वार्षिक प्रतिवेदन 2014 - 15

Annual Report

भा.कृ.अनु.प. - गन्ना प्रजनन संस्थान

कोयम्बत्तूर - 641 007

ICAR - Sugarcane Breeding Institute

(ISO 2001:2008 Institution)

Coimbatore - 641 007

ICAR-Sugarcane Breeding Institute
Coimbatore - 641 007, Tamil Nadu, India
Tel. No. : 0422 - 2472621
Fax No. : 0422 - 2472923
E-mail : info@sugarcane.res.in
Website : www.sugarcane.res.in

Correct citation
SBI Annual Report 2014 - 15
ICAR-Sugarcane Breeding Institute,
Coimbatore
Tamil Nadu, India

ISSN 0973-8177

Published by
Dr. Bakshi Ram
Director
ICAR-Sugarcane Breeding Institute
Coimbatore 641 007

Printed by
Udhayam Achagam
R.S. Puram, Coimbatore
Ph : 0422 - 2541551
E-mail : udhayamachagam@yahoo.com

Contents

Preface

ICAR-Sugarcane Breeding Institute, Coimbatore was founded in 1912 with the foremost objective of developing improved sugarcane varieties for the different agroclimatic regions of the country. Over a span of 103 years, the Institute had developed nearly 2930 'Co' canes which sustained the Indian sugar industry. At present, more than 95% of cane area in the country is occupied by 'Co' and allied varieties developed in collaboration with the Institute.

Recognizing the contributions made by the Institute, the Indian Council of Agricultural Research has bestowed the prestigious 'Sardar Patel Outstanding ICAR Institution Award 2013' among the larger Institutes. We deem it an honour to receive the award from the Hon'ble Prime Minister of India during the ICAR Foundation Day on 29 July 2014.

The sugarcane varietal scenario in the country needs to be improved. Still, the longstanding variety Co 86032 in tropical India and CoS 767 & CoSe 92423 in sub-tropical India are under cultivation. Many new varieties have been released for commercial cultivation in different agro-climatic zones of sugarcane in the country. In spite of that, the sugarcane varietal replacement rate is very slow. The variety CoS 8436 has succumbed to red rot disease and the area is on the decline in Punjab and Haryana. The Institute's Regional Centre at Karnal has identified Co 06034 (Karan 11) as a suitable replacement for CoS 8436 in the North Western Zone and its release proposal has been submitted to Central Varietal Release Committee. Thirty clones were selected during the Biennial Workshop of AICRP on Sugarcane held at Lucknow during November 2014 for testing in Peninsular zone (18), East Coast zone (10) and North Western zone (2). A total of 27 clones (22 from Coimbatore and 5 from Karnal) were selected as 'Co' clones from Final Clonal Trials.

SBI 2007-291, a red rot resistant and early high sugar hybrid with more than 18.0% sucrose at 8 months and 22.0% sucrose at 10 months with potential as a short duration variety was accepted for registration by the Plant Germplasm Registration Committee of ICAR and assigned the registration number INGR 14011. An intergeneric hybrid derivative with *E. arundinaceus* cytoplasm with high cane yield and sucrose % juice was assigned 'Co' number (Co 15015).

The test entry Co 11016 recorded the highest CCS yield among the early clones and CoM 11085, Co 11019, Co 11005 and Co 11007, among mid-late clones, had higher CCS yield than the standards in Initial Varietal Trials of the AICRP. In the Advanced Varietal Trial (Early) at Coimbatore, Co 09004 recorded the highest sugar yield, cane yield and sucrose % juice with tolerance to drought and salinity.

Twenty three participating centres of AICRP made nearly 550 crosses, polycrosses and selfs in the National Hybridization Garden facility at Coimbatore and 37.28 kg of fluff was supplied to the centres. World sugarcane germplasm collection comprising 3369 accessions at the Research Centre, Kannur; 1917 accessions at Coimbatore and 1600 clones at the Research Centre in Agali were maintained.

The Institute produced nearly 4840 quintals breeder seed of important varieties at Coimbatore and Karnal for supply to farmers and sugar factories. Besides, 31,000 tissue culture plants of Co 86032, Co 99006, Co 06030 and Co 0403 were supplied to sugar factories and progressive farmers.

The progress made in biotechnology research includes identification of *Erianthus* specific TRAP markers showing similarities with gene sequences

involved in stress responses, transgenic events with the incorporation of stress tolerance genes in the varieties Co 86032 and Co 0238 and mobilization of gene constructs with GLY I and II genes for salinity stress tolerance into *Agrobacterium* for genetic transformation into sugarcane.

On the crop production front, in ratoon crop, application of composted coir pith and dry trash in trenches and covering with soil resulted in 11% and 3% higher soil moisture, respectively than control. Trash mulching and *in-situ* incorporation also enhanced water use efficiency. Phosphorus and micronutrients spray up to 2.0% recorded 20-25% yield improvement in saline soil and in drought treatment, the nutrient spray improved cane yield by 26%. Micronutrient fertilization (Zn and Fe) gave 30.27% high average yield (96.31 t/ha) with differential varietal response. Application of S @ 200 kg/ha as gypsum and elemental sulphur + *Thiobacillus thiooxidans* culture gave on par yield of 124 t/ha, which was 28.5% higher than control (96.48 t/ha).

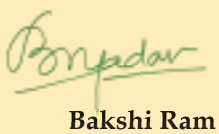
Impact studies of Yellow Leaf Disease (YLD) revealed decline in cane growth and cane yield; however, YLD-free seed nursery program was found to be successful. Differential interaction studies with 26 *C. falcatum* isolates on 26 varieties indicated that Cf94012 was the most virulent. Analysis of phytoalexin synthesis during host–pathogen interaction exhibited differential accumulation of phytoalexin compounds *viz*., luteolinidin, apigeninidin and cyanidin. Defense proteomics involving sugarcane smut pathogen indicated expression of candidate defense/stress responsive genes like phenylalanine ammonia lyase, L-Ascorbate peroxidase, Caeffoyl-CoA-methyl transferase etc. and were validated by quantitative RT-PCR.

*Cotesia flavipe*s continues to be the only larval parasitoid of internode borer with the highest activity (15.4%) during October 2014. Of the two egg parasitoids, namely *Telenomus* (dingus – group) and *Trichogramma* nr. *chilotraeae* recovered from the borer, the former was more predominant with high parasitism levels. *Beauveria bassiana* isolates NBAII 11, 23, 47, 58 and 61 were confirmed as endophytic to sugarcane. Screening of 143 Bt isolates for *cry* genes with primers of *cry1*, *cry6* and *cry8* revealed 112 to be putatively positive. Biochemical characterization of 10 symbiotic bacteria isolated from *G. mellonella* infested with entomopathogenic nematodes was carried out. Molecular characterization of symbiotic bacteria using primers specific for 16s rDNA and sequencing studies indicated that *Xenorhabdus* isolates had maximum similarity with *X. stockiae* and *Photorhabdus* had similarity with *P. luminescens* sub sp. *akhurstii*.

The outreach programs included 12 training programs, six frontline demonstrations at farmers' fields and participation of the Institute in ten exhibitions in Tamil Nadu, Haryana, Delhi and Uttar Pradesh. Survey based studies were conducted on technology dynamics of mechanical harvesting in sugarcane, technology mapping, constraint analysis and training need analysis in Tamil Nadu.

In order to break the cane yield and sucrose content plateau in sugarcane, many changes in sugarcane agriculture are envisaged. Requirement of large quantity of seed (~7 t/ha) is the important factor responsible for slow replacement and hence the continuation of old varieties of sugarcane. Research and extension efforts will be focused to reduce the seed requirement in the coming years. Emphasis will be on standardization of technique for commercial cultivation of sugarcane through raising settlings and transplanting, and development and cultivation of hybrids through true seed.

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 2014-15. 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 in time. Continuous encouragement and guidance received from Dr. S. Ayyappan, Secretary, DARE and the DG, ICAR, Dr. S.K. Dutta and Dr. J.S. Sandhu, previous and the present DDG (CS) and Dr. N. Gopalakrishnan, ADG (CC), ICAR are gratefully acknowledged.



Bakshi Ram
Director

2. INTRODUCING ICAR-SBI

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 2930 'Co' selections, many of them becoming popular as commercial varieties in different parts of the country. 'Co' canes bred at ICAR-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 31.03.2015

Category	Sanctioned	Filled	Vacant
Director	1	1	-
Scientific	78	66	12
Technical	73	69	4
Administrative	40	30	10
Supporting	79	62	17
Total	271	228	43

Financial Statement

Table 2. Abstract of expenditure during 2014-15

Head	Amount in Lakhs (Rs.)
Non-Plan	3089.58
Plan	321.99
Other Plan Schemes	18.64
Externally funded schemes	229.66
Total	3659.87

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).

Farm

The Institute has a total area of 80.09 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).

Library and documentation services

The Library provides information support to the research and development activities of the Institute. It has a collection of 11,937 books including bound volumes of journals, besides free publications such as annual reports, news letters, scientific and technical publications *etc*. received from Indian and foreign organizations.

Subscription was renewed / effected for 13 foreign journals and 15 Indian journals and 41 books. A photocopier machine and seven steel almirahs were purchased and the total amount spent was Rs.8,00,075.

