REGIONAL CENTRE, KARNAL

Breeding elite clones suitable for North West Zone

Hybridization, progeny evaluation and selection

(*Ravinder Kumar, M.R. Meena, N. Kulshreshtha* and *M.L. Chhabra*)

Identification of clone in AICRP(S): Co 09022, a mid-late clone was identified by the AICRP(S) varietal identification committee for North West Zone of the country. Performance of the variety is given in table 25.

Table 25. Performance of Co 09022 in comparison with standards under AICRP trials in North West Zone (2 Crop + 1 ratoon)

Characters	Co 09022	CoPant 97222	CoS 767	CoS 8436
CCS (t/ha)	10.06	8.89	8.88	8.38
% change over standards		13.33	13.75	20
Cane yield (t/ha)	83.59	73.48	75.69	69.28
% change over standards		13.86	10.93	20.76
Sucrose (%)	17.49	17.46	17.02	17.7
% change over standards		0.2	2.78	-1.19

Fluff sowing in mist chamber: The fluff of 2016-17 crossing season was received and the fluff of 113 bi parental, 11 polycrosses and 1 General Cross was sown in mist chamber for raising the seedlings.

Seedling ground nursery ratoon 2015-16: Nearly 13,172 seedlings of 100 cross combinations were field transplanted in July 2015 and were winter ratooned

in January 2016. Out of 7475 seedlings survived, 4328 were found good for screening for HR Brix. In September 2016, these seedlings were evaluated for HR Brix, cane diameter, NMC, plant height, presence of spines and splits. The average HR Brix, cane diameter and NMC of the total seedlings was 18.1%, 2.3 cm and 5.7 respectively. Based on general appearance, HR Brix, cane thickness, cane height and NMC, a total of 558 progeny were selected and assigned K14-001 to K14-558 selection numbers. The average HR Brix, cane diameter and NMC of the selections was 20.6%, 2.5 cm and 6.1, respectively. The average selection intensity was 16.2% (Table 26) and > 6 individuals were selected from 32 cross combinations. The highest number (66) of progeny was selected from CoV 89101 PC, followed by Co 0120 x Co 62198 (31). Among the larger progeny population crosses, Co 86002 x Co 68198 (22.1%), Co 86032 x CYMA09-1369/CYM08-922 (21.3%), Co 0120 x Co 62198 (20.7), Co 06033 x CoV 92102 (20.4%), CoH 99 x CoS 8436 (20.2%), Co 99006 x 85R186 (20.1%) and Co 86032 x 85R186 (19.9%) were better for HR Brix. Similarly, crosses MS68/47 x CoV 92102 (2.7cm), Co 0240 x Co 06037 (2.6), Co 86032 x 85R186 (2.6 cm) produced thick progeny and CoSe 85422 GC (7.6), CoJ 88 PC (7.6) CoS 8436 PC (7.4) and CoV 89101 (7.2) produced high NMC.

Seedling ground nursery 2016-17: A total of 22,890 seedlings representing 120 cross combinations were field transplanted in ground nursery in July 2016. The seedlings were winter ratooned during last week of December 2016.

Table 26. Performance of cross combinations for cane yield and juice quality contributing traits and selection% from ratooned ground nursery 2015-16

Cross combinations	Screenable seedlings	No. of Selections	% selections	Mean performance of crosses			Mean Performance of selections		
				Brix	Cane dia (cm)	NMC	Brix	Cane Dia (cm)	NMC
CoV 89101 PC	339	66	19.5	17.6	2.4	7.2	20.3	2.5	8.1
Co 0120 x Co 62198	94	31	33.0	20.7	2.4	5.9	22.0	2.6	7.4
MS68/47 x CoV 92102	102	28	27.5	16.8	2.7	5.0	18.9	2.6	6.5
CoH 99 x Co 97009	155	26	16.8	19.4	2.2	5.3	21.6	2.5	6.2
CoS 8436 x Co 89003	70	23	32.9	18.0	2.5	7.1	20.5	2.6	8.0
SP 80-185 GC	73	20	27.4	18.1	2.6	5.0	20.0	2.6	5.5
Co 8371 x CoT 8201	81	18	22.2	17.6	2.5	4.6	19.5	2.6	4.9
CoS 8436 PC	124	16	12.9	16.4	2.4	7.4	19.1	2.6	7.9
Co 0240 x Co 62198	107	16	15.0	19.0	2.1	3.8	21.0	2.5	5.9
Co 99006 x CoS 8436	102	14	13.7	17.2	2.3	5.7	19.5	2.6	7.6
CoH 99 x CoS 8436	40	13	32.5	20.2	2.2	5.1	21.8	2.5	5.2
Co 0240 x Co 06037	30	12	40.0	18.2	2.6	5.3	19.2	2.7	5.4
Co 0238 x CoSe 92423	72	11	15.3	19.1	2.4	4.2	20.4	2.7	4.4
Co 0120 x CoPant 97222	55	11	20.0	18.1	2.4	5.1	20.9	2.6	4.6
Co 99006 x CoSe 92423	38	11	28.9	18.6	2.4	5.9	20.1	2.8	5.0

Co 89010 x CoSe 92423	34	11	32.4	18.7	2.4	4.9	21.7	2.7	6.0
Co 86002 x Co 62198	44	10	22.7	22.1	2.2	3.9	23.2	2.3	5.0
Co 97015 x Co 1148	48	10	20.8	18.5	2.3	5.3	20.7	2.6	5.6
Co 86032 x CYMA09-1369/CYM08-922	85	10	11.8	21.3	2.3	5.2	22.3	2.4	5.6
CoSe 85422 GC	94	10	10.6	16.9	2.3	7.6	19.4	2.5	8.8
CoSe 92423 PC	194	10	5.2	15.2	2.4	6.1	18.1	2.7	8.2
Co 86032 x 85R186	21	10	47.6	19.9	2.6	4.1	21.0	2.7	4.7
CoS 8436 x CoPant 97222	102	9	8.8	17.7	2.4	5.2	19.5	2.4	6.0
Co 0240 x CoH 70	116	9	7.8	16.0	2.4	5.4	18.7	2.6	7.6
Co 8213 x CoPant 97222	73	8	11.0	16.5	2.4	5.8	19.5	2.6	6.4
Co 99006 x 85R186	22	8	36.4	20.1	2.4	4.5	21.5	2.5	5.0
Co 98010 x Co 89003	33	7	21.2	17.5	2.4	6.0	20.1	2.6	6.4
CoJ 88 PC	36	7	19.4	17.2	2.4	7.6	19.0	2.7	10.3
Co 06033 x CoV 92102	38	7	18.4	20.4	2.0	4.8	22.0	2.3	6.0
Co 0240 x CoS 88216	50	7	14.0	19.0	2.3	5.0	21.1	2.6	6.7
CoLk 94184 x BO 130	30	6	20.0	19.3	2.0	6.0	21.5	2.3	6.2
Co 0238 x Co 99006/ CoC 671/Co 99008	42	6	14.3	19.8	2.1	4.9	21.2	2.4	6.0
Experimental Average/ Total	**4328**	558	**16.2**	**18.1**	**2.3**	**5.7**	**20.6**	**2.5**	**6.1**

Preliminary trial: A total of 106 clones of K12 series selection were evaluated for cane yield and juice quality parameters along with standards Co 0238, CoJ 64, CoS 767 and CoS 8436. Based on cane yield, juice quality, red rot reaction and general appearance, 21 clones were selected and advanced to PZVT trial for further evaluation.

Red rot reaction: The 106 clones were screened against mixed inoculation of CF08 and CF09 isolates of red rot. The disease reaction of 4, 32, 27, 25 and 18 clones was R, MR, MS, S and HS, respectively.

Pre- Zonal Varietal Trial

(*Ravinder Kumar, M.R. Meena, N. Kulshreshtha* and *B. Parameswari*)

The clones were evaluated for cane yield and juice quality parameters at 8th, 10th and 12th month, general appearance and reaction against red rot disease. Six clones, three under early (K11-176, K11-328 and K11-270) and three under mid-late (K11-201, K11-228 and K11-444) category were proposed for awarding 'Co' status. These clones were awarded 'Co' status Co 17015 to Co 17020. Their performance in the PZVT experiment in comparison with standards is presented in Table 5 (for early clones) and Table 6 (mid-late clones).

Red rot: Out of 36 clones tested against CF08 and CF09 isolates of red-rot, 7, 15, 6 and 8 exhibited R, MR, MS and S reactions, respectively against CF 08, while against CF09 isolate 5, 18, 6 and 7 were R, MR, MS, S, respectively.

Evaluation of 'Co' canes: The ratoon experiment was evaluated for cane yield and juice quality traits. For cane yield, the experimental mean was 78.4 t/ha and Co 14036 (116.8 t/ha), Co 15027 (112.7 t/ha), Co 0238 (112.1 t/ha), Co 06034 (107.5 t/ha) and K07-14 (107.3 t/ha) were the best performers among the 13 superior clones which produced significantly higher yield over experimental mean. For pol% in cane juice, Co 15023 (20.23%), Co 0116 (20.01%), Co 0118 (19.9%), Co 0331 (19.8%), Co 0237 (19.78%), Co 0238 (19.44%), Co 15027 (19.38%) and Co 11027 (19.35%) were the promising entries over the experimental mean (18.0%).

Evaluation at Harinagar

(*M.R. Meena, Ravinder Kumar* and *M.L. Chhabra*)

At Harinagar Sugar Mill, Harinagar, West Champaran, Bihar, 25 'Co' canes were evaluated for cane yield and juice quality traits. Based on yield, field stand, NMC, cane thickness, red rot reaction and last year results, 13 clones namely CYM 11-22, CYMA 10-1488, Co 0116, Co 0327, Co 12026, Co 12027, Co 13033, Co 13034, Co 13036, Co 14034, Co 15023, Co 15025 and Co 15026 along with three standards viz., Co 0238, CoP 9301, CoP 2061 were planted in six row trials of six meter row length at 0.9 m spacing.

Advancement of selections to the next stage: From K13 series 488 selections of C1 stage, a total of 119 were advanced to preliminary (C2 stage) trial. From the preliminary trial, out of 106 selections, 21 along with 12 Coimbatore Co canes, two WL clones, one GUK clone, one PIO clone and four standards were planted in PZVT experiment.

Evaluation of sugarcane germplasm under sub-tropical conditions

Basic species: Co 0238 with 19.1% pol in juice and 110.25 t/ha cane yield was the best standard. Entries *Gungera* (18.83%), *Pathari* (18.4%), *Mangawa* (18.26) were best performing entries for pol% at harvest. Combining cane yield (124.91 t/ha) and juice quality *Gungera* was the promising entry.

Evaluation of sugarcane germplasm

(*Ravinder Kumar, M.R. Meena, S.K. Pandey, M.L. Chhabra* and *Pooja*)

Evaluation of exotic clones: The experiment was evaluated for cane yield and juice quality parameters at harvest. Co 0238 (105.4 t/ha) was the best standard for cane yield and four entries viz., CP57-614 (135 t/ha), CL 41-223 (132 t/ha), CP 80-1748 (123 t/ha), SP 80-5073 (120 t/ha) were the best entries for cane yield. For juice quality, Co 0238 with 19.52% pol in juice was the best standard and entries CP 80-1816 (21.33%), CP 98-1029 (21.27%), INDO-264 (20.99%), CP 53-99 (20.90%), CP 63-321 (20.03%), CP 80-1748 (19.82%), H52-182 (19.82%) were the promising high quality exotic entries at harvest. Combining cane yield, juice quality and resistance against red rot disease, CP80-1748 and CP98-1029 were found as promising entries.

Winter sprouting index (WSI) of the clones: The genotypes in the half portion of each block were tagged at top visible dewlap during II week of November 2016 to observe active elongation of shoot during winter (mid-November to mid-February) and the remaining half portion of each block was harvested during peak winter (Last week of December 16) to observe winter sprouting

potential. In general, the experimental average for active shoot elongation, number of sprouts/sprouted clumps, ratio sprouted/total clumps and WSI was 4.86 cm, 3.13, 0.177 and 0.66 respectively. Co 0238 with 5.55 cm shoots elongation in winter and 0.89 WSI value, was the best standard.

Five GUK clones *viz*., 84GUK526 (3.16), 81GUK242 (1.23), GUK00-464 (1.06), 97GUK10 (1.04) and 98GUK655 (1.04); four OS clones viz., IJ76-501 x SES 407-44 (6.5), IJ76-501 x SES 151-26 (1.15), IJ76-418 x 92-233-6 (1.08) and 51NG159 x 92-243-10 (1.01); two *S. barberi* clones viz., *Katha Coimbatore* (0.93) and *MANGWA* (0.91); 12 Co canes x *S. spontaneum* derivative clones viz., AS04-2153 (1.25), AS04-1391 (1.08), AS 2220 (1.02), AS 04-682 (1.01), AS04-1581 (0.97), AS04-2212 (0.97), AS04-1013 (0.96), AS04-1755 (0.96), AS04-1687 (0.96), AS04-2424 (0.95), AS04-1391 (0.94) and AS04-939 (0.92); two Co canes x *S. barberi / S. sinense* derivatives viz., GU97-503 (1.09) and GU98-7 (0.93); two Co canes x *S. robustum* clones viz., GU97-972 (0.98) and GU97-3 (0.91); two foreign hybrid clones viz., CP41-34 (1.31) and CP80-1748 (0.98) performed better than Co 0238 (0.89) the best standard while none of the WL clones could perform better than Co 0238 for winter sprouting potential.

SPAD value: Sixty-nine exotic clones, 22 basic species, 150 nine interspecific and intergeneric hybrid clones and four standards were evaluated for SPAD values. Higher average SPAD values were recorded in OS clones (44.74), followed by WL clones (42.26), GU clones (42.11), GUK clones (41.38), basic species (39.16) standard clone (38.62) and exotic clones (37.48).