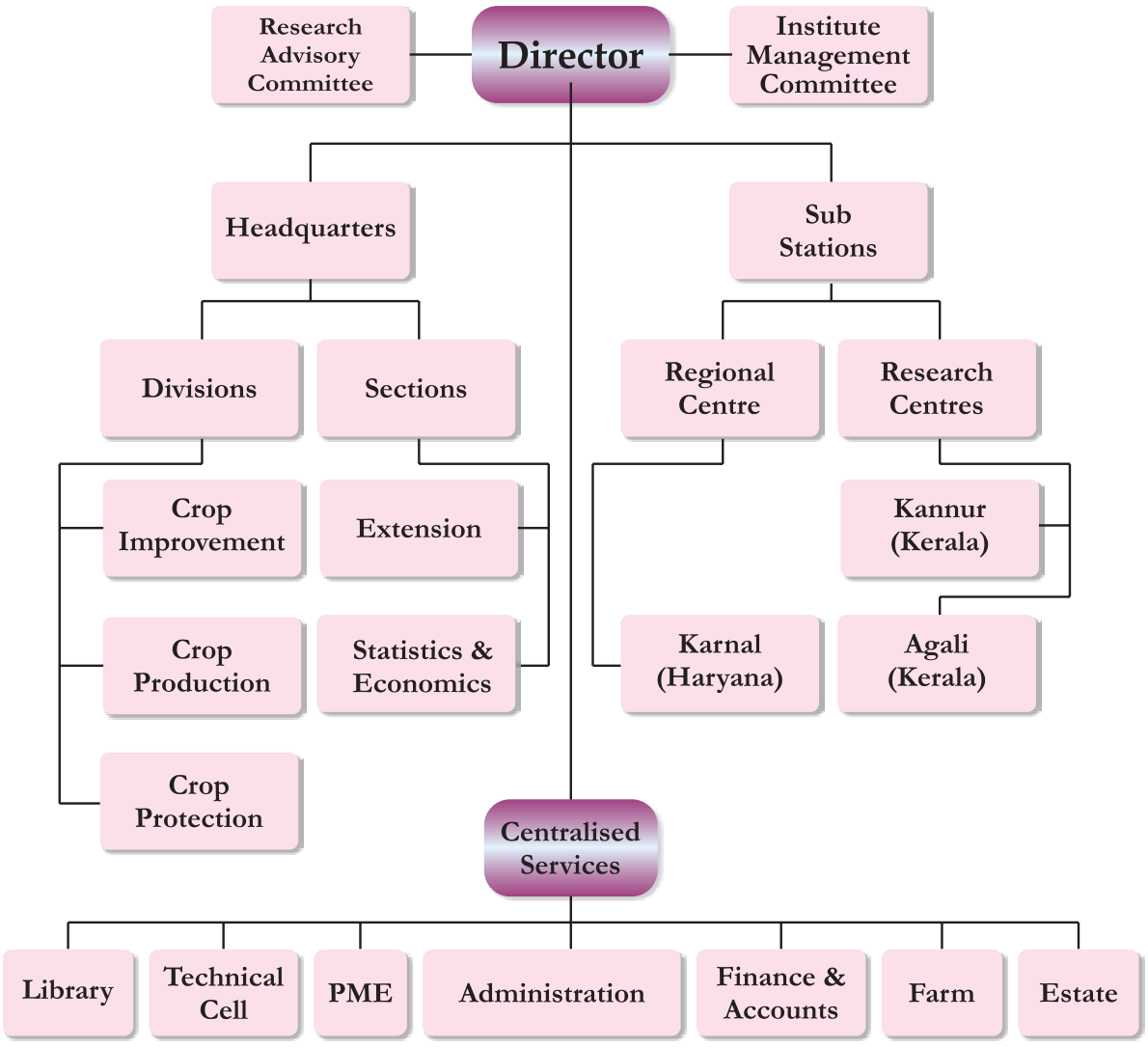


Fig.1. Organizational structure of ICAR-SBI

Weather data

Table 3. Weather data for the year 2014-15

Month	Temperature (^{0}C)		RH (%)		Wind velocity (km/h)	Open pan evaporation (mm/day)	Rainfall (mm)	No. of rainy days
	Maxi-mum	Mini-mum	Forenoon	After-noon				
April 2014	37.5	23.9	79	43	1.3	6.5	12.6	1
May	35.2	23.6	84	50	1.7	5.2	91.2	6
June	35.2	23.5	81	50	3.1	5.8	7.0	1
July	31.8	22.2	85	65	4.2	4.0	41.6	7
August	31.8	22.1	86	61	3.2	3.5	57.6	7
September	33.1	22.2	82	55	2.9	4.3	87.9	6
October	30.8	21.3	89	65	1.2	2.8	245.6	14
November	30.4	20.2	88	63	1.1	3.0	0.0	0
December	30.4	20.3	87	64	1.1	2.9	20.2	2
January 2015	31.5	18.8	86	59	1.3	3.9	0.0	0
February	33.6	18.5	85	50	1.5	4.8	0.0	0
March	35.7	22.6	84	46	1.7	5.7	0.0	0
Mean/ Total	33.1	21.6	85	56	2.0	4.4	563.7	44

The total rainfall received during the year was 563.7 mm while the sixty year (1930-1990) average rainfall is 674.2 mm. The mean maximum temperature was 33.1^{0}C, which was 1.6^{0}C higher than the sixty years average maximum temperature of 31.5^{0}C.

3. कार्यकारी सारांश

फसल सुधार

गन्ने की मध्यम देर से पकने वाली किस्म को. 06034 (करन 11) को उत्तर–पश्चिमी क्षेत्र के लिए पहचाना गया है। किस्म पहचान समिति के द्वारा अनुमोदन के बाद इसका प्रस्ताव केन्द्रीय प्रजाति प्रकाशन समिति को भेजा गया। नवम्बर 2014 में आयोजित गन्ने पर अखिल–भारतीय समन्वित अनुसंधान परियोजना की द्विवार्षिक कार्यशाला में प्रस्तावित 18 क्लोनों का प्रायद्विप क्षेत्र में परिक्षण के लिए चयन किया गया । 120 क्लोनों का मूल्यांकन कोयम्बत्तूर में किया गया । 22 सबसे उच्चतम कृन्तक को को. संख्या दी गयी । इनमें से सात क्लोन अगेती और 15 मध्यम देरी के है। क्लोन को. 15017 की अधिकतम उपज 148.1 टन/हैक्टेयर और अधिकतम चीनी की उपज 21.36 टन/हैक्टेयर है। क्षेत्रीय केन्द्र करनाल में 36 क्लोनों का मूल्यांकन अंतिम क्लोन परीक्षण में किया गया और पाँच क्लोनों को को. संख्या दी गयी।

कोयम्बत्तूर में 140 प्रायोगात्मक क्रास, 23 प्रुवन क्रास और 32 सामान्य संग्रह के 24300 पौध को वर्ष 2013 की जमीनी नर्सरी में प्रत्यारोपित किया गया है। वर्ष 2014 के पुष्पन मौसम के दौरान 163 क्रास को उष्णकटिबन्द्धीय क्षेत्र के लिए प्रजनन किस्मों के विकास पर परियोजना के तहत बनाए गए। 1165 क्लोनों के साथ पहला क्लोन परीक्षण किया गया जिसमें से 196 उच्चतम क्लोनों का चयन करके उसे द्वितीय परीक्षण में लगाया गया। एक दूसरे परीक्षण में 2804 कृन्तकों को गन्ने के बावक और पेडी फसल के अन्तर्गत परीक्षण में गन्ने की उपज और गन्ने के रस की गुणवत्ता को जाँचने के लिए मुल्यांकन किया गया । द्वितीय क्लोनल परीक्षण में 873 क्लोनों का चयन किया गया जिसमें को. म. 0265 x को. 99006 क्रास ने 36.5 सर्वोच्य चयन प्रतिशत दिया।

द्वितीय क्लोनल परीक्षण में 832 क्लोनों को आग्मेन्टिड डिजाइन में चार मानको के साथ लगाया गया। 46 क्लोनों में गन्ने के रस में सुक्रोज की मात्रा 330 दिनों में 20 प्रतिशत से ऊपर थी । गन्ने के लाल सडन रोग प्रतिरोधिता, उपज, गुणवत्ता और खेत में पौधों की संख्या के आधारों पर 80 क्लोनो को अतिंम क्लोनल परीक्षण में पदोन्त किया गया । विभिन्न प्रयोगों और परियोजना में से 172 अच्छे क्लोन का वर्ष 2016–17 के अतिंम क्लोनल परीक्षण में चयन करने हेतू उनके गुणन के लिए लगाया गया है।

आशावान क्लोनों का मुल्यांकन तमिलनाडू के शक्ति सुगर लिमिटेड अप्पकुडल और श्री अम्बिका सुगर लिमिटेड थुहीली के चीनी कारखानों के क्षेत्रों में किया गया। 24 क्लोनों का चयन अप्पकुडल और 12 क्लोनों का चयन थुहीली में करके आगे के चयन के लिए बड़े भूखँड परीक्षणों में लगाया गया ।

अखिल भारतीय समन्वित अनुसंधान परियोजना के अन्तर्गत प्रजाति परीक्षण में अगेती और मध्यम देरी वाले क्लोन को प्रायद्वीपीय क्षेत्र में परीक्षण के लिए कोयम्बत्तूर में 13 से 14 परीक्षण प्रवष्टियों की जाँच की गई। अगेती कृन्तकों में परीक्षण प्रवुष्टि को. 11016 की सी सी एस उपज सबसे ज्यादा दर्ज थी और को. म. 11085, को. 11019, को. 11005 और को. 11007 की सी सी एस उपज मानको के मुकाबले ज्यादा थी। कोयम्बत्तूर में उन्नत प्रजाति परीक्षण (ए वी टी) में को. 09004 किस्म की चीनी की उपज, गन्ने की उपज, रस में सुक्रोज की अधिकतम मात्रा दर्ज की । इसके साथ यह सुखे और लवणता के प्रति सहनशील थी।

अखिल भारतीय समन्वित अनुसंधान परियोजना के अंर्तगत राष्ट्रीय संकरण उद्यान के कार्यक्रम में भाग लेते हुए 23 क्षेत्रीय केन्द्रों द्वारा 454 स्टेशन क्रास, 56 प्रवुन क्रास, 21 पोली क्रास और 15 सेल्फ क्रास बनाए और 37.28 किलो ग्राम फलफ, अंकुरण परीक्षण के बाद, भाग लेने वाले केन्द्रों को भेजा दिया। क्रास को. जे 82315 x एस पी 80–185, को. शा. 96268 x को. 62198, को. 05011 x आई एस एच 176, को. 99006 x 85 आर 186 और 97 आर 401 x को. 775 इत्यादि का बहुत ही ज्यादा अकुँरण पाया गया है।

गन्ना प्रजनन संस्थान, क्षेत्रीय केन्द्र करनाल में को. 0118, को. 0124, को. 0237 को. 0238, को. 0239, को. 05011, को. 98014 और को. 05009 प्रजातियों का 3474 क्विंटल प्रजनक

बीज उत्पादन कर आपूर्ति की गई। कोयम्बत्तूर से को. 86032, को. 0403, को. 99004, को. 2001–13 और को. 2001–15 प्रजातियों का तीन स्तरीय बीज नर्सरी के लिए 1370 क्विंटल प्रजनक बीज उत्पादन कर आपूर्ति की गई।

गन्ने की को. 86032, को. 99006, को. 06030 और को. 0403 प्रजातियों के विभज्योतक संर्वधन के द्वारा 31000 से ज्यादा ऊतक संर्वधन पौधे की आपूर्ति तमिलनाडु, कर्नाटक, महाराष्ट्र और केरला के विभिन्न चीनी कारखानों और उन्नतशील किसानो को की गई। इसके अतिरिक्त 87 वायरस से मुक्त मातृक संर्वधन किस्मों जैसे को. 86032, को. 0403 और को. 06030 की उतक संर्वधन की प्रयोगशाला में आपूर्ति की गई।

छहः नये संभावित एनर्जी केन का अधिकतम जैव भार 233.65 टन/है और रेशे की मात्रा 27.4 प्रतिशत के साथ पहचाना गया। धर्मावरम आन्ध्रा प्रदेश में सुखे की अवस्था में इन एनर्जी केन्स का मुल्यांकन किया गया। इसमे चार क्लोनों की पहचान प्रकार 1 और तीन क्लोनों कि प्रकार 11 ऊर्जावान गन्ने के रूप में की गई।