Among the exotic clones, maximum SPAD values were recorded in CL 41-223 (50.15), LF 63-91 (48.42), LF 63-1617 (47.43) and LF 74-2148(47.42). Among the basic species, IK 76-48 (56.66) and SARETHA (43.33) have shown higher SPAD values. Among waterlogging (WL) clones, WL 09-785 (49.70), WL 09-510 (47.36), WL 12-544 (46.71) and WL 06-182 (42.66), showed maximum SPAD values. Among the OS, maximum SPAD values were recorded in OS2 (49.59), OS3 (51.68), OS 14 (48.66) and OS 15 (48.55). In GU and GUK clones maximum SPAD values were recorded in 98-3 (49.43), 07-0309 (49.33), AS 04 -1931 (45.80), GUK 08-03 (51.13), GUK 01-446 (49.70), 92 GUK 44 (49.29) and GUK 06-353 (48.59).

Red rot: Out of 68 exotic clones, six were resistant, 16 MR, 12 MS and 34 S/HS against red rot.

Insect pests: A total of 62 exotic clones were evaluated against early shoot borer (ESB), top borer (TB), root borer (RB) and stalk borer (SB). All the clones showed least susceptible reaction to early shoot borer and top borer (<15.0 and <10.0%, respectively). In case of root borer, 34 clones were least susceptible (<15.0 %); 24 clones were moderately susceptible (15.1 to 30.0%) and four clones showed highly susceptible reaction (>30.0%). In case of stalk borer, 28, 20 and 14 clones were least susceptible (infestation index < 2.0); moderately susceptible (infestation index 2.1 to 5.0) and 14 clones were highly susceptible (infestation index >5.1).

Evaluation of inter-specific and inter-generic hybrid clones

(*N. Kulshreshtha, M.R. Meena, Ravinder Kumar, S.K. Pandey* and *B. Parameswari*)

Co 0238 with 19.01% pol in juice and 104.01 t/ha cane yield was the best standard. Entries WL 10-49 (21.61%), WL 12-140 (20.61%), WL10-118 (20.35%), GUK08-03 (20.28%), WL 10-37 (20.24%), WL06-85 (20.04), 98-7 (20.03%), GUK09-198 (19.83%) and 84GUK 571 (19.82%) were promising for pol% in juice. Similarly for cane yield (t/ha), entries 94 GUK 2447 (164.5), 98GUK 116 (131.3), WL 08-338 (131.02), GUK 01-565 (129.72), GUK 01-596 (126.3), WL 10-40 (119.8), GUK 10-413 (112.8), 97 GUK 10 (112.47), 84 GUK 216 (111.3) found promising. Combining cane yield, juice quality and resistance against red rot disease, 84 GUK 216, GUK 10-413, GUK 01-596, WL 06-85 and WL 10-49 were found as promising entries.

Red rot: Of the 177 ISH/ IGH clones evaluated, 38 showed R, 75 MR, 19 MS, 25 S and 20 HS reaction to red rot.

Insect pests: A total of 193 ISH & IGH clones were evaluated against early shoot borer (ESB), top borer (TB), root borer (RB) and stalk borer (SB). Early shoot borer and top borer incidence was <15.0 and <10.0%, respectively. Hence, all the clones showed least susceptible reaction to early shoot borer and top borer. In case of root borer, 143 clones were found to be least susceptible (<15 %); 47 clones were moderately susceptible (15.1-30%) and 3 clones; PIO88-1703, Gungera and OSHIMA were highly susceptible (>30.0%). In case of stalk borer, 88 clones were least susceptible (infestation index < 2.0); 77 clones were found to be moderately susceptible (infestation index 2.1 to 5.0) and 28 clones were highly susceptible (infestation index >5.1).

Characterization and mining genetic variability in sugarcane germplasm against abiotic stress (salinity/ alkalinity and low temperature) under sub-tropical India (Karnal)

(*Ravinder Kumar, M.R. Meena, N. Kulshreshtha, A. Selvi* and *Ashwani Kumar (CSSRI, Karnal)*)

Winter ratoon trial: The experiment was compared for cane yield and juice quality parameters from winter and spring initiated ratoon crop. For cane yield, there was no significant difference between the time of ratooning but there was significant difference between genotypes and genotype and environment interaction. Entries IK 76-48, AS 04-635, AS 04-245 and CYMA 09-1447 produced significantly higher cane yield in winter initiated crop, indicates their winter tolerance potential. Whereas entries Co 419, Co 0118, CoJ 64, CoS 767 and CYMA 09-1268 produced significantly lower cane yield in winter initiated ratoon crop compare to spring initiated ratoon crop. For juice sucrose % the winter initiated ratoon crop recorded significantly higher pol% in juice compared to spring initiated ratoon crop. Entries AS 04-2097, Co 0238, GU 07-3774 and IND 00-1039 recorded significantly higher pol% in winter initiated ratoon crop compare to spring initiated ratoon crop.

Winter sprouting index and winter plant elongation: Half of the experiment (consisting of 30 genotypes and four replications) was ratooned during peak

winter (first week of January) to observe winter sprouting potential, whereas the top visible dewlap of remaining two replications of the experiment were tagged during second fortnight of November 2016 to record the plant elongation during winter. The observations on number of sprouted clumps, number of sprouts per clone, plant elongations were recorded during first fortnight of February 2017. The average plant elongation of the experiment during winter was 4.67 cm and clones IK 76-48 (19.55 cm), GU07-3774 (17.05 cm) and GU 04-2097 (10.78 cm) had highest elongation, whereas six entries viz., Co 0237, Co 12026, Co 13034, Co 14034, Co 14035 and Co 15025 did not show any elongation during winter. Based on the sprouting index entries Co 13033, Co 14035, Co 15025, Co 12026 and Co 0237 found winter sensitive and GU 07-3774, IND00-1038, AS04-635, AS04-2097 and CoS 767 were found winter tolerant.

Salinity trial: The experiment consisting of 30 genotypes was conducted under four salinity levels *viz*., Control, 4 EC_{iw}, 8 EC_{iw} and 12 EC_{iw} with three replications in each level. There was 27.97%, 51.6%, 31.64%, 11.37%, 26.82% and 33.50% reduction for six yield contributing traits viz., NMC ('000/ha), SCW, cane height, cane diameter, juice extraction% and tiller population respectively under 12 EC_{iw} compare to normal $_{iw}$. A salinity tolerant index was developed based on deviation of these traits under 12 EC_{iw} from the normal $_{iw}$. Based on this index entries GU07-3774 (0.88), GU04-2097 (0.92), AS04-635 (1.22), IK 76-48 (1.22) and AS04-245 (1.24) found tolerant, whereas Co 15027 (1.35), IND00-1038 (1.37), Co 13035 (1.39), Co 14034 (1.41), Co 12029 (1.51), Co 0238 (1.51), Co 0118 (1.53), Co 15026 (1.53), Co 13034 (1.55) and Co 14036 (1.57) were found moderately tolerant. Co 0237 (2.78), Co 06034 (2.67), Co 12026 (2.49), Co 13033 (2.48), Co 05009 (2.41), Co 14035 (2.12) and Co 13036 (2.11) were the sensitive test entries against salinity. The highest cane yield under 12 EC_{iw} conditions was recorded in genotypes Co 15027 (61.60 t/ha), Co 14036 (60.70 t/ha), Co 12029 (52.75 t/ha), Co 0238 (52.40 t/ha) and Co 14034 (51.98 t/ha) (Table 5).

Physiological studies: Various physiological parameters viz., photosynthetic rate, CF (Fv-Fm), Na+, K+, Na+/K+ ratio, Relative water content (RWC) and chlorophyll content were recorded at 240 days after planting. As compare to normal$_{iw}$ conditions there was 48.88%, 29.8%, -1266.72%, 58.73%, -3346.31%, 21.62% and 41.97% reduction at 12 EC_{iw} conditions for photosynthetic rate, CF(Fv-Fm) values, Na+ content in leaves, K+ content in leaves, Na+/K+ ratio, RWC and chlorophyll content. The genotypic response differed for the traits studied at different levels of salinity. At 12 EC_{iw} conditions highest photosynthetic rate was reported in GU 07-3774 (20.22), Co 0238 (20.19), Co 0118 (20.13) and Co 13035 (19.81). Under salinity the CF (Fv-Fm) values was highest in Co 0238 (0.534), Co 13035 (0.528), Co 0237 (0.523), Co 12029 (0.516) and Co 15027 (0.513). The correlation coefficient between physiological traits and yield & contributing traits, juice quality traits were insignificant except between RWC and Cane dia (0.436*), Brix (0.381*), NMC (-0.406*); between chlorophyll and purity (-0.367*). The correlation between the Na+/K+ and photosynthesis rate (-0.464**), between Na+ and content in leaves and photosynthesis rate (-0.422**) was negative.

Table 27. Performance of elite Co canes for cane yield (t/ha) under different levels of salinity and the % reduction over normal irrigation

Cane Yield (t/ha)	Normal iw	$4EC_{iw}$	$8EC_{iw}$	$12EC_{iw}$	Mean	% Reduction in cane yield at		
						$4EC_{iw}$	$8EC_{iw}$	$12EC_{iw}$
Co 98014	70.38	65.87	38.79	32.16	51.80	6.42	44.88	54.31
Co 0118	80.40	78.00	46.87	38.50	60.94	2.99	41.71	52.11
Co 0238	100.83	88.18	68.78	52.40	77.55	12.55	31.79	48.03
Co 0237	60.55	34.40	13.80	9.44	29.55	43.18	77.21	84.41
Co 05009	63.00	50.90	28.41	17.28	39.90	19.21	54.90	72.58
Co 05011	97.57	77.51	47.60	40.15	65.71	20.57	51.22	58.85
Co 06034	63.44	40.40	16.29	10.30	32.61	36.32	74.32	83.76
Co 12029	84.13	76.95	56.72	52.75	67.64	8.53	32.58	37.30
Co 13034	79.46	63.00	45.97	36.66	56.27	20.71	42.14	53.86
Co 13035	73.51	67.43	52.44	48.11	60.37	8.27	28.66	34.55
Co 14034	77.73	70.68	57.41	51.98	64.45	9.07	26.14	33.13
Co 14035	61.15	45.82	29.91	16.42	38.32	25.07	51.09	73.14
Co 14036	98.50	87.17	70.68	60.70	79.26	11.51	28.24	38.38
Co 15023	101.03	72.04	51.82	41.94	66.71	28.70	48.71	58.49
Co 15025	79.43	50.33	47.06	43.64	55.12	36.63	40.76	45.06
Co 15026	82.05	61.13	46.50	46.40	59.02	25.49	43.33	43.45
Co 15027	104.20	85.43	67.90	61.60	79.78	18.01	34.84	40.88
Experimental Mean	73.26	62.17	44.08	37.44	54.24	15.14	39.83	48.89

Genotypic behaviour of sugarcane under moisture stress in subtropical India

(*Pooja, Neeraj Kulshreshtha* and *Ravinder Kumar*)

Evaluation of ratoon of 'Co' clones under moisture stress conditions: An experiment was conducted to study the effect of moisture stress conditions in first ratoon of 53 'Co' canes during 2016-17. Moisture stress was imposed during formative phase of the crop by withholding irrigation. Maximum numbers of tillers were observed in entries Co 12029, followed by Co 14036 and Co 13033. Tiller production was significantly reduced under moisture stress conditions and maximum reduction was noticed in entry Co 62198 and least reduction in Co 07023. Clones Co 14036 (255 cm), Co 14035 (245 cm), Co 0331 (235 cm), Co 0238 produced significantly higher stalk length in control as well as in moisture stress. Maximum reduction in stalk length was recorded in entry Co 12028 (31.7%) and least in Co 62198 (1.39%) in moisture stress as compared to control. In control treatment, average cane yield was 78.05 t/ha and top ranking entries were Co 14036 (115.56 t/ha), Co 0238 (112.13 t/ha), Co 06034 (107.31 t/ha), K07-014 (107.30 t/ha), Co 15027 (107.30 t/ha),) Co 07026 (101.87 t/ha) and Co 05011 (100.46 t/ha). Under moisture stress average cane yield was 54.68 t/ha and entries Co 14036 (101.44t/ha), K07-014 (97.35 t/ha), Co 0238 (95.65 t/ha), Co 07026 (91.94

t/ha), Co 0331 (81.17 t/ha) and Co 09021 (80.93) produced significantly higher cane yield than average yield. Clones Co 14036, K07-014, Co 0238, Co 07026 Co 09021, Co 09022, Co 05011, and Co 12026 produced high cane yield in control as well as in moisture stress conditions. The juice quality parameters (Brix, pol%, purity% and CCS%) were not significantly affected under moisture stress as compared to control. However numerically higher values of Brix, pol% and purity% were recorded in moisture stress conditions as compared to control. Clones Co 15023 (20.2%), Co 0116 (20.1%), Co 0237 (19.9), Co 0118 (19.7%), Co 0331 (19.7%) and Co 0238 (19.5%) produced significantly higher sucrose% over the experimental average (18.1%).

Assessing the impact of non-fungal diseases in popular sugar varieties in subtropical region and their management

(*B. Parameswari, M.L. Chhabra* and *R. Viswanathan*)

Survey carried out in sub-tropical region revealed that grassy shoot disease (GSD) was the most prevalent followed by yellow leaf disease (YLD) in different varieties grown in Haryana, Uttar Pradesh and Uttarakhand states. Maximum incidence of GSD was reported in Co 89003 (up to 5%) and CoH 150 (1 to 3%) followed by other varieties viz. Co 0238, Co 98014, CoS 8436, CoJ 88, CoH160, CoH 152, CoH 119, CoH 13262, CoS 88230 and CoPant 13224 (trace to 3%). Similarly, the incidence and severity of YLD, leaf freckle disease and GSD was recorded periodically for the season at SBI Regional Centre, Karnal. Among the 1260 entries observed for the YLD incidence, 243, 44 and 17 entries have recorded YLD severity grades of 1, 2 and 3 respectively and 956 were free from the disease symptoms. The highest incidence and severity of YLD was reported in the ratoon trial of Co canes maintained at this centre. Leaf freckle disease caused by sugarcane bacilliform virus (SCBV) was observed in 273 entries out of 1260 entries and highest incidence of 3 to 5% was reported from DUS trial. Mosaic disease incidence (trace to 3%) was observed from different experiments maintained at this centre and GSD was also noticed from two varieties viz. CoH 11263 and CoLk 11206 maintained in ZVT trials.

Standardization of true seed production technique through developing homozygous parental lines and apomixes

Evaluation of hybrids

Subtropical (Karnal)

(*Ravinder Kumar, N. Kulshreshtha* and *M.L. Chhabra*)

The seedlings of crosses 778-136 x 1148-13-11-2-237 and 775-5-103 x 1148-61-390 received from Coimbatore were field transplanted in ground nursery during July 2016. The seedlings were winter ratooned and will be evaluated during September 2017.