तमिलनाडु में वर्ष 2012–14 के दौरान सी ए ई परीक्षण संचालित किया गया। जिसमें मध्यम देरी वाले क्लोन को. 0320 और को. 0209 में गन्ने की उपज और सी सी एस प्रतिशत कोयम्बत्तूर क्षेत्र में सबसे ज्यादा दर्ज की गई। वर्ष 2013–14 के दौरान को. 06015 उपज और गुणवत्ता के लिए कई स्थानों पर अच्छी पायी गयी। सेकेरम स्पोन्टेनियम या एरीएनथस अरूनडीनेसीयस साइटोप्लाजम संकर क्लोन का मुल्यांकन कोयम्बत्तूर और अगली में किया गया। उसमें से 9 क्लोनों का अतिंम क्लोन परीक्षण में अधिक उपज और सुक्रोज प्रतिशत के आधार पर चयन किया गया। ई. अरूनडीनेसीयस साइटोप्लाजम युक्त एक इटंरजैनरिक संकर को अधिक उपज और सुक्रोज प्रतिशत के आधार पर को. (को. 15015) संख्या दी गई। आर्वती चयन के द्वारा अधिक सुक्रोज वाला आनुवंशिक संग्रह विकासित करके उसका 300 दिनों के लिए रस में सुक्रोज की मात्रा का मुल्यांकन किया और उसमें 28 क्लोनों मे 22 प्रतिशत और आठ क्लोनों में 23 प्रतिशत से ज्यादा सुक्रोज मात्रा दर्ज की गई। दो क्लोन 05–0234 और 05–0257 की अधिक सुक्रोज और कम पुष्पन तीव्रता की क्षमता के साथ कम अवधि की किस्मों के रूप में फायदा उठाया गया। आर्वती चयन के द्वारा समूह में उपज और गुणवत्ता में सुधार पाया गया। जिसमे चौथे आर्वती संकरों में उपज के लिए काफी बदलाव दिखाई दिए। आर्वती चयन के चार चक्र में गन्ने के भार में पर्याप्त सुधार हुआ।

इक्कीस ऐरीएनथस विशेष टी आर ए पी मार्कस को अनुक्रमित किया गया जो फसल में तनाव संबधी जीन के साथ समानता को प्रर्दशित करते हैं, उनको ऐरीएनथस में मौजूदा तनाव संबधी गुण विशेषता को अन्तगार्मित करने संभावित उम्मीदवार जीन मार्कर्रों के तौर पर विकसित किया जा सकता है। प्रतिरोध जीन एनालोगस (आर जी ए) जो प्रतिरोधिता और संवेदनशीलता के साथ जुडे है उनका प्रतिरुपण और अनुक्रमण किया गया। जिसमें सें पॉच प्रतिरोधन विशिष्ट अनुक्रमण गन्ने के लाल सडन रोग प्रतिरोधिकता से संबधित और एक संवेदनशील विशिष्ट खंड संवेदनशीलता के साथ जुडें थे। सेकेरम स्पोन्टेनियम से 650 बी पी इनवरटेज अवरोध करने वाले जीन को प्रतिरुपित और अनुक्रमित किया गया। जो मक्का फसल में मौजूद जीया मेज इनवरटेज अवरोधन जीन के साथ 92 प्रतिशत तक अनुरुप देखा गया । उसका उपकोशिका स्थित स्थान एवं जिवों मे कार्य को जैव सूचना विज्ञान संसाधनों का प्रयोग करके इन सिलिकों में वर्णित किया गया। लिग्निन जैव संश्लेषण मार्ग मे शामिल कैफिक एसिड ओ मिथाइल ट्रासफरेज (सी ओ एम टी) जीन को सेकेरम आफिसिनेरम से प्रतिरुपित किया गया। और उसे इको आर I और हिन्द III निग्रह स्थान से रुपरेखित जीन विशिष्ट प्राइर्मस के साथ पूर्ण रुप से परिवर्तित किया गया। आगे उसे पी ई टी को प्रदर्शित करने वाले वाहक में उपप्रतिरुपित करके प्रोटिन्स प्रदर्शित विश्लेषण के लिए यथोचित बी. एल 21 मेजबान में रुपातरितं किया गया। फिनाईएलेलिन अमोनियम लाअेज (पी ए एल) जीन की प्रोटिन अनुरुपता को सरचंना डोमेन से अध्ययन की गयी। उसे प्रतिरुपित और वर्णित किया गया।

ट्रासजैनिक इवेंटस जो तनाव सहनशीलता इएडीआरइबी 2, इएएचएसपी 70, पीडीएच 45, और इएडीआरइबी 2 और पीडीएच 45 जीन के साथ है उन्हे गन्ने की को. 86032 किस्म में मृदा नमी की कमी की सहनशीलता के लिए चयनित किया गया। इनसे 18 आशाजनक इवेंटों को सूखा सहिष्णुता और

जलप्रयोजन कार्यक्षमता का अध्ययन करने के लिए चुना गया। पीडीएच 45 जीन को एग्रोबेक्टीरियम मध्यस्थ रुपातंरण से गन्ने की को. 0238 किस्म मे परिवर्तित किया गया। और इस इवेंट युक्त पौध को आगामी गुणन के लिए गमलो मे रोपित किया गया। लवणता सहिष्णु जीन जी एल वाई । और जी एल वाई ।। जीन्स के कन्सट्रक्ट जो अंतराष्ट्रीय आनुवंशिक अभियांत्रिकी जैव प्रोधोगिकी केन्द्र नई दिल्ली से लाए गए, उसे गन्ने के आनुवंशिक रुपांतरण के लिए एग्रोबेक्टीरियम मे इस्तेमाल किया गया। सेकेरम स्पोन्टेनियम कृन्तक आई एन डी 00–1307 से पूर्ण आर एन ए को पृथक किया गया जिसे ठँड सहिष्ण के रूप में पहचान गया और अतंरीय प्रदर्शित जीन्स को पहचाने हेतू उसका सी डी एन ए लायब्रेरी बनाया गया। सुक्रोज संश्लेषण और डबल्यु आर के वाई कुलों के जीन्स ट्रासक्रीप्ट एस एस आर र्माकर जो पोधे में विभिन्न शारीरिक क्रियाओं के नियमन में महत्वपूर्ण भूमिका अदा करते है को विकसित किया और 50 कृन्तक, जिसमें 19 प्रतिशत से ज्यादा सुक्रोज और डबल्यु आर के वाई ट्रान्सक्रिप्सन घटकों को अध्ययन के लिए पहचाना गया। गन्ने में सुक्रोज नियमन समस्त ट्रान्सक्रिप्टोम अनुक्रमन कार्य शुरू किया गया जिसमें सेकेरम आफिस्नेरम, सेकेरम स्पॉन्टेनियम और व्यवसायिक संकर कृन्तकों के पूर्ण आर.एन.ए. से रिर्वस ट्रान्सक्रीब कामपिलिमेन्टरी डी एन ए और सी डी एन ए सांचों को अनुठे ट्रान्सक्रिप्ट के लिए विश्लेषित किया गया। गन्ने के क्रोमोसोम के सेन्ट्रोमियर भाग से सी इ एन एच 3 जीन को पहचाना गया और प्रतिरूपित किया गया जिसे इन्टेरजेनेरिक संकरों में संभावित क्रोमोसोम उन्मुलन संबन्धी एलीलेक के बदलाव के अध्ययन में काम लाया जा सकता है। अनुक्रमन अध्ययन में उसने क्रमशः 96 और 91 प्रतिशत अनुरूपता ज्वार सी इ एन एच 3 और मक्का सी इ एन एच 3 सिक्वेन्स के साथ दिखाई दिए। संकर को. 7201 x (28 एन जी 210 x आई के 76–78) के पैतृक और संततियों से सी इ एन एच 3 जिनकों प्रवर्धित किया गया। गन्ने के अलग अलग सेकेरम स्पॉन्टेनियम साइटोटाइप बैक क्रास संकरों को गन्ना उपज और रस गणुवत्ता विशेषता के लिए मुल्यांकित किया गया और उसका आगामी उपयोग करने हेतु गुणन किया। सुधारित सेकेरम आफिसिनेरम, सुधारित सेकेरम रोबस्टम और सेकेरम बारबेरी को शामिल करके उनके क्रास बनाये गये और संकरित कृन्तकों को उपज और गुणवता के लिए मुल्यांकित किया गया।

खेत में गन्ने की रेशे की मात्रा का मापन करने हेतु एक उपकरण निर्मित किया गया और उसकी मापन की सत्यत्ता में सुधार लाने के लिए उसे परिस्कृत किया गया। उपकरण में लिखित रीडिंग को रेशे की मात्रा में परिवर्तित करने के लिए उचित एलगोरीदम को सुधारीत किया गया।

दुनियाभर से संग्रहित कन्नुर के खेत जीन बैंक मे 3369 क्लोन शामिल है, का रख रखाव किया गया। जिसमें क्रमशः 757, 145, 72 और 602 सेकेरम आफीसीनेरम, सेकेरम रोबुस्टम, सेकेरम बारबेरी/सेकेरम साइनेसिस और विदेशी संकर है। कोयम्बत्तूर में 1917 जंगली गन्ना जैव द्रव्य जिसमें सेकैरम स्पोन्टेनियम, एरीएनथस स्पीसीज और समवर्गी जेनेरा को खेत मे रखरखाव किया गया। व्यवसायिक संकरो और जैनेटिक स्टाक जिसका रख रखाव किया गया जिसमें 1305 को. केनस, 22 को. सबंधित 41 विदेशी कृन्तक और 204 आई एस एच कृन्तक शामिल है। गन्ने के राष्ट्रीय सक्रिय जैवद्रव्य संग्रह में 185 अधिसूचित और पंजीकृत जनेटिक स्टाक का रख रखाव किया गया। कुल 1600 कृन्तकों के संग्रह मे शामिल सेकेरम प्रजाति, इरीएन्थस प्रजाति, व्यवसायिक किस्में और इन्टरस्पेसिफिक/इन्टरजेनरिक संकरित कृन्तकों का रख रखाव गन्ना प्रजनन संस्थान क्षेत्रीय केन्द्र अगली मे किया गया।

उत्तर–पश्चिमी और उत्तर–पूर्व भारत से संग्रहित गन्ने के सेकेरम स्पोन्टेनियम कृन्तकों के आठ विभिन्न साइटोटाइपस थे जिनकी गुणसूत्र संख्या 2 एन = 54 से 80 तक सिमित थी।

गन्ना प्रजनन संस्थान, क्षेत्रीय केन्द्र करनाल मे दो किस्में डस परीक्षण के लिए प्राप्त हुयी और दो किसानों की गन्ना किस्मों को गुणन के लिए रोपित किया गया। इसी तरह से तीन उम्मीदवार किस्मों का डस परीक्षण के लिए रोपित किया गया और दो किसानों की किस्मों का गुणन के लिए कोयम्बत्तुर और गन्ना प्रजनन संस्थान, क्षेत्रिय केन्द्र, अगली में रोपित किया गया।

एस बी आई 2007–291 लाल सडन प्रतिरोधी अगेती ज्यादा सुक्रोज युक्त संकर जिसमें 8 वें और 10 वें महीने में क्रमशः

18 और 22 प्रतिशत सुक्रोज की मात्रा पायी गयी जो कम अवधि में तैयार होने वाली किस्म कि प्रबल दावेदार है, उसे भारतीय कृषि अनुसंधान परिषद, नई दिल्ली पौधा किस्म पंजीकरण समिति द्वारा पंजीकरण के लिए स्वीकृत कर आई एन जी आर 14011 पंजीकृत संख्या दी गयी।

फसल उत्पादन

गन्ने की किस्म को. 86032 ने क्रमशः 13,12, और 8 टन/हैक्टेयर/साल सुखी पत्तीया ग्रीन टाप्स, गन्ने की खोई और खुटियां के सुखे जैव भार की उपज दी। गन्ने की सुखी पत्तीयों से पाइरोलाइसिस में 10–13 प्रतिशत बायोचार मिला जिसमें ज्वलन आक्सीकृत तत्व की 78.52–80.82 प्रतिशत मात्रा थी।

गन्ने की फसल में कोयर पिथ खाद और गन्ने की सुखी पत्तीयों का प्रयोग नालियों में करने से परिणाम स्वरूप 11 प्रतिशत और 3 प्रतिशत मृदा नमी दर्ज की जो बिन उपचारित प्लाटों से ज्यादा थी। सिंचाई की 75 प्रतिशत की अवस्था में कोयर पिथ खाद प्रयोगित प्लाटों मे 7.5 प्रतिशत ज्यादा मृदा नमी पायी गयी। सिंचाई की 100 और 75 प्रतिशत के स्तरों पर एक समान दर्ज की गयी जो परिणाम स्वरूप 25 प्रतिशत सिचांई के पानी की बचत को दर्शाती है। मृदा में कोयर पिथ खाद (109.7 टन/हैक्टेयर) का प्रयोग करने से गैर उपचारित गन्ने की अपेक्षा काफी अधिक उपज मिली। दो ऑख वाले गन्ने के टुकडे को 90 से. मी. के अंतर पर लगाने की विधि ने बडचिप पौध रोपित करने से अधिक उपज दर्ज की। किन्तु बडचिप पौध को 150 से.मी. के अंतर पर लगाने और कोयर पिथ खाद का उपयोग तथा सुखी पत्ती (100.7 टन/हैक्टेयर) करने पर 90 से.मी. की अपेक्षा 150 से.मी. का अंतर रखने से अधिक उपज प्राप्त होती है।

गन्ने की किस्म को. 86032 में गन्ने की सुखी पत्तीयों के 15.67 टन प्रति हैक्टेयर की उपज हुई जिसे नालियों को ढक्कर प्रयोग करने से अधिक मृदा में नमी की मात्रा 0.70 से 5.92 ज्यादा दर्ज की । गन्ने की बुआई के 180 दिनों के बाद माइक्रोबीयल जैव भार कार्बन की मात्रा का नियंत्रण प्लाटों (86.91 माइक्रोग्राम/ग्राम मिट्टी) की अपेक्षा हरी खाद (112.25 माइक्रोग्राम/ग्राम मिट्टी) उपचारित मृदा में ज्यादा था। पत्ती प्रबंधन से मृदा तापमान 5 से.मी. गहराई पर 25.1 और 27.2 डिग्री सेंटीग्रेड के बीच में था जो बदलाव प्रतिरोधिकता दर्शाते है। गन्ने में पत्ती प्रबधंन के साथ सुक्ष्म जीवाणु समूह का प्रयोग करने से गन्ने की अधिक उपज 106.15 टन/हैक्टेयर प्राप्त हुई।

गन्ने की मिश्रित खेती में गन्ने की उत्पादकता और अर्थशास्त्र का अध्ययन पर आधारित परिणाम यह दर्शाते है कि 100 प्रतिशत प्रस्तावित नाइट्रोजन की मात्रा देने से गन्ने की उपज जो 76.82 टन/हैक्टेयर थी वह 75 और 50 प्रतिशत नाइट्रोजन प्रयोग करने की तुलना में ज्यादा थी। वर्ष 2015 के प्रयोग में मिश्रित फसल अमरेन्थस की उपज 100 प्रतिशत नाइट्रोजन के उपचार में (3.7 टन/हैक्टेयर ताजा भार) ज्यादा मिली थी। बुआई के 30 दिन बाद लाई कोर रेडिएशन सेन्सर का मिश्रित फसल अमरेन्थस में कुल प्रकाश अवरोधन सबसे ज्यादा दर्ज हुआ जो 13533 माइक्रो मोल/एस/मी^{2} मापा गया तदपश्चात पटसन (9043 माइक्रो मील/एस/मी^{2}) और तिल (8631 माइक्रो मील/एस/मी^{2}) में मापा गया।

टी जी की मात्रा 100° सेंटीग्रेड से ज्यादा वाले खाद्य योगज और वाहक ऐंजट जैसेकि 20 प्रतिशत मालटोडेक्सट्रीन के प्रयोग से अधिक गन्ने के रस का पाउडर (187 ग्राम/ली.) मिला जिसमें नमी की कम गतिविधि थी। ज्यादा टी जी की मात्रा के कारण जूस पाउडर 140 डिग्री सेल्सियस पर भी स्थिर रहा। गन्ने के रस के पाउडर की रोटेरी वेक्यूम सान्द्रता (–600 एम एम एच जी) 80° सेंटीग्रेड 30 मिनट के लिए प्राप्त हुई गन्ने के रस के पाउडर में नमी की मात्रा 16.8 प्रतिशत और पानी की गतिविधि 0.72 ए डब्ल्यु प्राप्त हुई। गन्ने के रस को –40° सेंटीग्रेड और अंदाजन 0.2 एम टोर वेक्यूम फ्रीज ड्राईग करने पर चमकीले पपडीयुक्त पाउडर मिला जिसमें पानी की गतिविधि 0.290–0.348 ए. डबल्यू और नमी की मात्रा 3.2–3.3 प्रतिशत थी।

18 गैर पुष्पन/विरल पुष्पन किस्मों में प्रकाश प्रेरण परिणामस्वरूप को. लख. 97154 किस्म में पुष्पन हुआ। कृत्रिम प्रकाश पुष्पन प्रेरण उपचार पश्चात 10 अगैती पुष्पन किस्मों में देर से पुष्पन होने वाली किस्मों के साथ समकालीन पुष्पन किया गया । जिससे को. शा. 8436 और को. से. 92423 किस्मों मे पॉच दिन विलंबन के साथ पुष्पन हुआ तथा को. लख. के

94184 में 17 दिन के विलंब पश्चात पुष्पन हुआ और उसे राष्ट्रीय संकरण उद्यान में उपयोग में लाया गया।

गन्ने की कटाई के समय गन्ने की को. 62175 किस्म में एकीकृत ऊर्जा का उत्पादन ज्यादा था जो 14877 किलो कैलोरी/मी^{2} तदपश्चात को. 09004 किस्म में 13332 किलो कैलोरी/मी^{2} दर्ज किया। एरीएनथस क्लोन आई के 76–44 ने अधिकतम ऊर्जा 3562 किलो कैलोरी/किलो और 3897 किलो कैलोरी/किलो जो पत्ती और तने के उतक में क्रमशः उत्पन्न करता है।

लवणीय मृदाओ में फास्फोरस और सुक्ष्म पोषक तत्व का छिडकाव, दर 1.0 प्रतिशत और 2.0 प्रतिशत, करके गन्ने की उपज में 20 प्रतिशत और 25 प्रतिशत का सुधार हुआ । सूखे की अवस्था में गन्ने की फसल में पोषक तत्व का छिडकाव करने से गन्ने की उपज में 26 प्रतिशत की बढोतरी हुई है।

अध्ययन करने से पता चलता है कि गन्ने की फसल में 30 दिनों तक परिवेश के तापमान से उपर तापमान 50 सेंटीग्रेड बढने से पौधो की बुआई के 180 दिनो बाद सुक्रोज फास्फेट सिन्थेज की गतिविधि में कमी 16.40 प्रतिशत और 11.5 प्रतिशत क्रमश पाई गई है । इसके साथ 19.5 प्रतिशत पी ई पी काब्रोजाइलेज की गतिविधि कम पाई गई। मुक्त मुलक सफाई की गतिविधि (पी ओ एक्स, ए पी एक्स और एस ओ डी की) अधिक तापमान पर बढ जाती है, हीट शॉक प्रोटीन स्पॉट की ज्यादा अभिव्यक्ति से नमुने की विभिन्न आणविक भार और घनता का पता चलता है। अर्द्ध मात्रात्मक पी सी आर के ऊपर अध्ययन का उपयोग हेटरोलोगस प्राइमरस के ऊपर विनियमन से प्रतिलिपी एनकोडिंग हीट शॉक प्रोटीन जैसे एच.एस.पी 90 , 70, 100 और एच एस पी 22 गन्ने की को. 06022, को. 99004 और को. 0403 अधिक तापमान को सहने योग्य होती है। जबकि गन्ने की को. 8021 किस्म अधिक तापमान के प्रति गैर अनुकुलित होती है गन्ने की किस्म को. 99004 को छोडकर अधिक तापमान की स्थिति में नमुनो में पी ई पी सी की दशाओं का स्तर कम दिखाई देता है।