Identification, characterization and verification of new sugarcane varieties for DUS testing

(*M.R. Meena, Ravinder Kumar* and *N. Kulshreshtha*)

Maintenance of reference varieties: One hundred and twenty six subtropical sugarcane reference varieties were maintained in disease free condition in two

row plots at Karnal. Photographs of reference varieties were taken as part of on digitization of DUS reference varieties.

DUS testing of two candidate varieties: Second year DUS test for two new sugarcane varieties *viz*., Co 05011 and Co 0237 was conducted along with eight reference varieties (Co 6425, Co 1158, CoS 767, CoS 91230, CoS 443, CoS 93259, CoS 95255 and CoSe 95436). A total of 160 settlings derived from single bud setts of each varieties were transplanted into RBD design with two replications in the DUS testing field. The plot size of 4 rows x 6 m length x 0.9 m row to row spacing was maintained. Observations on 27 morphological traits were recorded from the candidate as well as reference varieties. The results of 2nd year trial shows that the candidate varieties i.e. Co 05011 and Co 0237 were distinct from each other as well as from the reference varieties and the population of these varieties were uniform in both the years. The claimed / essential characters recorded from these entries had shown stable performance in second year as well.

DUS testing for farmer's varieties

Desi-I: The polybags raised settlings were transplanted at 0.9m x 6m x 4 rows in two plots. All the 27 DUS descriptors were recorded from the variety. DUS testing of this variety will be done as soon as reference varieties are decided.

Desi–II: The polybags raised settlings were transplanted at 0.9m x 6m x 4 rows in two plots. Observation at Karnal Centre revealed that this clone is of tropical nature. Hence, in consultation with the PPV&FR Authority the multiplied seed material of *Desi-II* was sent to ICAR-SBI, Coimbatore for testing under tropical condition.

KKK *(Kudarat ka karishma*): The polybags raised settlings were transplanted at 0.9m x 6m x 4 rows in two plots. This clone bears three buds in each node contrary to one bud in all other varieties. The persistence of this trait (3 buds) was observed in the subsequent vegetative propagation.

Kaptan Basti: The seed material of this variety was received on 26 April 2016. During the first year, this variety was multiplied. The settlings of kaptanbasti along with four reference varieties *viz*. BO 130, CoS 94270, CoS 96258, CoPant 96219 were raised and transplanted in RBD with two replications under field condition.

Mega seed Project- Seed production in agricultural crops and fisheries- Sugarcane

(*Ravinder Kumar*)

The breeder seed of sugarcane varieties viz., Co 0238, Co 0118, Co 05011, Co 0237, Co 0124, Co 98014, Co 06034 and Co 05009 was produced in 9.5 acres of land to supply the healthy seed cane to the various stakeholders of the country. A total of 3766.23 quintals of breeder seed worth Rs 11,92,958/- was supplied. The highest seed (1395.19 quintals) was produced and supplied of variety Co 0118, followed by Co 05011 (1120.74 quintals) and Co 0238 (844.95 quintals). Among the states, (Table 28) the highest quantity of seed was supplied to Uttar Pradesh (1292.4 quintals) followed by Haryana (1085.82 quintals) and Uttrakhand (853.38 quintals). The seed was also supplied through MTA

to the peninsular and North Central zone states as well to test their suitability in respective zones, since the demand of centers variety is arising due to ever time high recovery and better productivity in Uttar Pradesh. The average productivity of breeder seed was 99.11 t/ha (Table 29), it was highest for the variety Co 0238 (120.71 t/ha) followed by Co 0124 (112.1 t/ha and Co 05011 (112.07 t/ha). The productivity of varieties Co 0118 (81.12 t/ha) and Co 0237 (80.05 t/ha) was low.

Keeping in view the increasing demand for healthy seed of important sugarcane varieties, the micro propagated tissue culture seedlings of variety Co 05011 were brought from ICAR-SBI, Coimbatore and field transplanted. The carbendazim treated mini setts (single bud) raised settlings were field transplanted in two acres of land using settling transplanter designed by ICAR-SBI, Coimbatore.

Table 28. State and variety wise details of breeder seed supply from ICAR-SBI RC, Karnal

States	Co 98014	Co 0118	Co 0238	Co 0124	Co 05011	Co 0237	Co 05009	Co 06034	Total
Bihar				2.00				53.40	55.40
Gujarat			121.70						121.70
Haryana		517.39	368.98	84.0	121.81	4.34		2.0	1099.12
Karnataka			89.50						89.50
MadhyaPradesh		27.00	50.00		58.45			5.10	140.55
Punjab		50.5	14.05	1.23		20.0		11.4	97.18
Rajasthan		0.50							0.50
Tamil Nadu	0.4	0.40	14.50	0.4			0.4	0.4	16.50
Uttar Pradesh	8.0	490.20	149.02	61.58	514.9	32.7	2.0	34.00	1292.40
Uttarakhand		308.60	37.20	75.0	425.58	7.0			853.38
Total	8.40	1395.19	844.95	224.21	1120.74	64.04	2.40	106.30	3766.23

Table 29. Details of breeder seed production and productivity at ICAR-SBI RC, Karnal

Varieties	Co 98014	Co 0118	Co 0238	Co 0124	Co 05011	Co 0237	Co 05009	Co 06034	Total
Production	8.40	1395.19	844.95	224.21	1120.74	64.04	2.40	106.3	3766.23
Area	Very less	4.30	1.75	0.50	2.50	0.20	Very less	0.25	9.50
Productivity	0	81.12	120.71	112.1	112.07	80.05		106.3	99.11

5.7 ICAR-SBI RESEARCH CENTRE, KANNUR

Breeding superior sugarcane varieties of different maturity with improved cane yield, quality and resistance to biotic and abiotic stresses

Breeding varieties resistant to waterlogging

(K. Chandran, M.Nisha, R. Arun Kumar and *V. Krishnapriya)*

A final clonal evaluation trial was conducted for yield and quality traits under waterlogged condition with 16 test clones and three checks. Four clones viz., WL12-101, WL12461, WL12-498 and WL12-505 had significantly higher Brix % at 8th and 10th month in comparison to the best check Co 99006 indicating early high sucrose accumulation. Five clones had significantly higher pol% than Co 99006 and four clones had better CCS% than the checks. The clone WL12-749 performed significantly better than the checks for CCS yield/ plot and two clones (WL12-649 and WL12-92) were better than the checks. Two promising clones WL 12-749 and 649, which are resistant to red rot under CCT test were identified for PZVT. In the preclonal evaluation trial, 54 clones and three check clones were evaluated for germination, pre-monsoon tillering, NMC, cane thickness and hand refractometer brix (bottom, middle and top) at 8th month. Of these clones, 24 were selected for clonal trials based on cane thickness, NMC and Brix. In the ground nursery, 787 progenies from six crosses were evaluated for NMC, cane thickness and Brix and 56 progenies were selected for preclonal trial. Twelve new crosses were attempted and 757 seedlings from eight crosses were selected and transplanted in the field.

Fig. 109. Root mass in Co 62175

Twenty WL clones and 20 different species clones were planted in well drained and waterlogged area and data were recorded on root and biomass. Co 62175, SEL 74/1, WL11 2263, WL11 2230, Fiji15 and SS 60/1 recorded high root length, root surface area, root volume and diameter. Under waterlogged condition, Co 62175 showed better biomass with more roots (Fig. 109), internode number and single cane weight at formative phase. Among the studied species clones, Fiji 15 *(S. officinarum*) showed better root surface area (617 cm^2), while NG 77 230 (*S. officinarum*) recorded less root surface area (208 cm^2). Fiji 15 also recorded better root diameter (2.5 mm) and root volume (13.03 cm^3) besides length per unit volume under well-drained condition at the end of formative phase. Significant correlation was observed between the root volume data recorded using root scanner method and volume displacement method. Also among 20 species clones, the Boeton lict groen, Kavengerie and Hemja recorded better Brix under waterlogged condition.

Enhancement of sugarcane germplasm and development of pre-breeding material Utilisation of germplasm resources for developing new genetic stocks

(K. Chandran, M. Nisha and *R. Arun Kumar)*

A clonal evaluation trial was conducted with 29 back cross progenies from various interspecific hybridization and eight clones were selected for the final evaluation trial. Most of the clones evaluated in this trial were resistant/MR to red rot. In the pre-clonal evaluation, 177 clones were evaluated including 120 progenies of polycross of red-fleshed *S. robustum* and 78 clones were selected

for clonal evaluation. From 25 progenies of intraspecific crosses evaluated for germination, tillering, cane thickness and Brix, eight progenies were selected for clonal evaluation.

Twenty-one progenies of the intergeneric cross, sugarcane x bamboo were evaluated in preclonal trial and were characterized for anatomical traits. In the cross section of lamina, there was difference in the distribution pattern of smaller and larger vascular bundle between the genotypes and position of bulliform cells and bundle cap (Fig 110). In bamboo, fusoid cells were present on either side of all vascular bundles, and they are distinguished by their extremely thin walls and by being achlorophyllous which is absent both in female parent and in progenies. The characters like sinus of the cell wall, nature and shape of the short cells (cork and silica cell) showed intermediate traits between the parents. In a cluster analysis done based on these anatomical traits, the clones GUK 14-539 and GUK 14-538, GUK 14-533, GUK 14-540, GUK 14-534 and GUK 14-530 showed closer relationship with bamboo parent confirming the hybridity of these lines. The clone GUK 14-530 was morphologically distinct and was backcrossed with sugarcane and bamboo and fluff from slelfs and GC were also collected. The seeds from selfing did not germinate while from GC, 13 seedlings were yielded. In back crossing with sugarcane (WL 10-49), 144 seedlings and with bamboo, 37 seedlings were obtained. The BC1 and other seedlings were observed for cane thickness and tillering and pre-monsoon shoot height. The GC seedlings and back cross with bamboo were very thin canes but back crossed with sugarcane (WL 10-49) showed some thick and short canes. When the second type of F1 progeny with thick cane and 19.5% Brix (GUK 14- 541) was back crossed with sugarcane (WL 10-102), out of 156 progenies 149 were had thick canes and seven were thin canes similar to GUK 14-530. Co 99006 once again pollinated with bamboo pollen and 13 seedlings obtained showed medium thick and hardy canes, which are distinct from the female parent for morphological traits.

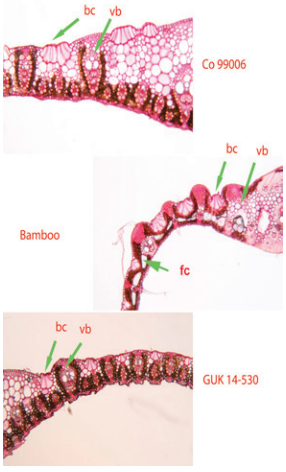


Fig. 110. Cross-section of lamina

384 seedlings from seven crosses mainly back cross progenies derived from interspecific crosses were evaluated. Tillering, leaf length, leaf width, pre monsoon shoot height, cane thickness and HR Brix at 9th month were recorded. The average Brix was maximum 20.8% in the progenies of the cross between 14 GUK 541 x WL 10-102 and 94 progenies were selected for further evaluation in preclonal trial. Thirteen new inter specific crosses were attempted and seedlings were raised in ground nursery.

Maintenance of world collection of sugarcane germplasm

Maintenance and evaluation of germplasm

(K. Chandran, M. Nisha and *V. Krishnapriya)*

3373 germplasm clones were maintained and monitored for germination, flowering, pests and diseases. In general, good flowering was observed in this season with a range of 12.02 (*S. officinarum*) to 96.0% in IA clones. All clones were re-planted during February- March 2017.

Monitoring of diseases and quarantine

(V. Jayakumar and *R. Gopi)*

Bud chips of 454 germplasm clones, i.e., 157 *S. officinarum*, 145 *S. robustum*, 42 *S. barberi*, 30 *S. sinensis* and 80 'Co' canes were treated in hot water

(52ºC) mixed with fungicide (carbendazim 0.1%) for 30 min and then planted. Monitoring of newly established crop in June 2016 showed incidence of Pokkah boeng disease in 15 *S. officinarum* and foreign hybrid clones and subsequent spray with 0.1% Bavistin showed recovery of plant growth and crop appeared normal. In November the *S. officinarum* clones Barbados white sport, 28 NG 10 showed and Co canes, Co 1003 and Co 1088 showed wilt incidence; foreign hybrid clones D1135, D1135STR showed mosaic symptom and F 31-407, F 31-436 showed YLD symptom. The clones CP 31-294 (FH clone) and Khari (*S. barberi*) in which smut infected was noticed last year and subsequently hot water cum fungicide treatment was done and planted, established well and appeared healthy throughout the crop season.

Monitoring of insect pests

(P. Mahesh)

Among the pests, internode borer, pink borer, root borer, termite, pyrilla, woolly aphid and leaf mite were observed to occur at various levels and their natural incidence has been recorded on selected clones. In addition to these, mealy bug, leaf folder and leaf miner incidence was noticed in a few clones at negligible levels. The incidence of internode borer in *Saccharum* sp was recorded. The infestation in *S. officinarum* was relatively more compared to the other collection. The mean per cent incidence of internode borer varied from 10-30% in this species. The parasitoid *Cotesia flavipes* was released against internode borer. The extent of pink borer dead hearts ranged 5-15%. Thirty clones were examined for the incidence of underground insect pests by destructive sampling. Of these, 11 clones were noticed with root borer tunnels. Application of fipronil 0.3% G @ 30 kg/ha and chlorantraniliprole 18.5% SC @ 1ml/2 lit of water was given as a prophylatic measure against the borer pests. Sugarcane leaf mite infestation was observed in almost the entire germplasm collection. Application of monocrotophos @ 2ml / lit of water was adopted to control the infestation. The population of pyrilla and its parasitoid occurrence was surveyed in the germplasm. The activity of the egg parasitoid *Tetrastichus pyrillae,* nymphal parasitoid *Dryinus pyrillae* and fungal pathogen *Hirsutella citriformis* was observed. A light trap was installed in the germplasm collection to catch adult insects. The trap catches included pink borer (3 adult/ day), INB (2 adult/ day), pyrilla (5 adult/ day), sorghum stem borer (2 adult/ day), rice leaf folder (5 adult/day), *Maruca vitriata* (4adult/ day), fruit sucking moth (2adult /day), hairy caterpillar (2 adult/day), rice horned caterpillar (1 adult/ day), white grub (*Popilla clara*) and other beetles (5 adult/day) and large number of insects not deemed to be crop pests.

In vitro conservation of germplasm

(K. Chandran, R. Arun Kumar and *M. Nisha)*

One hundred and twenty S. *officinarum* clones having poor crop stand in the field are multiplied *in-vitro* through shoot tip culture and maintained through sub culturing. Studies were initiated to understand the effect of antibiotics (rifampicin, tretracycline, cephotaxime and combination) to prevent saprophytic microorganism contamination. Nevertheless, the antibiotic treatment was not significant in preventing saprophytic contamination individually.

DNA fingerprinting

(K. Chandran and *M. Nisha)*

Fifty *S. officinarum* clones belonging to 24 genotypes and their 'sports' were genotyped using 40 SSR markers. Of that, 22 were polymorphic and SMC series primers found to be more efficient in detection polymorphism. Expressed sequence tags based primers are more efficient in trapping the genetic variation than enriched genomic sequence based and also unigene derived primers. The 40 SSR markers used amplified a total of 264 alleles, out of which 206 (95.37%) were polymorphic. Each marker produced a varied number of alleles ranging from 2 to 13, with an average of 7.5. Highest allele number of 13 was produced by markers NKS 17, NKS6 and SMC 597, whereas mSSCIR 53 produced the smallest number of alleles. Pair wise genetic similarity coefficients were calculated between the genotypes and 'sports' using Jacquards coefficient. Maximum similarity of 92% was observed among NG77-116 striped, NG77-116 non-striped. In most of the pairs the similarity was above 75%. However, two pairs showed similarity less than 50%. The least similarity was exhibited by 57 NG 67 N.STR & 57 NG 67 STR with 37%. Primers NKS2 (Fig. 111), SMC 334, mSSCIR 1 and SMC 278 produced maximum variation among the genotypes.

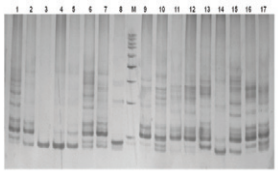


Fig. 111. PCR Amplification with primer NKS2:1-Pakaveli 2, 2-PAkaveli2str,3-Zwart Cheribon 4-Zwart Manila, 5-NC 24Dark purple, 6-NC 24,7-NC 32, 32Sport, 9-96NG 24A, 10-96NG 24, 11-28 NG 288, 12-28NG 288sport, 13-51NG 115, 14-51 NG 115G, 15-51 NG 115Str,16-51 NG 131, 17-51 NG 131sport.

5.8 ICAR-SBI RESEARCH CENTRE, AGALI

Enhancement of sugarcane germplasm and development of pre-breeding materials

Germplasm maintenance, hybridisation and off-season nursery

Germplasm maintenance: A total of 1,300 germplasm accessions including species clones of *Saccharum*, *Erianthus*, *Sclerostachya, Naranga*, *Miscanthus* and advance generation breeding materials were maintained in field through clonal propagation. Forty clones of *S. sponteneum* (collected from North East region of India) and four clones of *E. procerus*, one clone in each of *E. fulvus* and *Miscanthus* species were brought from ICAR-IARI, Wellington and planted at Agali Centre in August 2016. Forty-four *Erianthus arundinaceous* clones, which were affected by termites, drought etc were re-planted using fresh planting materials obtained from main institute.

Flowering behaviour of parental clones during 2016: Out of 1271 parental clones maintained at Agali, 623 clones flowered during 2016. The percentage of flowered clones was 53.2% which is 12% higher than the flowering intensity of previous year. None of the clones of *S. robustum* and *S. edule* flowered during this season whereas in case of *Erianthus bengalensis, E. elephantinus* and *E. procerus* all the clones flowered. Among the species clones, flowering intensity was low in *S. barberi* (6.1%). In the previous year (2015), flowering was not observed in *S. barberi* and *S. sinense*. However, in 2016 season, two clones of *S. barberi* namely, Pathri and Manjuria and six clones of *S. sinense* namely Kavengiri, Khadya, Khaki, Maneria IMP 1648, Uba seedling and Uba white flowered. In both the species, tip emergence was observed during second fortnight of October 2016. Flowering continued till first fortnight of November 2016. Out of 256 core collection of *S. officinarum,* 44 clones flowered in this year which was higher than previous year flowering intensity (20 clones in 2015). In *S. officinarum,* tip emergence was noticed on 7th October 2016 and

flowering continued till first fortnight of November 2016. The early flowering *S. officinarum* clones include Awela, IJ 76-315, IJ 76-316, NG 77-142, NG 77-154, Sinense, Sugar doctor, Tomohonzwart, 28 NG 288, 28 NG 39, 51 NG 036, 51 NG 197 and 51 NG 234. Flowering intensity in 'Co' and 'Co' allied clones were 67.1% and 84.6%, respectively. In this group, flowering symptom appeared from 2ndweek of September 2016. Spikelet opening commenced from 3rd week of September and lasted up to second fortnight of November. Flowering started on 23 September 2016. The early flowering 'Co' clones were Co 09021, Co 0409, Co 8335, Co 96002, Co 8311, Co 7424, Co 85006, Co 88013 and 'Co' allied clones were BO 32, BO 89, BO 96, BO 110, BO 130, BO 147, CoH 14, CoH 15, CoJ 46, CoJ 53, CoJ 73, CoJ 88, CoL 9, CoLk 7901, CoLK 8002, LG 94164, LG 05828 and CoS 07233.

Table 30. Flowering intensity of parental clones planted at Agali Centre

Species / Germplasm category	No of clones planted during Feb-Mar 2016	No of clones flowered during Sept-Dec 2016	Flowering intensity (% of flowered clones)
S. officinarum	256	44	17.2
S. sinense	21	6	28.6
S. barberi	33	2	6.1
S. robustum	17	0	0.0
S. edule	1	0	0.0
S. spontaneum	78	30	38.5
Erianthus arundinaceus	163	78	47.8
Erianthus bengalensis, E. elephantinus, E. procerus, E. ravennae	4 clones in each species	12	75.0
Narenga porphyrocoma, Neyraudia arundinacea and Sclerostachya fusca	2 clones in each species	6	100.0
Co canes	210	141	67.1
Co Allied clones	279	236	84.6
Exotic clones	65	33	50.8
ISH and IGH clones	69	57	82.6
Population improved *S. officinarum* (PIO)	38	31	81.6
Population improved S. *robustum* (PIR)	19	10	52.6
Total /Mean	**1271**	**676**	**53.2**

Hybridization and fluff supply: Out of 140 crosses made, 60 crosses were meant for the participating Centres of AICRP(S) programmes, 73 crosses for Agali Centre, 5 crosses for Karnal Centre and 2 crosses for Coimbatore. Besides, 86 crosses were made in the National Distant Hybridization Facility using marcotted clones. About 4.33 kg fluff was harvested which include crossed fluff of 2.52 kg and 1.81 kg GCs. Sugarcane breeders from 12 research stations in the country (Mandya, Padegaon, Perumalapalle, Pune, Sankeshwar, Thiruvalla, Vuyyuru, Kapurthala, Lucknow, Shajahanpur, Pantnagar and Bethuadahari) visited Agali Centre in 2016 and made 73 crosses. A total of 1.73 kg fluff was harvested and supplied to them. Crosses made for the on-going breeding programmes of Agali Centre mostly involved YLD free tropical x subtropical parents and species clones. About 26 biparental crosses involving YLD free clones were made. Seven crosses were made between Co, Co allied commercial varieties x *S. officinarum*. Six crosses were made between Co, Co allied commercial varieties x *S. sinense* and one cross was made between *S. barberi* x CoH 70. Six inter-specific crosses were made between *S. barberi* x *S. officinarum* (2 Nos), *S. sinense* x *S. officinarum* (2Nos) and *S. officinarum* x *S. spontaneum* (2 Nos). Three inter-generic crosses were made between *S. sinense* x *Erianthus bengalensis* (1 No), Co cane x *E. procerus* (1 No) and *S. officinarum* x *E. arundinaceus* (1 No).

Seedling selection: A total of 13,519 seedlings were produced in 2016 from the crosses involving YLD free clones, short duration clones and inter-specific crosses. The seedlings were transplanted in ground nursery during May-June 2016. From the ground nursery 253 elite clones were selected and planted in 1st clonal nursery during March 2017.

National off-season nursery: Provided support to ICAR-NRC for Banana, Tiruchirapalli for maintaining banana germplasm in 2.0 acres.

DUS testing of sugarcane

Second year DUS test for three new sugarcane varieties (Co 0403, Co 06027 and Co 06030) and two farmers varieties (Siddhgiri-1234 and Dhyaneshwar-16) were conducted during 2016-17. Eighty settlings from each new variety Co 0403, Co 06027 and Co 06030 were transplanted in main field on 21 March 2016. Eighty settlings of seven reference varieties namely, Co 86032, Co 85004, Co 94008, CoA 7602, CoA 90081, CoC 671, CoM 6806 were also transplanted in the same DUS testing plot. The field design was RBD with 2 replications. The plot size per entry was 4 rows x 6 m length x 0.9 m spacing. The number of plants per replication was kept as 40. Data on 27 morphological traits were recorded as per the DUS test guidelines issued by the PPV & FR Authority. The results of DUS test conducted at Agali Centre revealed that the new varieties Co 0403, Co 06027 and Co 06030 were distinct and different from the reference varieties. Each variety was uniform during the subsequent propagation and its essential characters were stable.

During 2015-16 season, DUS test for two farmers' varieties namely Siddhgiri-1234 and Dhyaneshwar-16 were conducted at Agali Centre and the report was sent to the PPV & FR Authority. However, for confirmation of DUS traits, the farmers varieties were replanted on 22 March 2016 and evaluation

continued during 2016-17 season as well. Observations recorded showed that the farmer's variety Shiddhgiri-1234 did not differ from the earlier released variety Co 92005 and Dhyaneshwar-16 did not differ from the variety Co 86032.

Maintenance breeding: A total of 189 sugarcane varieties was maintained in field at Agali Centre through clonal propagation as reference collection for conducting DUS test for tropical sugarcane varieties.

6. EDUCATION AND TRAINING

6.1 EDUCATION - M.Phil. / Ph.D. PPROGRAMME

Bharathiyar University: The Institute has been recognized by Bharathiyar University, Tiruchirappalli to conduct M.Phil. / Ph.D. programme in the disciplines of Biotechnology, Botany, Zoology, Agricultural Chemistry, Agricultural Entomology and Plant Pathology.

Bharathidasan University: The Institute has also been recognized by Bharathidasan University, Tiruchirappalli to conduct Ph.D. programme in the discipline of Biotechnology. One student in Biotechnology has been enrolled for Ph.D.

Ph.D. awarded: Ph.D. degree was awarded to Mrs. Punnya Raj by Bharathiar University for the thesis entitled 'Molecular characterization of *Saccharum* species and related genera' under the guidance of Dr. N.V. Nair, Director (Retd.), ICAR- Sugarcane Breeding Institute.

M.Sc. (Sugarcane Technology) course in Open and Distance Learning mode is being conducted in collaboration with Tamil Nadu Agricultural University, Coimbatore. Two batches of students, 26 in their II semester and 18 in their fourth semester are undergoing the course.

6.2 TRAINING PROGRAMMES ORGANIZED

At Coimbatore

- Training was organized to 19 Skilled Support Staff of the Institute on 'Basic official work flow and rules and regulations' during 5-6 April 2016, 12-13 April 2016 and 21-22 April 2016.
- Five national level training programmes on 'Scientific sugarcane cultivation' were organized during July-September 2016 for cane development personnel from the states of Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Uttar Pradesh, Puducherry, Uttarakhand, Bihar, Punjab and Gujarat.
- Three two-days capacity building programmes were conducted for sugarcane farmers from eight districts of Tamil Nadu in April 2016.
- Three one-day training programs on 'Sugarcane agriculture' were organized were organized for farmers / cane officials.
- A total of 101 UG / PG students were provided with exposure training and 21 UG/PG students carried their research project work at the institute.

Fig. 112. Participants of training programme (11 - 16 July 2016)

At Karnal

Training for Cane Development Inspectors: Six days training was organized for 32 cane development inspectors of Uttar Pradesh sponsored by Lal Bahadur Shastri Ganna Kisan Sansthan, Lucknow during 11-16 July 2016 (Fig. 112) . Dr. Bakshi Ram, Director, ICAR-SBI, Coimbatore inaugurated the training program and gave the Presidential Address. During valedictory function, Mr. Satender Singh, Deputy Cane Commissioner, Saharanpur Region, Uttar Pradesh and Dr. RoshanLal, Cane Advisor, Haryana Sugarfed, Panchkula

were present and distributed certificates to the participants. A Hindi training manual '*Ganna Krishiki Navintam Prodhyoki'* was released.

Training for farmers: A six days training program was organized for 20 farmers of Uttar Pradesh sponsored by Lal Bahadur Shastri Ganna Kisan Sansthan, Lucknow during 16-21 January 2017 (Fig. 113). Dr. Bakshi Ram, Director, ICAR-SBI, Coimbatore inaugurated the training program and released a Hindi training manual on *'New teaching for sugarcane cultivation*'. During the Valedictory Function, Mr. Chander Parkash Kathuria was the Chief Guest and Chairman, Haryana Sugarfed, Panchkula distributed certificates to the participants.

Apprenticeship training: Miss Renu was imparted apprenticeship training as Secretarial Assistant under Skill India Mission of Government of India from 20 September 2016 to 19 March 2017.

Fig.113. Participants of training programme (16-21 January 2017)

- On-farm training on 'Importance of healthy seed in sugarcane' was organized in village Dabkauli on 09 December 2016.
- Seed crop monitoring and advice to farmers in Muzaffarnagar district, of Uttar Pradesh on 16 December 2016.
- More than 200 farmers from Punjab, Haryana and Uttar Pradesh states visited Karnal centre and learnt about different varieties suitable for North West Zone and management of pest and diseases affecting sugarcane.