आई डी आर आई एस आई के भूआंकडे भाग के अनुसार गन्ने की पैदावार खेत संख्या 1 में प्रति हेक्टेयर 65 से 175 टन तथा खेत संख्या 2 में 78 से 198 टन है। खाद की विभिन्न मात्रा के प्रयोग द्वारा खेत संख्या 1 में खर्च बढकर 1960 रू. प्रति हेक्टेयर तथा खेत संख्या 2 में खर्च कम होकर 1700 रू. प्रति हेक्टेयर तक हो गया। गन्ने का उत्पादन खेत संख्या 1 में बढकर 70 टन प्रति हेक्टेयर तथा खेत संख्या 2 में 20 टन प्रति हेक्टेयर हो गया था। सल्फर का 200 किलो ग्राम/प्रति हेक्टेयर का प्रयोग जिप्सम और सल्फर तथा थाओबेसिलस थीयोआक्सीडैंस कल्चर के रूप से प्रयोग से उत्पादन 124 टन प्रति हेक्टेयर था जो 28.5 प्रतिशत अधिक था। जहाँ सल्फर का प्रयोग नही किया गया वहाँ उत्पादन 96. 48 टन प्रति हेक्टेयर था। गन्ने की 15 जीनोटाइप आनुवंशिक रूप को 01–13, को. 0238, को. 0240, को. 0403, को. 06022, को. 06027, को. 06030, को. 8021, को. 8338, को. 86032, को. 91010, को. 92005, को. 99004 को. 99006 और को. एम. 0265 क्लोरोसिस रोग के प्रति रोग सहनशील थी । वही 12 जीनोटाइप सुक्ष्म पोषक तत्व और आयरन वाले खाद के प्रति संवेदनशील थी । सुक्ष्म पोषक तत्व जिंक और आयरन वाले खाद के प्रयोग से गन्ने का उत्पादन 96.31 प्रति हेक्टेयर था। जो 30–27 प्रतिशत अधिक था। आयरन और जिंक खाद का असर दो प्रजातियों में अलग अलग था। गन्ना उत्पादित जिले कोयम्बत्तुर, इरोड, तिरपूर, करूर, तिरूचीरापल्ली और विलुपुरम की मिट्टी का आंकडा फसल वृद्धि रूप में समाविष्ट किया गया है। एक निर्णय समर्थन प्रणाली विकसित कि जिसमें गन्ने की फसल के लिए मिटटी प्रबंधन की जानकारी दृश्य के रूप में दिखायी गयी थी और इसकी जांच विंडो, विस्टा, विंड़ो 7 और विंडो 8 जैसे स्थिर और अनुकुल प्लेटफार्म पर किया गया था। एक उन्नत गन्ना डीट्रेशिंग मशीन बनाया गया जिसमें सोलिड वर्क सोफटवेयर का प्रयोग किया गया था जिसका वजन 290 ग्राम है जहॉ पुराने मशीन का वजन 430 ग्राम था। मशीन की क्षमता का प्रयोग पाँच तथा सात महीने की फसल पर किया गया जिसमें इसकी क्षमता प्रतिदिन 0.3 एकड़ थी, जिसमें स्टेनलेस स्टील मशीन का खर्च 480 रू. तथा अल्प स्टील मशीन का खर्च 180 रू. था।

फसल सुरक्षा

नियंत्रित दशा के अन्तर्गत लगभग 3000 संततियो को लाल सड़न के लिए परिक्षण किया गया और उनमें से 1170 संततियो को लाल सड़न के प्रति रोग प्रतिरोधी के रूप में पहचान की

गयी । भूमी परिस्थिति दशा के अन्तर्गत 129 क्लोनों और 41 क्षेत्रिय प्रविष्टी को लाल सड़न और कंडुवा रोग के प्रति रोग प्रतिरोधी के रूप मे पहचाना गया। कोयम्बत्तूर और रोग प्रभावित क्षेत्र तमिलनाडू के थूहली मे किये गये प्रयोग में लाल सड़न के प्रति रोग प्रतिरोधी क्षमता वाले क्लोन चिन्हित किये गये थे। लाल सड़न कारको पर किये गये प्रयोग से पता चला कि 26 सी. फाल्केटम की तुलनात्मक उग्रता के अध्यन से पता चला की इसकी उग्रता सी एफ वी 09356 सी एफ वी 09356 (इलंगुर), सी एफ वी 09356 (किरांगगूडी) सी एफ वी 091017 (एन के एम) सी एफ वी 86032(बारी), और सी एफ वी 92012 (नागा) से अधिक थी।

सी.फाल्केटम से ग्रसित विभिन्न अंतर के विस्तार से विश्लेषण से पता चला कि अलग प्रकार के फाइटोएलेकिसन यौगिक जैसे ल्युटीलीडीन, स्पीनुडीन और सायानीडींग का संचयन अलग–अलग तथा प्रतिरोधी क्षमता वाले क्लोन मे जैविक रसायनो का सचमुच अधिक था इससे पता चलता है कि लाल सड़न रोग के प्रति प्रतिरोधक क्षमता संभवतः इन यौगिकों का योगदान है। गन्ने के कंडूआ रोगाणू के होस्ट–पैथोजन इटॅरक्शन आधारित बचावत्मक प्रोटियोमिक्स अध्ययन कई बचात्माक/तनाव उत्तरादाई उम्मीदवार जिनों को अभिव्यक्त करने के संकेत देते है तथा उन्हे कॉन्टिटेटिव रियल टाईम पीसीआर में अनुरूप पारस्परिक क्रिया द्वारा मान्यता दी गयी।

सी.फालकेटम के विरूद्ध ट्राइकोडरमा का प्रतिरोध संबधित प्रतिफंफूद प्रथिनों और मेटाबोलाइटस की पहचान करने के लिए पारस्परिक प्रभाव प्रोटेमिक/मैटोबोलेमिक अध्ययन किये गये। रोगाणू और प्रतिद्वंद्वि कि पारस्परिक क्रियाओं के दौरान रासायनिक प्रारूपों के तहत प्रमुख द्वितियक मैटाबोलाइटो को पहचाना गया। अवतरित द्वितियक मैटाबोलाइटस/प्रतिफंफूद प्रोटिन्स के जैव आमापन से सी. फालकेटम पर प्रभावी प्रतिफंफूद प्रतिक्रिया दर्शाते है। जीनोमिक एवं प्रोटियोमिक अध्ययनों से लाल सडन रोगाणू के रोगजननता क्रियाविधि को सुलझाने में काफी प्रगती की गयी। विविध आयसोलोटों जो बदलती विषाक्ता से है उनमें चुनिंदा रोगजननता संबधी जीनों के व्यक्तिकरण अध्ययन में उनका सी.फालकेटम के रोगजननता में योगदान की पुष्टि की गयी। सी.फालकेटम विष को वर्णित अध्ययन में सी.फालकेटम मेटाबोलाइटों के वर्णलेखिकी विश्लेषण और जैव आमापन में विष अंश की घुलनशिलता को पहचाना गया जो धृविय से मध्यधृविय परिसीमा में निस्सारित थे।

फंफुदजनिक रोगों के प्रबंधन के लिए प्रभावशाली फंफुदनाशी छिडकाव पद्धती पर अनुसंधान कार्यो से पुष्टी हुयी है कि खेत में गन्ने के टुकडों का फंफुदनाशीद्वारा मशिनीकृत एकल उपचार या फंफुदनाशीद्वारा मशिनीकृत उपचार तथा उसके बाद ड्रिप सिंचाई द्वारा जैवनियंत्रकों का छिडकाव एकिकृत पद्धती से लाल सडन एवं कंडुवा रोगों की रोगथाम की जा सकती है। रोग व्यवस्थापन के अलावा, उच्चतम रोपवाटिका को विकसीत करने हेतु एक पैकेज तैयार किया गया जिसमें एकल आँख कलिकायुक्त गन्ने के टुकडों का मशिनिकृत उपचार के लिए 0.5 प्रतिशत सुपर लाइम , 0.5 प्रतिशत युरिया और 0.1 प्रतिशत कार्बेन्डाजिम के घोल को विकसित किया। इस उपचार से गन्ने की को. 86032 किस्म में सुखा सहनशिलता में बढ़वार दिखाई दी। किटों का प्रबंधन करने हेतु गन्ने के टुकडों का मशिनीकृत उपचार पद्धती में कवकनाशी एवं नई पिढी के किटकनाशीओं का एकिकृत प्रयोग अनुकुलतम किया गया। बैसिलस अमायलो लिक्वेफंसियन इ एस आर 3 और बैसिलस पेमिलस इ एस आर 21 जैसी कुछ एन्डोफिटीक स्ट्रेन्स द्वारा खेतों में लाल सडन रोग के प्रति आशाजनक सक्रियता दिखाई। रोगों का नैनो छिडकाव प्रणाली से प्रबंधन करने हेतु आयन जैलेशन तकनिक से चिटोसॅन नैनो कणों को संश्लेषित करने कि कार्यपद्धती को मानकीकृत किया गया।

पिली पत्ती रोग (वाय एल डी) का तमिलनाडु एवं आन्ध्रप्रदेश राज्यों के चीनी मिलों के प्रभागों में विस्तारित आंकलन से प्रभाव का खुलासा हुआ कि इस क्षेत्रों में लागाई जाने वाली बहुत सी प्रचलित किस्मों में इस रोग का संक्रमण हुआ है। इस रोग से प्रभावित इंडेमिक प्रभागों में वाय एल डी मुक्त रोपवाटीकाओं का निर्माण करके रोगमुक्त रोपन सामग्री पूर्ति करना एक बहुत कारगर रोग प्रबंधन तकनिकी साबीत हुयी। इससे संबधित अध्ययन में मेलानाफीस सैकेरी रोग वाहक के संख्या बदलाव से पता चला है कि भिन्न–भिन्न गन्ना प्रजातियों के 4–6 महिने की अवस्था में रोगवाहक का पर्याप्त उपनिवेशन था। आणविक वायरॉलाजी के अंतर्गत गन्ने को संक्रमित करने वाले विषाणूओं के आर एन ए में विषाणू अवरोधन प्रोटिन्स जैसे पीओ गन्ना पीली पत्ती विषाणू जीन,

गन्ने के स्ट्रिक मोझाइक विषाणू संबधीत पी–1 और एच सी –प्रो जीन्स का वर्णन किया गया। ऍग्रोइनफिलट्रेशन द्वारा जी एफ पी रिपोर्टर जीन के प्रारूप के साथ इन अवरोधन जीन्स का निकोटिआना टेबॅकम जैसे आदर्श पौधो पर सायलेन्सींग आमापन और विस्तार से किया गया। आमापन में एस सी वाय एल व्ही के पीओ और एस सी एस एम व्ही के पी–1 जीन्स की आर एन ए सायलेंसिंग अवरोधन सक्रियता सिद्ध हुई। हेअरपीन कन्स्ट्रक्ट के साथ लक्षित जीन को लेकर अनुवंशिक रूपांतरन पर अध्ययन जारी है।

विषाणू सुचिकरण कार्यक्रम में तमिलनाडु आंध्रप्रदेश और बिहार के अंतर्गत उती संवर्धीत पौध इकाई में से उती संवर्धीत पद्धती से उगाऐ गये पौधों के 518 समूह का तीन आर एन ए विषाणू एवं घासदार तनें का फायटोप्लाजमा के लिए सुचिकरण किया गया।

भारतीय संकरित प्रजातियों में 186 किस्मों को पौरीबेधक अवरोधकता की जाँच कराने हेतु खेत में मुल्यांकन किया जिसमें 50 किस्में 15 प्रतिशत से कम पौरीबेधक प्रकोप के तहत प्रतिरोधी पायी, 31 किस्मों में सामान्य रूप से प्रतिरोधी (15 से 30 प्रतिशत का प्रकोप) और 105 गन्नों की किस्मों में पौरीबेधक का स्तर 30 से 95 प्रतिशत था जो अत्याधिक रूप से संवेदनशिल थी। पौरीबेधक का प्रकोप को. 293 किस्म में कम (4.50 प्रतिशत) और को. 1183 किस्म में ज्यादा (95.00 प्रतिशत) पाया गया।

कोटेशिया फ्लेव्हीपस जो एकमात्र पौरीबेधक डिंबक परजीवी है उसकी सक्रियता 15.4 प्रतिशत अक्तुबर 2014 में ज्यादा पायी गयी। प्रयोगशाला में किय गये अध्ययन में तमिलनाडु के आपकुडल एवं कोयम्बत्तूर से स्थित परजीवी समुहों का परजीवीकरण एकसमान पाया गया। ऑगमेन्टेटीव परिक्षण बढती पैरासिटॉइड सक्रियता के संकेत देते है। गन्ना बेधकों से पायो गये दो अंडपरजीवी नामक्रमशः टेलेनॉमस (डिंगश वर्ग) और ट्रायकोग्रामा कायलोट्रेई में से पहले वर्णित परिजीवी ज्यादा परजीवीकरण स्तर के साथ अधिकतर पाया गया। प्रयोगशाला में किये गये प्राथमिक परिक्षणों में बेधकों के हाल ही दिये अंडीपुंज को परजीवीकरण करते हुए टेलेनॉमस स्पीजीज को पाया गया।

बिव्हेरिया बॅसीयाना के एन बी ए आय आय 11,23,47,58 और 61 आयसोलेटो को गन्ने के लिए एन्डोफाइटिक पाया गया। डिंबक और कोशों की रिकव्हरी तथा कोशों के वजन के साथ उनकी प्रजनन क्षमता बढाने के लिए आय एन बी खादय में सुधार किया गया। स्ट्रेप्टोमाइसीन सल्फेट और कार्बेन्डाजीम को आहार में जीवाणू और फंफूद संदुषण को परावृत्त करने के लिए क्रमशः मुल्यांकित किया गया।

मेटाराइजीयम ॲनिसोफिली के एम टी सी सी (10) , एम सी सी (2), आय टी सी सी (9)और एन ए आय एम सी सी (9) आयसोलेटों के जैविक वर्णन से पता चला है कि एफ 01299 और एफ 01300 श्रृंखला जो एन ए आय एम सी सी से ह, वह अन्य श्रृंखला में बेहतर है। जैव आमापन में एन ए आय एम सी सी आयसोलेटों का सफेद गिंडार और तनाछेदकों के प्रथम अवस्था के डिंबक मर्त्यता में अच्छा प्रभाव है। इसी तरह से एम टी सी सी कल्चर को दीमक के प्रति प्रभावी पाया गया। भूमी में बने रहने के अध्ययन में इन आयसोलेटों में पाँच माह के बाद भी उत्तरजीवीता दिखाई दी। अन्य आयसोलेटों के तुलना में एम टी सी सी 6060 आयसोलेटों का रायझोस्पियर स्थित जडों में अच्छा उपनिवेशन देखा गया। गॅलेरिया मेलोनेला आमापन अध्ययन में गटल्स से प्राप्त ज्यादा आणविक भार एच पी एल सी अंश डिंबक अवस्थानुसार कम होती हुई मर्त्यता को दर्शाते है और आयसोलेटों के संवर्धन निस्यंदन तत्वों से अनेक इन्स्टार्स में मृत्युशिलता दिखाई दी।

क्राय जीन के लिए 143 बी.टी. आयसोलेटों का क्राय–1 क्राय–6 और क्राय–8 प्रायमर के साथ चयन किया उनमें 23, 47 और 42 आयसोलेटों को क्रमशः क्राय–1, क्राय–6 और क्राय–8 के लिए पुटिटेव्हली पाझिटिव्ह थे तथा इन आयसोलेटों के संदर्भ बी.टी. आयसोलेटों के क्राय जीन प्रायमरों के समान बॅन्ड परिवर्धीत किये। संदर्भ बी.टी. सेरोवर जैपोनेनसिस बुइबुइ स्ट्रेन जिसमें क्राय 8 जीन है उसने 373 बेसपेअर्स खंड को परीवर्धीत किया जबकी क्राय–1 और क्राय–6 जीन आयसोलेटों ने क्रमशः 558 और 800 बेसपेअर्स बॅन्ड को परिवर्धित किया।

डी.एन.ए. बारकोड और स्पिसीज स्पेशिफीक मार्कर्स अध्ययन में गन्ने के पर्यावरण में मौजुद किटों के बखुबी वर्णीत अलेरोडीड बारकोड जो पद्धती का अवलंब करके एन सी बी आय के

जीन बैन्क में प्रस्तुती के लिए भेजे गए। गन्ने के पाँच किट क्रमशः तनाछेदक (कायलो इनफसकेटुलस) स्टाल्क छेदक (कायलो ऑरीसिलीयस) गन्ना माहू (मेलानाप्सीस सैकेरी) स्केल किट (मेलानाप्सीस ग्लोमेरेटा) और जडों को माहू (टेट्रान्यूरा जावेन्सीस) के लिए नैदानिक किट विकसित किए गऐ। मेलानाप्सीस ग्लोमेरेटा और टेट्रान्यूरा जावेन्सीस के लिए जो डी. एन. ए. बारकोड जेनेरेट किया है वह दुनिया का पहला काम है और इस तरह का काम किसी भी पब्लिक डोमेन में नही है।

गन्ने के रस में फोरेट और उसके यौगिक पदार्थ नामशः फोरेट–ऑक्झान और फोरेट सल्फोन के अंश साथ–साथ निकालने के लिए वर्णलेखी पद्धती में पहली बार बहुतही संवेदनशिल गैस क्रोमेटोग्राफी–मास स्पेक्ट्रोमेट्रिक (जी.सी.एम.एस) पद्धती अवलंब किया गया। असिटोनाइट्राइलयुक्त सत्वन के पश्चात प्रायमरी–सेकेंडरी अमाईन (पी एस ए) से सफाई करने से तिनों यौगिक पदार्थो की 80 प्रतिशत से भी ज्यादा पुनःप्राप्ती मिली और यह विधि युरोपियन आयोग के सुक्ष्म अंश विष्लेषण (2010) के अधिनियम से पूर्णतः अनुरूप है।

गलेरिया, जो कीटरोगजनक सुत्रकृमी से संक्रमित थे, से 10 सहजीवी बैक्टीरीया को पृथक किया गया और उनके जीव–रासायनिक गुणधर्मो का अध्ययन किया गया। सहजीवी बैक्टेरिया का 16 एस आर डी एन के लिए विशिष्ट प्राइमर्स की सहायता से आणविक अध्ययन और सिक्वेंसिंग जीनोरहैब्डस आयसेलेटों की जीनोरहैब्डस स्टॉकैइ के साथ अधिकतम समानता दर्शाते है जबकी फोटोरहैब्डस को पी लुमीनेशनस उपजाती अखुरस्टाइ के समान पाया गया।

गलेरिया मेलोनेला के भिन्न अवस्थाओं पर पी लुमीनेशनस उपजाती अखुरस्टाइ (एस बी आय पी एल 78) और पाँच जीनोरहैब्डस स्टॉकैई द्वारा मृत्युशिलता दिखाई दी। जीनोरहैब्डस स्टॉकैई (एस बी आय एस 52) के मेथोनॉल अंश की दो अलग–अलग तापमानों में सफेद गिंडार होलोट्रायका सेरेटा और गलेरिया मेलौनेला के भिन्न अवस्थाओं पर मृत्युशिलता सिद्ध हुई। दूसरी और तिसरी अवस्थाओं के गलेरिया मेलौनेला पर पी लुमीनेशनस उप जाती अखुरस्टाइ (एस बी आय पी एल 78) अंशोद्वारा भी मृत्युशिलता दर्ज की।

सांख्यिकी और अर्थशास्त्र

को. केन्स और दुसरी प्रजातिया/जैनेटिक स्टॉक्स के पैतृकों की वंशावली का डाटाबेस आधुनिकृत किया गया। अ.भ.स. अनु.प. गन्ना को अधिक गहन विश्लेशन के लिए एकत्रित किया गया तथा इनके औसत का विश्लेषण (अनोम) प्रयोग कर औसत स्थापित अन्तर के आधार पर रैंक प्रदान किये गये। भा.कृ.अनु.प. के मार्गदर्शन अंतर्गत www.sugarcane.res.in डोमेन नाम से संस्थान वेबसाईट का रखरखाव एवं समय–समय पर आधुनिकिकरण कृषि ज्ञान प्रबंधन इकाई (अे.के.एम.यु) द्वारा किया गया।

विस्तार अनुभाग

आयोजित किये प्रसार कार्यक्रमों में एक मॉडल प्रशिक्षण कोर्स, पाँच राष्ट्रिय, दो राज्य स्तरिय और पाँच एकदिवसिय प्रशिक्षण कार्यक्रम थे। छः प्रथम पंक्ती प्रदर्शनों का आयोजन किसानों के खेत पर किया गया। संस्थान ने चार प्रदर्शनी में हिस्सा लिया जिसमें अॅग्री इंटेक्स 2014 कोडिस्सिया व्यापार मेला परिसर कोयम्बत्तूर, अॅग्री हॉर्टी टेक 2014 विजया फेयर मैदान, कोयम्बत्तूर, राष्ट्रिय केला अनुसंधान केंद्र, तिरूच्चिरापल्ली में आयोजित किसान दिवस तथा तमिलनाडु कृषि विश्वविदयालय द्वारा आयोजित राज्यस्तरिय किसान दिवस में हिस्सा लिया।

गन्ने मे मशिनीकृत कटाई प्रौद्योगिकी में बदलाव इस विषय पर सर्वेक्षण आधारित अध्ययन किया गया। गन्ना किसानों की प्रशिक्षैणिक आवश्यकताओं की पहचान कराने हेतु तमिलनाडु के धर्मापूरी, वेल्लूर, आम्बूर, करूर और तिरूनेलवेली जिलों में सर्वेक्षण किया गया। गन्ना प्रौद्योगिकी का अभिग्रहण स्वरूपो का तमिलनाडु के कुंबकोनम, धर्मापूरी, वेल्लूर, और अम्बूर जिलों में अध्ययन किया गया।

4. EXECUTIVE SUMMARY

Crop Improvement

The sugarcane mid-late variety Co 06034 (Karan 11) was identified for release in North Western zone by Varietal Identification Committee and the release proposal has been submitted to Central Varietal Release Committee. At the Biennial Workshop of AICRP on Sugarcane held in November 2014, 18 clones proposed were selected for testing in Peninsular zone, two clones for testing in North West zone and ten clones were selected for testing in East Coast zone.

Out of 120 clones evaluated in final clonal trial at Coimbatore, 22 superior clones were assigned 'Co' numbers, of which seven were early and 15 were mid-late. The highest cane yield was 148.1 t/ha and the highest sugar yield was 21.36 t/ha for Co 15017. At Karnal, 36 clones were evaluated in final clonal trial and five clones were assigned 'Co' numbers.

In ground nursery at Coimbatore, 24,300 seedlings from 140 experimental crosses, 23 proven crosses and 32 general collections made in 2013 were transplanted. During the 2014 flowering season, 163 crosses were made under the project on breeding varieties for tropical region. A first clonal trial was conducted with 1165 clones out of which 196 superior clones were selected and planted in second clonal trial. In another clonal trial with 2804 clones evaluated for cane yield and juice quality traits in the plant and ratoon crop, 873 clones were selected for second clonal trial of which the cross CoM 0265 x Co 99006 gave the highest percentage (36.5) of selection.