6.3 INTERNATIONAL VISIT

- Dr. R. Viswanathan, Principal Scientist & Head i/c, Division of Crop Protection attended the 29th Congress of the International Society of Sugar Cane Technologists (ISSCT) held at Chiang Mai, Thailand during 5-8 December 2016.

6.4 TRAINING AND CAPACITY BUILDING

Programme	Participants(s)
Professional Attachment Training at IASRI, New Delhi during 11 April 2016 to 14 May 2016	Shri. T. Lakshmi Pathy Shri. H.K. Mahadevaswamy
Professional Attachment Training at CRIDA, Hyderabad during 11 April 2016 to 14 May 2016	Dr. V. Krishnapriya
Professional Attachment Training at NRCPB, New Delhi during 11 April 2016 to 14 May 2016	Smt. V. Vinu
Professional Attachment Training at Directorate of Weed Research, Jabalpur during 11 April 2016 to 14 May 2016	Dr. S. Anusha
Awareness Workshop on Guidelines for access to biological resources under the Biological Diversity Act, 2002 at Bengaluru on 28 July 2016	Dr. A. Ramesh Sundar
A Solar energy applications in agriculture at ICAR-Central Arid Zone Research Institute, Jodhpur during 14-23 September 2016	Dr. T. Arumuganathan
Cyber Security at ICAR-Indian Agricultural Statistics Research Institute, New Delhi during 28 September 2016 to 5 October 2016	Smt. D. Subhadra

High-throughput phenotyping techniques for studying root system architecture at ICAR-Indian Agricultural Research Institute, New Delhi during 30 December 2016 to 10 January 2017	Dr. V. Krishnapriya
Analysis of experimental data organized by National Academy of Agricultural Research Management, Hyderabad during 20-25 February 2017	Mr. R. Raja
Physiological and molecular aspects of improving crop adaptation to drought at University of Agricultural Sciences, GKVK, Bengaluru during 27 February 2017 to 11 March 2017	Dr. R. Arun Kumar
Winter school on Advanced statistical techniques in genetics and genomics at ICAR-Indian Agricultural Statistics Research Institute, New Delhi during 2-22 March 2017	Mr. T. Lakshmi Pathy

7. AWARDS / RECOGNITIONS

Fig. 114. Dr. Bakshi Ram, Director, ICAR-SBI being felicitated by Chairman, Global Canesugar Services Pvt. Ltd. New Delhi

Fig. 115. Dr. Bakshi Ram, Director, ICAR-SBI being felicitated by the Director, National Sugar Institute, Kanpur

Fig. 116. Dr. Bakshi Ram, Director, ICAR-SBI receiving the award from Smt. Pratibha Patil, ex-President of India

- Dr. Bakshi Ram, Director, ICAR-SBI was conferred the 'Best Innovator of the Year-2016 (Agriculture) Award' by North Indian Sugarcane and Sugar Technologists Association (NISSTA) during the first NISSTA Annual Convention held at ICAR-IISR, Lucknow during 29-30 June 2016. The Agricultural Production Commissioner, Government of Uttar Pradesh gave away the award.
- Dr. Bakshi Ram, Director, ICAR-SBI was felicitated in recognition of the immense contribution to the Indian Sugar Industry by way of development of high yielding and high sugared varieties by Dr. G.S.C. Rao, Chairman, Global Canesugar Services Pvt. Ltd. New Delhi on 9 July 2016 (Fig. 114).
- Dr. Bakshi Ram, Director, ICAR-SBI was felicitated in recognition of the contribution to the Indian Sugar Industry by way of development of high yielding and high sugared variety Co 0238 by the Director, National Sugar Institute, Kanpur on 9 July 2016 (Fig. 115).
- Dr. Bakshi Ram, Director, ICAR-SBI received the Award of Excellence for his professional excellence and outstanding contribution in the development of sugarcane agriculture by STAI at New Delhi on 28 July 2016 (Fig.116). Her Excellency Smt. Pratibha Devi Singh Patil, ex-President of India gave away the award.
- Dr. R. Viswanathan, Head i/c, Division of Crop Protection received NAAS Fellow on the occasion of NAAS Foundation Day on 5 June 2016.
- ICAR has awarded Jawaharlal Nehru Award for Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences (2015) to Dr. C. Chinnaraja, for his Ph.D. thesis on 'Molecular characterization of sugarcane yellow leaf virus causing yellow leaf in sugarcane and its impact on crop growth and yield' under the supervision of Dr. R. Viswanathan, Head i/c, Division of Crop Protection.
- Dr. R.Viswanathan, Head i/c, Division of Crop Protection has been nominated to International Society of Sugarcane Technologists

Fig. 117. Dr. V.P. Sobhakumari receiving Silver Medal Award

Fig. 118. Dr. Bakshi Ram receiving the Cashless ICAR Institute Award from Shri Radha Mohan Singh, Hon' ble Minister of Agriculture, Co-operation and Farmers Welfare, GoI

(ISSCT) Plant Pathology Committee as Member for the period 2016-2019.

- Drs. G. Hemaprabha, S. Alarmelu and R.M. Shanthi received STAI Silver Medal for the best research paper in the Agricultural Session for 2015. The award was presented in the 74th Annual Convention of Sugar Technologists Association of India held at New Delhi during 28-30 July 2016.
- Drs. G. Hemaprabha , K. Mohanraj, Sarath Padmanbhan, S. Vasantha, C. Appunu and Bakshi Ram received the best poster award for the poster on 'Genetic improvement for drought tolerance in sugarcane through breeding and gene identification' in the International Conference and Exhibition on Sugarcane Value Chain- Vision 2025 Sugar, conducted at VSI, Pune during 13-16 November 2016.
- Dr. V.P. Sobhakumari received the Silver Medal Award (2016) for the best paper entitled 'Tissue culture induced variation: A strategy for sugarcane improvement' among the papers published in SISSTA Sugar Journal in the year 2015 (Fig.117).
- ICAR-SBI Coimbatore was conferred with the "Cashless ICAR Institute Award" during the inaugural session of the Directors' Conference on 14 February 2017. The certificate and cash award of Rs. 3.00 lakhs was received by Dr. Bakshi Ram, Director from Shri Radha Mohan Singh, Hon'ble Minister of Agriculture, Cooperation and Farmers Welfare, Government of India (Fig. 118)
- Dr. Bakshi Ram was felicitated by Dhampur Sugar Mills group for his contribution in evolving 12 sugarcane varieties and specially Co 0238 at Dhampur on 21 March 2017. A folk song (Ragni) on excellence of Co 0238 and his contributions was also released during the felicitation function.

8. LINKAGES AND COLLABORATIONS IN INDIA INCLUDING EXTERNALLY FUNDED PROJECTS

The Institute has established linkages with ICAR Institutes like IARI, NBPGR, NRCPB, NBAIR, IISR, Sugarcane Research Centres (24 Nos.) of SAUs under AICRP, International Centre for Genetic Engineering and Biotechnology (ICGEB), Ministry of Consumer Affairs, Food and Public Distribution, Ministry of Agriculture, GoI, Ministry of Food Processing Industries, DST, DBT/GoI, Directorate of Sugarcane Development, MoA/GoI, TNPL (a Govt. of Tamil Nadu Undertaking), MSSRF, Chennai and sugar industies in critical areas of emerging technologies for deriving maximum benefit.

Project title and scientist involved	Source of funding	Total outlay (Rs. in lakhs)
Climate resilience in sugarcane agriculture: metabolic and molecular response to high temperature (R. Gomathi)	DST (SERB)	10.80
Identification and characterization of proteinase inhibitors influencing resistance against shoot borer, *Chilo infuscatellus* (Snellen) and internode borer, *Chilo sacchariphagus indicus* (Kapur) (Lepidoptera: Crambidae) in sugarcane (M. Punithavalli)	DST (SERB)	10.80
Evaluation of MIDAS on yield and quality of sugarcane (S. Vasantha and D. P. Prathap)	Contract Research	17.85
Evaluating the effect of Sea6- Biostimulant formulations on the quality and yield of sugarcane (R. Gomathi)	Contract Research	5.88
Evalation of customised fertilizers on nutrient uptake, growth, yield and quality of sugarcane under field condition (C. Palaniswami, A. Bhaskaran and A. Vennila)	Contract Research	6.48
National level training for implementation of sugarcane development programme under NFSM (Commercial crops) (T. Rajula Shanthy)	DAC, MoA	2.00
Tribal Sub Plan - Phase II (T. Rajula Shanthy, C. Jayabose, A. Bhaskaran and T. Arumuganathan)	Min. of Tribal Affairs	27.00
Farmer support programme for sustainable sugarcane production in India (T. Rajula Shanthy)	SOLIDARIDAD	17.50
Developing *e-ganna* mobile app for sugarcane: An initiative towards digital India (T. Rajula Shanthy, S. Alarmelu, C. Jayabose, P. Malathi and T. Arumuganathan)	ICAR Extramural	17.75
Pyramiding of transcriptional factor and ROS candidate genes for improved drought tolerance in sugarcane (C. Appunu)	ICAR Extramural	45.00
An application of drone with satellite data for precision agriculture monitoring and yield production with drone assisted surveillance and diagnosis for biotic and abiotic stresses in sugarcane (T. Arumuganathan, A. Bhaskaran and P. Malathi)	ICAR Extramural	41.31
Innovative training module for development of sugarcane farm leaders (SFL) for up-scaling sugarcane production and protection technologies in Tamil Nadu (V. Venkatasubramanian, P. Murali, D. Puthira Prathap and T. Rajula Shanthy)	NABARD	4.07

Sugarcane seed production: Mega seed project- seed production in agricultural crops and fisheries-sugarcane (A.J. Prabakaran, N. Rajendra Prasad, D. D. Neelamathi and C. Karthikeyan)	MoA/GoI	53.45
Development of hand held instrument for on-field fibre content measurement in sugarcane (P. Govindaraj, K. Hari, Ravindra Naik and Nachiket Kotwaliwale)	DST	8.35
Isolation and functional characterization of low temperature tolerance responsive genes from high cold tolerant *Saccharum spontaneum* Arunachal Pradesh collection (Dr. C. Appunu)	DST	22.40
Genetic engineering of sugarcane for water deficit stress tolerance (C. Appunu and M.N. Premachandran)	DBT	54.52
Developing new technologies for processing sugarcane juice (K. Hari, K. Sivaraman and T. Arumuganathan)	MFPI	37.40
Characterization of virus suppressor proteins in RNA viruses infecting sugarcane and developing transgenic sugarcane lines resistance to SCSMV and SCYLV through RNAi approach (R. Viswanathan, P. Malathi, K. Lakshmi and B. Parameswari)	DBT	64.23
Outreach project on *Phytophthora, Fusarium* and *Ralstonia* diseases of horticultural and field crops – sugarcane wilt (R. Viswanathan, P. Malathi, A. Ramesh Sundar, R. Selvakumar, M.L. Chhabra and B. Parameswari)	ICAR	19.49
Evaluation of Imidacloprid 40% + Fipronil 40% + 80 WG (RM) against early shoot borer and termites in sugarcane (S.K. Pandey)	M/s Bayer Crop Science Ltd	8.47
DNA finger printing of *Saccharum officinarum* using simple sequence repeat markers (M. Nisha and K. Chandran)	DST (SERB)	12.00
Strengthening of designated fielfdand laboratory for DUS testing (Coimbatore, Karnal and Agali) (R. Karuppaiyan)	MoA/GoI	72.26
Digital inclution of rural youth for sustainable development : A comparative assessment (D.P. Prathap, P. Murali and V. Venkatasubramanian)	RGNIYD	3.95

9. ALL INDIA COORDINATED RESEARCH PROJECT ON SUGARCANE

The All India Coordinated Research Project on Sugarcane was started in the year 1971. A National Hybridization Garden was established in the Institute to facilitate the national breeding programmes. The Institute is guiding and monitoring the crop. The following are the research areas under this project:

- ◊ Fluff supply to various sugarcane research Institutes / centres.
- ◊ Evaluation of 'Co' canes for different sugarcane growing regions and acting as the coordinating unit for the identification of 'Co' and other Co- regional selections.To gather information on general and specific combining ability of biparental crosses.
- ◊ Collaboration for development of national varieties.
- ◊ Collaborative research on agronomy, soil science, physiology, entomology and pathology.

Dr. Bakshi Ram, Director is the Principal Investigator of Crop Improvement and Dr. R. Viswanathan, Head i/c, Division of Crop Protection is the Principal Investigator of Pathology.

VARIETAL DEVELOPMENT - SCHEMATIC DIAGRAM

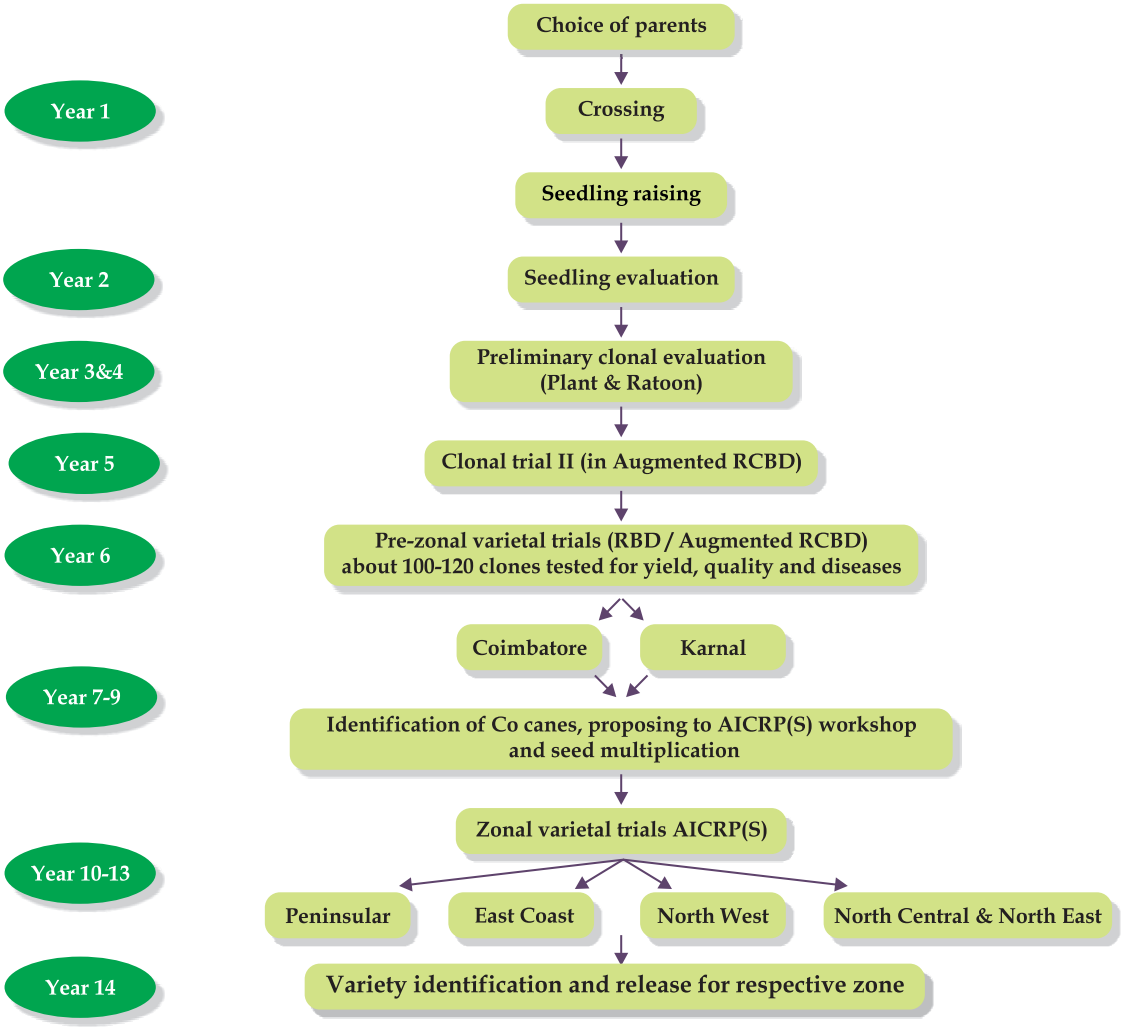


Fig. 119. Varietal development – Schematic Diagram

10. PUBLICATIONS

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11. RESEARCH PROJECTS

1. Breeding superior sugarcane varieties of different maturity with improved cane yield, quality and resistance to biotic and abiotic stresses
2. Enhancement of sugarcane germplasm and development of pre-breeding material
3. Sugarcane genomics and molecular markers
4. Gene discovery and genetic transformation in sugarcane
5. Development of cropping systems and improved agronomic practices to enhance sugarcane productivity
6. Enhancing physiological efficiency of sugarcane
7. Natural resource management for enhancing productivity and sustainable sugarcane production
8. Host resistance, interactomics, pathogen variability, diagnosis and disease management in sugarcane
9. Studies on sugarcane pests and their management
10. Basic and applied studies of sugarcane phytonematodes and entomopathogenic nematodes
11. Economic and statistical studies in sugarcane and sugar production system
12. Transfer of sugarcane technologies
13. Standardization of true seed production technique through developing homozygous parental lines and apomixes
14. All India Coordinated Research Project (Sugarcane)

12. CONSULTANCY, PATENTS, COMMERCIALIZATION OF TECHNOLOGIES

'Sugarcane sett treatment device' technology developed jointly by ICAR-SBI, Coimbatore and ICAR-CIAE-RC, Coimbatore was licensed to M/s CLEANTEK, Coimbatore on 26 August 2016.

13. EVENTS

Particulars	Dates
Institute Research Council meeting	09-13 & 24 May 2016
Tribal Farmers meet at Kuzhiyur village	3 June 2016
International Yoga Day	21 June 2016
Yoga sessions for the Institute staff	21-24 June 2016
National Kisan Mela	26-27 August 2016
Institute Foundation Day	24 October 2016
XXV Meeting of ICAR- Regional Committee No VIIII	11-12 November 2016
National Science Day	28 February 2017
Women's Day	11 March 2017

National level 'Kisan Mela' at ICAR-SBI

Fig. 120. Inauguration of Kisan Mela by Dr. K. Ramaswamy, Vice Chancellor, TNAU

ICAR - SBI has organized a two days National Level Kisan Mela during 26-27 August 2016 at Coimbatore (Fig. 120-127). The main theme of the event was to increase the sugarcane productivity and reduce the cost of cultivation through technological interventions. Dr. K. Ramasamy, Vice-Chancellor, Tamil Nadu Agricultural University, Coimbatore inaugurated the Kisan Mela on 26 August 2016. Dr. M. Manickam, Managing Director, Sakthi Sugars Ltd. was the Chief Guest of the Valedictory Function on 27 August 2016. ICAR-Central Institute of Agricultural Engineering Research Centre, Coimbatore, ICAR-Central Institute of Cotton Research - Research Centre, Coimbatore, ICAR-National Research Centre for Banana, Tiruchirapalli, ICAR-Indian Institute of Horticultural Research, Bengaluru, ICAR-Indian Institute of Spices Research, Kozhikode, ICAR-Indian Institute for Soil and Water Conservation Research Centre, Udhagamandalam and Tamil Nadu Agricultural University, Coimbatore also participated in the Kisan Mela. The following events were organised during the Kisan Mela:

Fig. 121. View of stalls in the exhibition

Live Demonstrations:

- National Hybridization Garden
- Effect of pre-emergence spray of weedicide
- Water saving technologies
- Soil sampling
- Implements for mechanization of sugarcane cultivation
- Sugarcane trash management
- Sugarcane varieties

Fig. 122. Field demonstration of machineries to farmers

Exhibition: An exhibition consisting of 36 stalls was organized. Of these, 11 stalls were of Government organisations and 25 stalls were of private firms dealing with agricultural inputs, machinery, drip irrigation etc.

Seminars: Seminars on all aspects of sugarcane cultivation and interactive sessions were organized in the meeting hall on both the days. This served as a platform to get feedback from farmers about the performance of released technologies and researchable issues were identified.

Fig. 123. Release of book on 'Sugarcane Technologies'

Fig. 124. Interactive Seminar in progress

Fig. 125. Honouring 'Best Sugarcane Farmer'

Fig. 126. Interactive Session with Awardee farmers

Fig. 127. Valedictory Address by Dr. M. Manickam

Video shows : Video films on different sugarcane technologies were continuously played in a separate hall for the benefits of farmers.

Release of extension materials:

- Sugarcane cultivation – An introduction (Tamil) – Distributed free to all farmers
- Sugarcane cultivation (Tamil) – Priced: Rs. 130.00
- Handbook on Sugarcane (English) – Priced: Rs. 130.00
- Sugarcane Technologies (English) – Priced: Rs. 220.00
- Video DVD: Integrated disease management (Tamil, Hindi & English)
- Video DVD: Integrated pest management (Tamil, Hindi & English)
- Video DVD: New sugarcane varieties (Tamil, Hindi & English)
- Video DVD: Seed production in sugarcane (Tamil, Hindi & English)
- Video DVD: Integrated nutrient management (Tamil, Hindi & English)

Transfer of Technology: Manufacturing rights of the Sett Treatment Device, developed by the Institute in collaboration of ICAR-CIAE, Research Centre, Coimbatore, were transferred M/s Cleantek, Coimbatore.

Felicitation of Best Farmers: On the basis of nominations from Cane/Sugar, Commissioners of different sugarcane growing states, 14 farmers from 8 states (Bihar, Haryana, Karnataka, Madhya Pradesh, Punjab, Tamil Nadu, Telangana and Uttar Pradesh) were felicitated as Best Farmers for their contribution to the sugarcane cultivation in their respective states.

- Shri Sachin Singh, Katsikari village, West Champaran, Bihar
- Shri Chandrasekhar Pandey, Bhairoganj, West Champaran, Bihar
- Shri Sumer Mohan Chand, S/o Shri Sadhu Ram, Panjokhra, Karnal, Haryana
- Shri Gian Ghai, Kachhwa village, Karnal, Haryana
- Shri Kallappa Timmappa Sarwad, Chanal village, Mudhal Taluk, Bagalkot, Karnataka
- Shri Chandrasekar Tiwari, Village Migali, Gotegaon, Narsinghpur, Madhya Pradesh
- Shri Vimlesh Dubey, Village Kartaj, District Narsinghpur, Madhya Pradesh
- Shri Baldev Singh, S/o Shri Milkha Singh, Village Sarangdev, Amritsar, Punjab
- Shri Harwinder Singh, S/o Shri Sukhdev Singh, Village Bhadalwad, Sangrur, Punjab
- Shri B. Jayapal, Village: Vaiyapurigoundan Pudur, Seyur, Avinashi Taluk, Tirupur, Tamil Nadu
- Shri R. Natarajan, S/o Shri Ramana Gounder, Padimari Kadu, Perundurai, Erode, tamil Nadu
- Shri Ajay Rajendra Wadiyar, S/o Shri S.R. Wadiyar, Bodhan, Telengana

Fig. 128 . Participants of the training programme

- Shri Brahampal Singh, Village Balapur, Bijnor, Uttar Pradesh
- Shri Abdul Haadi Khan, S/o Shri Abdul Bari Khan, Bakhriya, Sitapur, Uttar Pradesh

An interactive meeting among the above farmers and scientists, chaired by Dr. Bakshi Ram, Director, ICAR-SBI, Coimbatore, was organized on 27 August 2016 to discuss about the new techniques adopted by each farmer and the problems faced by them in their respective states. Solutions to the problems faced by farmers were offered during the meeting.

SHORT COURSE

An ICAR-sponsored Short Course on 'Techniques in insect molecular biology and toxicology' was organized at the institute during 7-16 September 2016 (Fig. 128). Out of 25 participants, 21 belonged to the discipline of Agricultural Entomology, two from Zoology with specialization in Entomology and one each from Nematology and Sericulture. During the Inaugural Session of the Short Course held on 7 September 2016, Dr. Bakshi Ram, Director, ICAR-SBI delivered the Presidential Address and Dr. K. Ramaraju, Director, Centre for Plant Protection Studies, TNAU delivered the Inaugural Address. A total of 21 lectures and 16 practical classes were held during this 10 days training programme. DNA barcoding for insects, BOLD (Barcode of Life Database), pesticide residue analysis in HPLC, LCMS and GC with ECD/FPD/MS, theory and practice of insecticide resistance, isolation of *Bacillus thuringiensis* strains from soil were among the important topics covered during this training programme. Exposure visits were arranged to NABL-Accredited Pesticide Toxicology Laboratory of TNAU and Insect Molecular Biology Laboratory at Centre for Plant Molecular Biology and Biotechnology, TNAU, Coimbatore.

Fig. 129. Smt Chitra conducting the Hindi Workshop

Fig. 130. Dr. Ganesan conducting the Hindi Workshop

HINDI WORKSHOP

Quarterly Hindi Workshops were conducted on 4 April 2016 and 20 July 2016, wherein Smt Chitra Krishnamoorthy, Assistant Professor, Shri Narayana Guru College of Arts and Science, Coimbatore was the Chief Guest and she spoke on Noting and drafting in Hindi (Fig. 129). Three Hindi workshops were organized during 15 September 2016, 14 December 2016 and 14 February 2017, wherein Dr. Ganesan, Assistant Professor, Shri Nehru College of Arts and Science was the Chief Guest and he spoke on Noting and drafting in Hindi and Use of Hindi language in everyday life (Fig. 130).

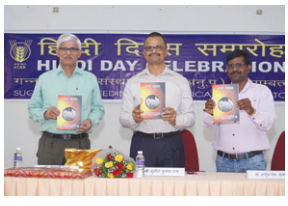

Fig. 131. Release of 'Ganna Prakash' during Hindi Day celebration

HINDI DAY

Hindi day was celebrated on 21 September 2016. Shri Sunit Kumar Roy, Deputy Inspector General (Police) was the Chief Guest of the celebration. Various competitions were conducted and the winners were awarded. A Hindi magazine 'Ganna Prakash' was release during the Hindi Day by the Chief Guest (Fig. 131).

Fig. 132. Hon'ble Minister for Agriculture, Puducherry inaugurating the Regional Committee meeting

At Karnal

- The third quarterly staff meeting of *Rajbasha Hindi* was held at ICAR-SBI, Regional Centre, Karnal on 19 July 2016 and 22 March 2017.
- Hindi Pakhwara was organized during 14-29 September 2016 and different competitions were conducted. Dr. A.K. Srivastava, Director

& Vice Chancellor, ICAR- NDRI, Karnal was the Chief Guest of the Valedictory Function and distributed prizes and certificates to the participants.

Fig. 133. Dr. Mohapatra, DG, ICAR honouring Shri R. Kamalakannan, Hon'ble Minister for Agriculture

Fig. 134. Dr. Bakshi Ram, Director, ICAR-SBI giving the Welcome Address

Fig. 135. Dr. Mohapatra, DG, ICAR addressing the gathering

Fig. 136. Release of publications during the Regional committee meeting

Fig. 137. Meeting in progress

ICAR REGIONAL COMMITTEE MEETING No. VIII

The 25th meeting of ICAR Regional Committee No. VIII was held during 11-12 November 2016 at Tamil Nadu Agricultural University, Coimbatore under the Chairmanship of Dr. T. Mohapatra, Secretary (DARE) & Director General (ICAR), New Delhi (Fig. 132-137).

Hon'ble Minister for Agriculture, Government of Puducherry, Shri R. Kamalakannan, inaugurated the meeting by lighting the traditional lamp. Dr. A.K. Singh, DDG (Agricultural Extension) welcomed the august gathering. In his welcome address, the DDG elucidated the purpose and importance of the Regional Committee meetings. The Agricultural scenario in the Region VIII was also briefed by the DDG. He also indicated that the problems faced by the farmers of the region and the challenges before the research organizations and other line departments would be discussed during the two days meeting and action points would be delineated.

Dr K. Ramasamy, Vice Chancellor of Tamil Nadu Agricultural University highlighted that the agricultural lands were shrinking and industries were competing for land, water and labours. He emphasized the need for conserving rain water and rejuvenating the vegetative cover. Technologies like raising seedlings in trays could reduce the crop duration in field and thereby irrigation water. He called upon the institutions to invest on young talents to sustain agricultural production. He emphasized the need to utilize the native resources and pave the way for a second green revolution.