The second clonal trial was conducted with 832 clones in augmented design along with four standards. Forty six clones were having high juice sucrose of above 20% at 330 days. Based on red rot resistance, yield, quality and field stand, 80 clones were promoted to final clonal trial. A total of 172 promising clones selected from various experiments and projects for final clonal trial in 2016-17 were planted for multiplication.

Clonal evaluation of promising clones was conducted in sugar factory areas at Sakthi Sugars Ltd., Appakudal and Sree Ambika Sugars Ltd., Thuhili in Tamil Nadu of which 24 selected clones at Appakudal and 12 selected clones at Tuhili were planted in larger plot trials for further selection.

The AICRP Initial Varietal Trials of early and mid-late clones of Peninsular zone was conducted at Coimbatore in which 13 test entries and 14 test entries respectively were tested. The test entry Co 11016 recorded the highest CCS yield among the early clones and CoM 11085, Co 11019, Co 11005 and Co 11007 had higher CCS yield than the standards. In the Advanced Varietal Trial (Early) at Coimbatore, Co 09004 recorded the highest sugar yield, cane yield and sucrose % juice and this clone showed tolerance to drought and salinity.

Twenty three participating centres of AICRP made use of the National Hybridization Garden facility at Coimbatore for making a total of 454 station crosses, 56 proven crosses, 21 poly crosses and 15 selfs. Fluff weighing 37.28 kg of crosses made was supplied to the participating centers after having the test germination. The crosses CoJ 82315 x SP 80-185, CoS 96268 x Co 62198, Co 05011 x ISH 176, Co 99006 x 85 R 186 and 97R401 x Co 775, *etc*. gave very high germination.

From Karnal, 3474 quintals breeder seed of varieties Co 0118, Co 0124, Co 0237, Co 0238, Co 0239, Co 05011, Co 98014 and Co 05009 was supplied. From Coimbatore, 1370 quintals of breeder seed of varieties Co 86032, Co 0403, Co 99004, Co 2001-13 and Co 2001-15 was supplied for the three tier seed nursery programme. More than 31,000 tissue culture plants produced through meristem culture of Co 86032, Co 99006, Co 06030 and Co 0403 were supplied to various sugar factories and progressive farmers in Tamil Nadu, Karnataka, Maharashtra and Kerala. Besides that, 87 virus free mother culture flasks of variety Co 86032, Co 0403 and Co 06030 were also supplied to tissue culture laboratories.

Six new potential energy canes were identified with high harvestable biomass up to 233.65 t/ha and fibre content up to 27.4%. Based on evaluation of energy

canes under drought condition at Dharmavaram in Andhra Pradesh, four clones were identified as the best Type I energy canes and three clones were found to be good as Type II energy canes.

In the CAE trial conducted in Tamil Nadu during 2012-14, the mid-late clones Co 0320 and Co 0209 recorded the highest cane yield and CCS % in the Coimbatore region. Among the entries tested during 2013-15, Co 06015 was good for yield and quality across locations.

Among the hybrid clones with *Saccharum spontaneum* or *Erianthus arundinaceus* cytoplasm evaluated at Coimbatore and Agali, nine clones with high cane yield and sucrose % were selected for final clonal trial. An intergeneric hybrid derivative with *E. arundinaceus* cytoplasm with high cane yield and sucrose % juice was assigned 'Co' number (Co 15015).

The high sucrose genetic stocks developed through recurrent selection were evaluated for juice sucrose content at 300 days and 28 clones recorded 22.0% and eight clones recorded more than 23.0%. Two clones, 05-0234 and 05-0257, with high sucrose and less flowering intensity have the potential to be exploited as short duration varieties. In the population improvement for yield and quality through recurrent selection programme, variability was high for the yield parameters in the cycle four hybrids. Over four cycles of recurrent selection, there was a substantial improvement for cane weight.

Twenty one *Erianthus* specific TRAP markers sequenced showed similarities with gene sequences that are involved in stress responses in an array of crop species, which could be developed as potential candidate gene markers for monitoring the introgression of important stress resistance traits from *Erianthus*. The resistance gene analogues (RGAs) associated with resistance and susceptibility were cloned and sequenced of which five resistant specific sequences showed associations with red rot resistance and one susceptible specific fragment was associated with susceptibility.

A 650 bp invertase inhibitor gene cloned and characterized from *S. spontaneum* was found to have 92.0% similarity with *Zea mays* invertase inhibitor gene. Its subcellular location and in vivo function were characterized in silico using various online bioinformatics resources. Caffeic acid O Methyl transferase (COMT) gene involved in lignin biosynthesis pathway has been cloned from *S. officinarum* and full-length COMT was amplified with gene specific primers designed with EcoRI and HindIII restriction sites and sub cloned into pET expression vector and transformed into appropriate BL21 host for protein expression analysis. Protein homology by domain architecture was studied of Phenylalanine ammonium lyase (PAL) gene which was cloned and characterized.

Transgenic events with stress tolerance genes EaDREB2, EaHSP70, PDH45, and EaDREB2 & PDH45 in sugarcane variety Co 86032 were screened for tolerance to soil moisture stress and 18 promising events were selected for further screening for drought tolerance and studying the water use efficiency. Sugarcane variety Co 0238 was transformed with PDH45 gene through *Agrobacterium* mediated transformation and the transgenic events were being pot planted for further multiplication. The gene constructs with GLY I and II genes for salinity stress tolerance procured from ICGEB, New Delhi was mobilized into *Agrobacterium* for genetic transformation into sugarcane.

Total RNA was isolated from *S. spontaneum* clone IND 00-1307 identified as cold tolerant, after exposing to cold stress and cDNA library was prepared for identification of differentially expressed genes. Transcript-SSR markers for sucrose synthesis and WRKY gene family, which play important roles in the regulation of various physiological programs in plants, were designed and 50 clones with more than 19.0% sucrose and 50 clones for WRKY transcription factors were identified for the study. Whole transcriptome sequencing of sucrose regulating genes in sugarcane was initiated and the reverse transcribed complementary DNA and cDNA templates from total RNA from one *S. officinarum, S. spontaneum* and commercial hybrid clone each are being analysed for novel transcripts.

A CENH3 gene in centromeric region of chromosomes was identified and cloned from sugarcane to study the allelic variation if any involved in chromosome elimination in intergeneric hybrids. Upon sequencing, it showed 96% homology with *Sorghum* CENH3 sequences and 91% with Zea mays CENH3 sequences. Amplification of CENH3 has been obtained in the parents and four progenies of hybrid Co 7201x (28 NG 210 x IK 76-78).

Backcross hybrids of sugarcane with different cytotypes of *S. spontaneum* were evaluated for cane yield and juice quality traits and promising hybrids were multiplied for further utilization. Many crosses involving improved *S. officinarum*, improved *S. robustum* and *S. barberi* were made and the hybrid clones were evaluated for yield and quality parameters.

An instrument for on-field fibre content measurement in sugarcane was fabricated and is being refined to improve the accuracy and appropriate algorithm is being worked out to convert the observed value into the fibre units.

In the field gene bank at SBIRC, Kannur 3369 accessions were maintained which included 757 accessions of *S. officinarum*, 145 accessions of *S. robustum*, 72 accessions of *S. barberi /S. sinense* and 602 foreign hybrids of the world collection of sugarcane. At Coimbatore, 1917 wild germplasm clones comprising *S. spontaneum, Erianthus* spp, and allied genera were maintained. The commercial hybrids and genetic stocks maintained included 1305 'Co' canes, 22 'Co' allied canes, 41 foreign clones and 204 ISH clones. In the National Active Germplasm of sugarcane, 185 notified and registered genetic stocks are being maintained in field. A total of 1600 clones including core collection of *Saccharum* species, *Erianthus* spp., commercial sugarcane varieties and other interspecific/ intergeneric hybrid clones were maintained at SBIRC, Agali.

The somatic chromosome number of recently collected *S. spontaneum* clones from North West and North East regions of India were of eight different cytotypes with chromosome number ranging from 2n=54 to 80.

Two candidate varieties were received at SBIRC, Karnal for DUS testing and two farmer's varieties were planted for multiplication. Three candidate varieties were planted for DUS testing and two farmer's varieties were planted for multiplication at Coimbatore and SBIRC, Agali.

SBI 2007-291, a red rot resistant and early high sugar hybrid with more than 18.0% sucrose at 8 months and 22.0% sucrose at 10 months with potential as a short duration variety was accepted for registration by the Plant Germplasm Registration Committee of ICAR and assigned the registration number INGR 14011.

Crop Production

Sugarcane variety Co 86032 yielded 13, 12 and 8 t/ha/year trash + tops, bagasse and stubbles dry biomass, respectively. Pyrolysis of dry leaves gave 10 to 13% biochar with a flame oxidizable matter content of 78.52 to 80.82%.

Application of composted coir pith (CCP) and dry trash in trenches and covering with soil resulted in 11% and 3% higher soil moisture than control in ratoon crop. At 75% irrigation, the CCP registered 7.5% higher soil moisture. The cane yield in 100% and 75% irrigation levels were on par resulting in 25% savings in irrigation water. Cane yield in CCP applied (109.7 t/ha) and trash applied plots (100.7 t/ha) were on par but significantly higher than control. Two budded setts planted at 90 cm spacing gave higher yield than bud chip planting at 150 cm spacing.

A trash yield of 15.67 t/ha was obtained in the plant crop of Co 86032. Trash mulching and *in-situ* incorporation recorded higher soil moisture content by 0.70 to 5.92% over control. Microbial biomass carbon at 180 DAP was higher in *in-situ* trash mulching combined with green manuring (112.25 µg/gram soil) than control (86.91 µg/gram soil). It also buffered the soil temperature at 5 cm depth between 25.1 and 27.2^{O}C. *In-situ* trash management coupled with microbial consortia application resulted in higher cane yield (106.15 t/ha).

The study on productivity and economics of sugarcane based intercropping systems revealed

that 100% recommended dose of N gave higher cane yield (76.82t/ha) than 75% and 50% N (64.41 and 52.71 t/ha, respectively). The amaranthus intercrop yield in the 2015 experiment was high in 100% N treatment (3.7 t/ha fresh weight). The total light interception measured using LI COR radiation sensor was higher in amaranthus intercropping system (13533 µ mol/s/m^2) followed by sunnhemp (9043 µ mol/s/m^2) and sesame (8631 µ mol/s/m^2) at 30 DAP.

Food additives and carrier agents having Tg values > 100°C like 20% maltodextrin gave higher sugarcane juice powder (187 g/l) with low moisture activity. Powder was stable beyond 140^{0}C due to higher Tg values. Rotary vacuum concentration (RVC) of sugarcane juice powder obtained at -600 mmHg and 80°C for 30 min had a moisture content of <16.8% and water activity of <0.720 aw. Freeze drying of sugarcane juice at -40°C and ~0.2 mTorr vacuum gave glistening flake powders with a water activity of 0.290 to 0.348 aw and moisture content of 3.2% to 3.3%.