Dr. T. Mohapatra, Secretary (DARE) & Director General (ICAR), New Delhi in his Presidential Address invited the institutions of the region to deliberate, identify the problems, define ways and means of addressing them and provide solutions to move forward. He appreciated the Universities for imparting quality education and producing the best students. He insisted that the Institutes should generate 25% of the resources and called for an integrated approach. He said that those who were interested in farming should be trained at school stage and their skills should be developed. Creating entrepreneurial opportunities in agricultural sector would support the unemployed for which institutes should come out with technologies covering complete package including value chain as in the case of banana. He urged the Universities to come out with matching outcomes and develop entrepreneurs.

He reiterated that with the availability of diverse institutions in the region, there was tremendous scope to develop and disseminate technologies for diversification of agriculture, horticulture, fisheries and animal husbandry, value addition and marketing and thereby increasing the income. He emphasized that value addition to agricultural products was a must to address the nutritional security. He concluded his address by informing that the format of discussion in the meeting was changed to discuss the problems and come

out with solutions for each problem. He emphasized the Institutes in the region to concentrate more on the problems put forth by the State Departments and provide them with meaningful solutions.

A publication on Technology Inventories by the UAS, Dharwad, and 31 farmer friendly publications by Karnataka Veterinary and Animal Sciences University were released by the Hon'ble Minister for Agriculture, Government of Puducherry.

Fig. 138. Dr. Bakshi Ram, Director, ICAR-SBI discussing with tribal people of Kuzhiyur tribal village

In his Inaugural Address, Hon'ble Minister for Agriculture, Government of Puducherry, Shri R. Kamalakannan praised TNAU for its invaluable contributions for more than 110 years towards agricultural development in this area. He lauded the contributions of ICAR-SBI in terms of more than 2980 sugarcane varieties during the past 104 years of its existence. He said that in spite of Puducherry being awarded the best performer in agriculture among small states, shrinking agricultural land was the major concern. He highlighted some of the issues concerning agriculture in Puducherry. The ground water was dwindling and hence, ICAR should concentrate its research on improving the water productivity. Stress tolerant varieties should be developed for all the crops. A technology package for crop diversification to augment farmers' income during water stress situations was needed. He insisted that a reliable weather forecasting system to pinpoint the locations rather than the quantum of rainfall was needed. He further emphasized on a dedicated extension system to address the queries of the farmers with right information at right time and expected help of ICAR in revamping the Extension system in Puducherry. He also opined that providing entrepreneurial opportunities in term of agricultural machineries and infrastructure would help to retain youth in agriculture. The focus should be on post-harvest and value addition technologies, credit and warehousing facilities. Also to retain farmers in agriculture, the Hon'ble Minister insisted that the insurance scheme should be subsidized and extended to all the farmers irrespective of the risk factors involved which might be price and weather linked.

Fig. 139. Dr. Bakshi Ram, Director, ICAR-SBI distributing tractor and other accessories to Kuzhiyur tribal villagers

TRIBAL SUB PLAN

Under the Tribal Sub Plan being implemented in the institute since 2015, a 'Tribal Farmers Meet' was organized in Kuzhiyur, one of the beneficiary villages on 3 June 2016. Kuzhiyur is a tribal village in Karamadai division with 81 acres of land under cultivation. Based on the discussions held with the Tribal Head and other tribal people in the village and transect analysis, various technological interventions were agreed upon and implemented. As a means of livelihood and to fulfill their felt need, we had given to the villagers a four-wheel drive mini tractor, trailer, tiller, cultivator, battery operated sprayers and induction stoves to the tribal villagers (Fig. 138-140). Dr. Bakshi Ram also looked at the functioning of sewing machines and flour mill supplied earlier by the institute.

Fig. 140. Demonstration of power weeder in Kuzhiyur village

Under tribal sub plan, 250 coconut saplings and 200 lemon air layering plants were distributed to Kuzhiyur village on 5 July 2016.

MERA GAON MERA GAURAV

Sixteen teams comprising four scientists had identified 80 villages (Coimbatore - 65, Karnal - 10 and Kannur - 5) for adoption. Baseline surveys were conducted to collect information on the demographic details, description of farming situation, major crops grown, cropping pattern, infrastructural facilities available, problems in agriculture and organizations working in the village. Preliminary analysis indicated that the major crops in Coimbatore district were coconut, banana, paddy, pulses, vegetables, turmeric, onion and arecanut. Major problems were drought, non-availability of inputs in time, poor marketability of the produce, high cost and unavailability of labour and livestock health issues. Wheat, paddy and sugarcane were the major crops grown in Karnal district whereas paddy, coconut and banana were the major crops grown in Kannur district. Regular visits were made to the adopted villages and technical guidance was provided to the farmers for improving their livelihood.

Fig. 141. 'Cleanliness Drive' at Vellamari tribal village on 23 May 2016

Regular group meetings were organized in the adopted villages. In a farm women self-help group of 19 members of Idigarai village in Sarkar Samakkulam block in Coimbatore, an informal discussion on various issues in taking up sugarcane farming was held and extension literature on 'Using Soil Moisture Indicators' and 'Drought management' was distributed.

Fig. 142. Cleanliness Drive in Kuzhiyur tribal village on 3 June 2016

At Karnal

Under MGMG program, the farmers of adopted villages were provided with extension support especially with respect to varietal spread and sugarcane production technology as mentioned below:

Fig. 143. Cleaning of water bodies at SBIRC, Kannur

- ◊ Visited Breeder seed crop of varieties Co 0238, Co 0118 and Co 05011 in the fields of Mr. Sumer Mohan Verma of adopted village Budhanpuron 23 July 2016 and suggested control measures for Pokkahboeng disease.
- ◊ Organized a farmer meeting at village Navipur on 01 August 2016.
- ◊ Visited village Dabkauli on 09 December 2016 and advised farmers about importance of healthy seed in sugarcane.
- ◊ A 'Kisan Goshti' was arranged at MGMG village Kachwa on 20 January 2017 and appraised the farmers about intercropping with sugarcane and importance of healthy seed.
- ◊ Visited the village Jadoli, Kranal on 28 March 2017 and advised the farmers about control of insect pests and diseases.

SWACHCHH BHARAT ABHIYAN

Cleanliness campaigns were conducted at the Institute and the residential quarters among the employees and the residents. Campaigns were also conducted in the adopted tribal villages viz., Kuzhiyur and Vellamari among the tribal people. The participants were made to realize the importance of clean surroundings, collection and segregation of household and office wastes as bio-degradable, non-degradable, recyclable and toxic wastes. In each campaign, all the participants were involved in cleaning the pathways and surroundings, collection and segregation of wastes.

Fig. 144. Cleanliness campaign on 'Solid waste management'

Fig. 145. Cleanliness Drive including Parthenium removal in the institute

Fig. 146. Shri Jagadesh Pattur addressing the gathering

Fig. 147. Dr. Bakshi Ram, Director, ICAR-SBI felicitating Dr. Narendra Singh

Fig. 148. RAC meeting in progress

Swacchta Pledge was taken by the institute staff on 13 May 2016. As a part of the Swachchh Bharat programme being implemented in the institute, a 'Cleanliness Drive was organized at Vellamari tribal village (adopted village under Tribal Sub Plan) on 23 May 2016. Scientists from the institute along with the tribal villagers cleaned the entire village removed the weeds, mainly Parthenium and inculcated the importance of cleanliness among the tribal villagers. (Fig. 141). Another Cleanliness Campaign was launched in Kuzhiyur tribal village by Dr. Bakshi Ram, Director, ICAR-SBI on 3 June 2016 (Fig. 142).

At ICAR-SBI Research Centre, Kannur, cleaning of the channels was done on 23 June 2016 (Fig. 143).

Conducted a campaign on Solid waste management in the institute premises with the participation of the residents in the campus on 08 July 2016 (Fig. 144). Efforts are on to prepare Vermicompost from kitchen waste collected from the residential quarters and canteens, and farm wastes from the campus.

Conducted a 'Cleanliness drive' at the institute involving all the staff of the institute. The institute building and the premises were cleaned (Fig. 145).

At Karnal

- Observed 'Parthenium Awareness Week' during 16-22 August 2016 and uprooted Parthenium in and around the Institute.
- Conducted 'Cleanliness Campaigns' on the occasion of 'Gandhi Jayantih', the 2nd October 2016.

FOUNDATION DAY

ICAR- Sugarcane Breeding Institute foundation day was celebrated on 24 October 2016. Felicitation of Retired scientist and presentation of Sir T. S. Venkatraman Awards took place during the function. Shri. Jagadesh Pattur, M/s. Eco Foundation, USA was the Chief Guest (Fig. 146 -147)

14. COMMITTEES

Research Advisory Committee Meeting

The 22nd Research Advisory Committee meeting of ICAR Sugarcane Breeding Institute, Coimbatore for the year 2015 was held at Coimbatore on 9 September 2016 (Fig. 148 - 150). Dr. P.L. Gautam, Former Chairman, Protection of Plant Varieties and Farmers Rights Act / National Biodiversity Authority, Government of India and presently, Vice Chancellor, Career Point University, Hamirpur, Himachal Pradesh and Chairman, RAC of the Institute presided over the meeting. The members present included Dr. V.P. Singh, Former Director of Research, RAU, Bihar; Dr. J. Vasantha Kumar, Registrar In charge and Dean, Faculty of Agriculture and Professor, Department of Agricultural Extension, Annamalai University, Chidambaram; Dr. H.E. Shashidhar, Professor, Dept. of Biotechnology, University of Agricultural Sciences, Bangalore; Dr. M.S. Palaniswami, Thiruvananthapuram; Dr. Bakshi Ram, Director, ICAR SBI; Dr. R. Viswanathan, Member Secretary, RAC. Apart from them, non-official

Fig. 149. RAC team visiting experimental fields

Fig. 150. Release of a pamphlet on Organic Farming during RAC

members, Dr. M. Manickam, Executive Vice Chairman, Sakthi Sugars, Coimbatore and Shri ShivajiRao Deshmukh, Director General, VSI, Pune also participated in the meeting. The achievements during the period were presented by the Heads of Divisions / Sections and the RAC appreciated the work done.

Institute Research Council meeting

The Institute Research Council meeting was conducted during 9-13 and 24 May 2016 under the chairmanship of Dr. Bakshi Ram, Director, ICAR-SBI. The progress of the ongoing projects was reviewed, suggestions were offered and new projects were implemented for implementation in the ensuing year.

15. SCIENTIFIC PARTICIPATION

Title	Date	Participant(s)
Site Selection Committee meeting for establishing KVKs at Tirupur and Villupuram in Tamil Nadu held at ATARI, Bangalore	19 April 2016	Dr. Bakshi Ram
Interface Meeting between ICAR and VSI, Pune on development of drought tolerant GM sugarcane varieties	25 April 2016	Dr. Bakshi Ram
Meeting of QRT, AICRP on Sugarcane at IISR, Lucknow	25 April 2016	Drs. N. Kulshreshtha Dr. S.K. Pandey Dr. M.L. Chhabra
IMC meeting with members of QRT, AICRP on Sugarcane at IISR, Lucknow	27 April 2016	Dr. N. Kulshreshtha
1st Annual Convention of North Indian Sugarcane and Sugar Technologists Association (NISSTA) held at ICAR-IISR, Lucknow as Guest of Honour and chaired the session on Discussions on Innovations/Technology Providers	29-30 April 2016	Dr. Bakshi Ram
Farmers' Fair and Pradhan Mantri Fasal Beema Yojana at Shri Avinashilingam KVK	7 May 2016	Dr. T. Rajula Shanthy
Group Meeting of the All India Coordinated Research Project on Biological control of crop pests at Visakhapatnam	17-18 May 2016	Dr. J. Srikanth
Meeting of Indo-German Bilateral Workshop organized by PPVFRA at NASC Complex, New Delhi	23-24 May 2016	Dr. N. Kulshreshtha
Germplasm Evaluation Committee meeting at CSSRI Karnal	27 May 2016	Dr. N. Kulshreshtha
Farmers Meet organized at Avinashilingam KVK	6 June 2016	Dr. T. Rajula Shanthy

Meeting of Standing Committee of time and cost overrun at New Delhi	21 June 2016	Dr. Bakshi Ram
UNIQUEST Research Commercialization workshop at Customs House Brisbane, St Lucia, Australia	28-29 June 2016	Dr. K. Lakshmi
Meeting of Department of Agriculture, Cooperation and Farmers' Welfare and gave a presentation on the details of the Soil Moisture Indicator	28 June 2016	Dr. Bakshi Ram
Scientific Advisory Committee meeting of KVK, Papparappatty, Dharmapuri	29 June 2016	Dr. T. Rajula Shanthy
Workshop on Take it to Breeders and Researchers- the Plant Breeders and Researchers Rights through awareness and mainstreaming of Farmers' Varieties organized by the PPVFRA, New Delhi	30 June 2016	Dr. Bakshi Ram
Meeting of Board of studies in Biotechnology to focus on academic programme in tissue culture at Hindustan College, Coimbatore	02 July 2016	Dr. A. Suganya
Conference on Innovations in Agricultural Mechanization organized by Department of Agriculture Cooperation and Farmers' Welfare in Vigyan Bhawan and gave a presentation on Soil Moisture Indicator	8 July 2016	Dr. Bakshi Ram
International Symposium organized by National Sugar Institute, Kanpur and delivered a lecture on 'Energy canes as emerging bio-economy for the sugar sector'	9 July 2016	Dr. Bakshi Ram
46th Annual Convention of South Indian Sugar and xSugarcane & Technologists' Association (SISSTA) held at Chennai	15-16 July 2016	Dr. Bakshi Ram Dr. C. Sankaranarayanan
Annual Convention of STAI at New Delhi and delivered the S.N. Gundurao Memorial Lecture on 'Sugarcane agriculture in India – Current scenario and prospects'	28 July 2016	Dr. Bakshi Ram
One-day Awareness Workshop on Guidelines for access to Biological resources under the Biological Diversity Act, 2002 at Bangalore	28 July 2016	Dr. A. Ramesh Sundar
Sugar Technologists Association of India (STAI), 74th Annual Convention held at New Delhi	28-30 July 2016	Dr. Bakshi Ram Dr. R. Viswanathan Dr. S. Alarmelu Dr. G. Hemaprabha Dr. K. Hari Dr. C. Sankaranarayanan
2nd National conference on 'Agricultural Science in Tamil' at Coimbatore, Tamil Nadu	5-6 August 2016	Dr. P. Geetha
5th Task Force committee on 'Basic plant biology, agriculture & frontier areas' organized by Department of Biotechnology at New Delhi	11 August 2016	Dr. A. Ramesh Sundar
Germplasm Registration Committee Meeting at NBPGR, New Delhi	17 August 2016	Dr. Bakshi Ram

Delivered Inaugural Address in 'Scientia' on 'Research Organizations in India' at PSGR Krishnammal School for women, Coimbatore	23 August 2016	Dr. A. Suganya
AICRP(S) monitoring team of the AICRP (S) trials of North Central and North Eastern Zone	31 August to 09 September 2016	Dr. M.L. Chhabra
XXXV meeting of Plant Germplasm Registration Committee at NBPGR, New Delhi	1 September 2016	Dr. Bakshi Ram
AICRP(S) monitoring team of the AICRP (S) trials of North West Zone	08 -16 September 2016	Dr. Ravinder Kumar
17th meeting of Sugarcane R&D workers of Northern Karnataka at Belagavi	16-17 September 2016	Dr. Bakshi Ram Dr. R. Viswanathan Dr. G. Hemaprabha Dr. J. Srikanth Dr. D. Neelamathi Dr. D. Puthira Prathap Dr. A. Bhaskaran
4th Annual South Asia Biosafety Conference organized by Biotech. Consortium Limited at Hyderabad	19-21 September 2016	Dr. A. Ramesh Sundar
Next Gen Genomics, Biology, Bioinformatics and Technologies (NGBT) Conference at Cochin, Kerala	3-5 October 2016	Dr. C. Appunu Dr.A. Ramesh Sundar
SISMA-TN & ICAR-SBI Interactive Meeting	7 October 2016	Dr. Bakshi Ram Dr. R. Viswanathan Dr. G. Hemaprabha Dr. C. Palaniswami Dr. T. Rajula Shanthy Dr. C. Appunu Dr. A. Bhaskaran Dr. T. Arumuganathan
Farmers- Scientist interactive workshop at ICAR- IIWBR, Karnal	7 October 2016	Dr. M.R. Meena
47th Meeting of Sugarcane Research & Development Workers of Tamil Nadu & Puducherry at Dhanalakshmi Srinivasan Hotels, Perambalur	14-15 October 2016	Dr. Bakshi Ram Dr. G. Hemaprabha Dr. J. Srikanth Dr. A.J. Prabakaran Dr. D. Neelamathi Dr. D. Puthira Prathap Dr. A. Bhaskaran Dr. T. Arumuganathan
Varietal Identification Committee Meeting at VSI, Pune	16 October 2016	Dr. Bakshi Ram
Farmers- Scientist interactive workshop	17 October 2016	Dr. M. R.Meena Dr. Pooja Dr. Vishal Goel
National level seminar on Genetic transformation-A research perspective'' at GRD College, Coimbatore	20 October 2016	Dr. A. Suganya

Delivered Shri G. Narasimha Rao Memorial Lecture entitled Improved varieties and technologies for sustainable sugarcane cultivation in Andhra Pradesh at Acharya N. G. Ranga Agricultural University at Tirupathi	20 October 2016	Dr. Bakshi Ram
One day training/workshop for the Nodal Officers, RTI, at NAARM, Hyderabad organized by DOPT, GOI	25 October 2016	Dr. A. Ramesh Sundar
One day interactive meeting with progressive farmers and cane officials from various sugar factories of Tamil Nadu held at Coimbatore	3 November 2016	Dr. Bakshi Ram Dr. G. Hemaprabha Dr. R. Viswanathan Dr. A. Bhaskaran Dr. C. Appunu Dr. D. Puthira Pratap Dr. K. Mohanraj
10th International Conference on Controlled atmosphere and fumigation in stored products at ICAR-IARI, New Delhi	6-11 November 2016	Dr. T. Arumuganathan
XXV Meeting of ICAR-Regional Committee No. VIII held at TNAU, Coimbatore	11-12 November 2016	Dr. Bakshi Ram Dr. A. Bhaskaran
International Conference on Climate change and its implication on crop production and food security at Banaras Hindu University, Varanasi	12-13 November 2016	Dr. Pooja
International Conference on Sugarcane Value Chain-Vision 2025 organised by Vasantdada Sugar Institute, Pune	13-16 November 2016	Dr. Bakshi Ram Dr. R. Viswanathan Dr. N. Kulshreshtha Dr. G. Hemaprabha Dr. R.M. Shanthi Dr. K.P. Salin Dr. S. K. Pandey Dr. T. Rajula Shanthy Dr. A. Annadurai Dr. P. Govindaraj Dr. A.S. Tayade Dr. A. Anna Durai Dr. Ravinder Kumar Dr. M.L. Chhabra
31st Biennial workshop of All India Coordinated Research Project (Sugarcane) held at VSI, Pune	16-17 November 2016	Dr. Bakshi Ram Dr. R. Viswanathan Dr. N. Kulshreshtha Dr. G. Hemaprabha Dr. R.M. Shanthi Dr. K.P. Salin Dr. S. K. Pandey Dr. A. Annadurai Dr. P. Govindaraj Dr. A.S. Tayade Dr. A. Anna Durai Dr. Ravinder Kumar Dr. M.L. Chhabra

Fourth International Agronomy Congress on Agronomy for sustainable management of natural resources, environment, energy and livelihood security to achieve zero hunger challenge held at IARI, New Delhi	22-26 November 2016	Dr. A.S. Tayade Dr. P. Geetha Dr. S. Anusha
International Conference on Open and distance learning for sustainable development in agriculture at TNAU, Coimbatore	24-25 November 2016	Dr. T. Rajula Shanthy
International Symposium on biological sciences - Genomics &bioinformatics held at United Arab Emirates University, Al Ain, United Arab Emirates	23-25 November 2016	Dr. R. Manimekalai
Northern Regional Agricultural Fair organized by the ICAR- IIFSR, Modipuram at Muzaffarnagar, Uttar Pradesh	28-30 November 2016	Dr. N. Kulshreshtha Dr. S. K. Pandey Dr. M. L. Chhabra Dr. Ravinder Kumar Dr. M.R. Meena Dr. B. Parameswari
Indo-German Bilateral Cooperation Workshop on Seed sector development held at NASC, New Delhi.	29-30 November 2016	Dr. Bakshi Ram
CAFT training programme on Advance computational and statistical tools for omics data analysis at ICAR-IASRI, New Delhi	1-21 December 2016	Dr. R. Selvakumar
Biotechnological and conventional tools for biotic and abiotic stresses management in sugarcane at ICAR–SBI, Coimbatore	7-27 December 2016	Dr. V. Vinu Dr. H.K. Mahadeswamy Dr. T. Lakshmipathi
3rd International Symposium on Coconut research and development at ICAR-CPCRI, Kasaragod	10-12 December 2016	Dr. T. Arumuganathan
National Conference on Innovative and current advances in agricultural and allied sciences at PJTSAU, Hyderabad	10-11 December 2016	Dr. M. R. Meena
Meeting of the Sub-Committee for grant-in-aid under Sugar Development Fund (SDF) to research projects held at Krishi Bhawan	14 December 2016	Dr. Bakshi Ram
International Seminar on New Frontiers in Cytogenetics and XIII Conference of the Society of Cytologists and Geneticists organized by Department of Botany, University of Kerala	15-17 December 2016	Dr. G. Hemaprabha Dr. V.P. Sobhakumari
Academic council meeting of Central University Tamil Nadu	16 December 2016	Dr. A. Suganya
Inaugural session of the National Symposium on Challenges, opportunities and innovative approaches in sugarcane: Agriculture, bio-energy and climate change as a Special Guest at UP Council of Sugarcane Research, Shahjahanpur	21 December 2016	Dr. Bakshi Ram
Emergent BOD meeting of Punjab Sugarfed at Mohali, Punjab	21 December 2016	Dr. N. Kulshreshtha
Indian Science Congress at Tirupathi, Andhra Pradesh	3-7 January 2017	Dr. C. Appunu

One day workshop to the Field staff and officers of TAS Ltd Thirumandangudi	13 January 2017	Dr. A. Bhaskaran
Review meeting of ICAR-Extramural projects at NASC Complex, New Delhi	23 January 2017	Dr. T. Arumuganathan
Breeders meeting of three Zones held at IISR, Lucknow	23 January 2017	Dr. Bakshi Ram
IMC meeting of IIWBR, Karnal	23 January 2017	Dr. N. Kulshreshtha
'Kisan Gosthi' organized by HARCOFED at Kaithal Cooperative Sugar mills, Kaithal	31 January 2017	Dr. S.K. Pandey Dr. Ravinder Kumar
Fifth National Conference on Biological control: Integrating recent advances in pest and disease management at NBAIR, Bengaluru	09-11 February 2017	Dr. M. Punithavalli
Brainstorming Session on Role of plant breeding and genetics in meeting sustainable goals organized by Indian Society of Genetics and Plant Breeding at IARI, New Delhi	11 February 2017	Dr. Bakshi Ram
Workshop on Competency enhancement programme for effective implementation of training functions for HRD Nodal officers of ICAR at NAARM, Hyderabad	13-15 February 2017	Dr. K. Hari
District level Scientists-Extension Workers-Farmers KVK Interface Meet	14 February 2017	Dr. T. Rajula Shanthy
Director's Conference	14-15 February 2017	Dr. Bakshi Ram
National Symposium on Advances in agriculture through sustainable technologies and holistic approaches at Goa	15-17 February 2017	Dr. T. Arumuganathan
International conference on Technological advancement for sustainable agriculture and rural development	20-22 February 2017	Dr. B. Parameswari
Interdrought–V International Conference at Hyderabad	21-25 February 2017	Dr. K. Mohanraj Dr. C. Appunu
11th DUS Review Meeting held at Raipur, Chhattisgarh	26-28 February 2017	Dr. S. Alarmelu Dr. R. Karuppaiyan
Rabi Kisan Mela at ICAR- CSSRI, Karnal	08 March 2017	Dr. S.K. Pandey Dr. M.L. Chhabra Dr. B. Parameswari Dr. Pooja
National Agriculture Fair 'Krishi Unnati Mela' at ICAR-IARI, New Delhi	15-17 March 2017	Dr. Neeraj Kulshreshtha Dr. M.L. Chhabra Dr. Ravinder Kumar Dr. B. Parameswari Dr. M.R. Meena
National Symposium on Sugarcane Mechanization Challenges and Opportunities at Shri Bannari Amman Institute of Technology	17-18 March 2017	Dr. Bakshi Ram Dr. R. Viswanathan Dr. T. Rajula Shanthy Dr. P. Malathi Dr. P. Murali Dr. T. Arumuganathan

Meeting of Board of studies in Biotechnology to focus on academic programme in tissue culture at GRD college and Hindustan College, Coimbatore	18 March 2017	Dr. A. Suganya
Varietal Identification Committee Meeting at New Delhi	20 March 2017	Dr. Bakshi Ram
'Kisan Sahkarsam melan' organized by HARCOFED at Rohtak Sugar mill	22 March 2017	Dr. Neeraj Kulshreshtha Dr. S.K. Pandey Dr. Ravinder Kumar
178th TNAU Board held at Tuticorin	25 March 2017	Dr. Bakshi Ram
State wise Coordination Committee meeting, as convener, for doubling the farmers' income of Tamil Nadu state by March 2022 held at Chennai	27 March 2017	Dr. Bakshi Ram
All India student Research Convention organized by the Association of Indian Universities, New Delhi held at Annamalai University	27- 28 March 2017	Dr. A. Ramesh Sundar

16. DISTINGUISHED VISITORS

At Coimbatore

- ICAR- Sugarcane Breeding Institute foundation day was celebrated on 24 October 2016. Felicitation of Retired scientist and presentation of Sir T. S. Venkatraman Awards took place during the function. Shri. Jagadesh Pattur, M/s. Eco Foundation, USA was the Chief Guest.
- Shri. Sudarshan Bhagat, Hon'ble Union Minister of State for Agriculture and Farmers' Welfare visited ICAR-Sugarcane Breeding Institute, Coimbatore and inaugurated Pollen Collection Chamber and addressed the staff of the Institute on 20 January 2017.
- Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR visited the institute on 10 November 2016 and inaugurated the Estate Building (Fig. 151-152). Dr. A.K. Singh, DDG (Agricultural Extension) also accompanied the Director General (Fig.153).

At Karnal

- Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR visited the Centre on 14 April 2016. Dr. K. Srivastava, Director, NDRI, Karnal also accompanied with the DG during plantation of Ashoka tree (Fig. 154).
- Dr. J.S. Sandhu, DDG (Crop Science), ICAR visited the Centre and discussed with scientists about ongoing research activities on 25 May 2016 (Fig. 155).
- A delegation from Maharashtra State Cooperative Sugar Factories Federation Ltd., Mumbai (Shri Shivajirao N. Nagavade, Chairman, Vice Presidents, Shri. Sanjeev Babar, Managing Director), Dr. J.P. Singh, Chief Cane Advisor, National Federation of Coop. Sugar Factories Ltd, New Delhi and Dr. RoshanLal, Cane Advisor, Haryana Sugarfed, Panchkula visited the Centre on 15 June 2016 (Fig. 156). The delegation discussed with scientists about the short duration cane variety of the Centre suitable for Maharashtra state. Three sugarcane varieties viz., Co 0238, Co 0118 and Co 98014 were suggested for testing under Maharashtra conditions.

They also visited the farmer's field at village Kachhwa (Karnal) and appraised the performance of seed crop of variety Co 0238.

◊ Mr. Pramod Kumar Sharma, Deputy Director, Rajbhasha, Ministry of Home Affair, GOI, visited and observed on going Hindi activities of the Centre on 24 June 2017.

Fig. 151. Dr. T. Mohapatra addressing the staff of ICAR-SBI

Fig. 152. Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR inaugurating the Estate Building

Fig. 153. Dr. A.K. Singh, DDG (Agricultural Extension) addressing the gathering

Fig. 154. Dr Mohapatra planting tree sapling at ICAR-SBIRC, Karnal

Fig. 155. Dr. J.S. Sandhu, DDG (CS) discussing with Scientists at ICAR-SBIRC, Karnal

Fig. 156. Chairman and team observing Co varieties at Karnal Centre

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