Induction of 18 non- flowering/rare flowering varieties resulted in flowering of CoLk 97154 in light treatment. Post-inductive constant day length treatment by artificial lighting for 10 early flowering varieties to synchronize flowering with late flowering varieties resulted in a delay of five days in CoS 8436 and CoSe 92423 to 17 days in CoLk 94184 and were used in National Hybridization Garden.

The integrated energy production at harvest was high in Co 62175 (14,877 kcal/m^2), followed by Co 99004 (13,332 kcal/m^2). The *Erianthus* clone IK 76-44 produced maximum energy of 3562 kcal/kg and 3897 kcal/kg in the leaf and stem tissues, respectively.

Phosphorus and micronutrients spray @1.0 and 2.0% recorded 20 and 25% yield improvement in saline soil. In drought treatment, the nutrient spray improved cane yield by 26%. Studies on the adaptive response of sugarcane to elevated temperature by subjecting plants at 5°C above ambient temperature for 30 days revealed reduced sucrose phosphate synthase (SPS) and sucrose synthase (SS) activities by 16.40% and 11.5% at 180 DAP, respectively. A reduction of 19.5% in PEP carboxylase activity was also observed. Free radical scavenging activities (POX, APX and SOD) were enhanced upon elevated temperature. The samples also showed over expression of heat shock protein spots (HSPs) with different molecular weight and density. Semi quantitative RT-PCR studies using heterologous primers revealed up-regulation of transcripts encoding heat shock protein *viz*., hsp 90, hsp 70, hsp 100 and hsp 22 at elevated temperature in adapted varieties *viz*., Co 06022, Co 99004 and Co 0403 while, its expression was absent in the non-adapted variety Co 8021. Expression level of PEPC was lesser in treated samples except Co 99004 which showed higher PEPC transcripts accumulation under elevated temperature.

Sugarcane yield variability studied using geostatistics module of IDRISI revealed a field variability of 65 to 175 t/ha in field 1 and 78 to 198 t/ha in field 2. Variable rate of fertilizer application resulted in an increase in fertilizer costs by Rs. 1960 /ha in field 1 and a saving of fertilizer cost Rs.1700/ ha in field 2. The cane yields were increased by 70 t/ha and 20 t/ha in field 1 and 2, respectively. Application of S @ 200 kg/ha in the form of gypsum and elemental sulphur + *Thiobacillus thiooxidans* culture gave on par yield of 124 t/ha each, which was 28.5% higher than control where no S was applied (96.48 t/ha).

Fifteen sugarcane genotypes (Co 01-13, Co 0238, Co 0240, Co 0403, Co 06022, Co 06027, Co 06030, Co 8021, Co 8338, Co 86032, Co 91010, Co 92005, Co 99004, Co 99006 and CoM 0265) were tolerant to chlorosis while 12 genotypes (Co 01-12, Co 01-15, Co 0218, Co 0314, Co 62175, Co 6806, Co 7219, Co 85019, Co 86249, Co 87025, Co 94008 and Co 97010) were susceptible to micronutrients (Zn and Fe) deficiencies. Micronutrient fertilization (Zn and Fe) gave 30.27% higher average yield (96.31 t/ha). Varietal variations in response to Fe and Zn fertilization was observed.

The soil profile database of sugarcane growing soils of Coimbatore, Erode, Tiruppur, Karur, Tiruchirappalli and Villupuram districts were incorporated in the DSSAT crop growth model.

A Decision Support System was developed in Visual Basic incorporating the knowledge base on sugarcane soil constraints management and tested for its stability and compatibility on Windows Vista, Windows 7 and Windows 8 platforms.

An improved sugarcane de-trashing tool was designed using SOLID WORKS software and developed which weighed 290g as against 430g model of the early design. Field tests on fifth and seventh month crop revealed that the field capacity of the tool is 0.3 acre/ day and the cost of the tool is Rs.480 for stainless steel and Rs.180 for mild steel tool.

Crop Protection

Under controlled condition testing, out of ~ 3000 progenies were tested for red rot, 1170 were identified as resistant to red rot. Under field conditions, 129 PZVT clones and 41 zonal entries were screened for red rot and smut resistance and identified resistant types. Field tolerance to red rot in promising clones were identified in the trials conducted at Coimbatore and disease endemic location, Tuhuli in Cauvery Command area Tamil Nadu.

Studies on variation in red rot pathogen revealed possible emergence of a virulent strain from the cv CoV 09356. Comparative virulence among 26 *C. falcatum* isolates on new differentials indicated that Cf94012 was the most virulent followed by CfV09356 (Elanganur), CfV09356 (Keerangudi), Cf91017 (NKM), Cf86032 (Bari) and Cf92012 (Naga).

Detailed analyses of phytoalexin induction during *C. falcatum* infection revealed differential accumulation of phytoalexin compounds *viz.*, luteolinidin, apigeninidin and cyaniding among different genotypes and the biochemical induction was high in resistant clones and this suggests possible role of these compounds in red rot resistance. Studies on defense proteomics of host-pathogen interaction involving sugarcane smut pathogen indicated expression of many candidate defense/stress responsive genes and they were validated by quantitative real time PCR in the compatible interactions.

Interactive proteomic / metabolomic studies were continued to identify antifungal proteins and metabolites from *Trichoderma* during its antagonism against *C. falcatum*. Based on the chemical structure, the major secondary metabolites were identified as antimicrobial compounds expressed during interaction of the pathogen and the antagonist. Bioassays with extracted secondary metabolites / antifungal proteins exhibited strong antifungal activity on *C. falcatum*. Progress has been made to unravel pathogenicity mechanism of red rot pathogen through genomic and proteomic studies. Expression studies of selected pathogenicity related genes in different isolates varying in virulence confirmed their role during pathogenesis of *C. falcatum*. For characterization of *C. falcatum* toxin, chromatographical analysis and bioassay of *C. falcatum* metabolites identified the solubility of toxin fraction, *i.e.*, the toxin could be eluted in polar to mid-polar range.

Research on effective fungicide delivery to manage major fungal diseases established that under field conditions, mechanized fungicide sett treatment alone or combination of mechanized sett treatment with fungicides and subsequent delivery of fungicides/ biocontrol agents through drip system or spray were to be effective in reducing red rot and smut incidences. Apart from disease management, a package for raising quality nursery through mechanized treatment of single bud setts with a mixture of 0.5% super lime, 0.5% urea and 0.1% carbendazim was developed. This treatment also increased drought tolerance in the cv Co 86032. Further treatments were optimized for a combination of fungicide and new generation insecticides in mechanized sett treatment to manage insect pests also. Some of the endophytic strains *Bacillus amyloliquefaciens* ESR3 and *B. pumilus* ESR 21 showed promising biocontrol activity against red rot under field conditions. For nano-delivery approach in disease management, a methodology has been standardized for synthesis of chitosan nano particles by ion gelation technique.

Detailed assessment on the impact of yellow leaf disease (YLD) in different factory areas of Tamil Nadu and Andhra Pradesh revealed serious disease

epidemics in many of the popular varieties under cultivation. In the endemic regions, creation of YLD-free seed nurseries to supply disease-free planting materials was found to be highly effective in managing the disease. In a related study, population dynamics of the vector *Melanaphis sacchari* showed abundant colonization during 4-6 months crop growth stage in different varieties. In the area of molecular virology, virus suppressor proteins in RNA viruses infecting sugarcane, P0 gene of Sugarcane yellow leaf virus (SCYLV), P1 and HC-Pro genes of Sugarcane streak mosaic virus (SCSMV) were characterized. Further, detailed studies were conducted on silencing assays of these suppressor genes on a model plant *Nicotiana tabacum* through agroinfiltration with GFP as the reporter gene. The assays proved that P0 of SCYLV and P1 of SCSMV have the RNA silencing suppressor activity. Further studies on hairpin constructs with the target genes for genetic transformation is in progress.

Under virus indexing programme, 518 batches of tissue culture raised plants from various tissue culture production units in Tamil Nadu, Andhra Pradesh and Bihar were indexed for three RNA viruses and grassy shoot phytoplasmas.

In ongoing field studies to identify internode borer resistance in Indian hybrid varieties, of the 186 varieties evaluated in the current season 50 were found to be resistant (R) with less than 15% incidence, 31 were moderately susceptible (MS) with an incidence range of 15-30% and 105 were highly susceptible (HS) with an incidence range of 30-95%. While the lowest incidence level was recorded in Co 293 (4.50%), the highest was in Co 1183 (95.00%).

Cotesia flavipes continues to be the only larval parasitoid of internode borer with the highest activity in (15.4%) October 2014. A parasitoid population from Aapakudal, Tamil Nadu, showed parasitization levels on par with Coimbatore population in the laboratory. Augmentative trials indicated enhanced parasitoid activity in some trials. Of the two egg parasitoids, namely *Telenomus* (dingus – group) and *Trichogramma* nr. chilotraeae recovered from the borer, the former was more predominant with high parasitism levels. In preliminary laboratory tests, *Telenomus* sp. parasitized freshly laid egg masses of the borer.

Beauveria bassiana isolates NBAII 11, 23, 47, 58 and 61 were confirmed as endophytic to sugarcane. INB diet has been improved to get high larval recovery, pupal recovery, weight of the pupae and fecundity. Streptomycin sulphate and carbendazim were evaluated as additives to prevent diet contamination from bacteria and fungi, respectively.

Biological characterization of MTCC (10), MCC (2), ITCC (9) and NAIMCC (9) isolates of *Metarhizium anisopliae* indicated that F-01299 and F01300 of NAIMCC series were better than the others. In bioassays, NAIMCC isolates produced considerable mortality in first instar white grub and internode borer larvae; MTCC cultures were effective against termites. In soil persistence studies, isolates showed differential survival after five months. In studies on the effect of rhizosphere, MTCC 6060 has proven to be colonizing the root better than other isolates tested. In bioassays against *Galleria mellonella*, while a high molecular weight HPLC fraction obtained from guttules showed decreasing levels of mortality with larval stage, culture filtrate extracts of isolates caused mortality in different instars.

Screening of 143 Bt isolates for cry genes with primers of cry1, cry6 and cry8 revealed that 23, 47 and 42 isolates were putatively positive for cry1, cry6 and cry8, respectively. The positive isolates for each cry gene amplified a similar band as that of reference standard Bt isolate for each cry gene primer. The reference *B. thuringiensis* serovar. japonensis, strain Buibui containing cry8 gene, amplified a fragment of 373 bp while positive isolates for cry1 and cry6 gene amplified bands of 558 and 800 bps, respectively.

In studies of DNA barcodes and species-specific markers for insects in sugarcane ecosystem using standard methods and barcode primers, well-characterized barcodes of aleyrodids were submitted in the GenBank of NCBI. Molecular diagnostic kits were developed for five sugarcane pests, namely shoot borer *Chilo infuscatellus*, stalk borer *Chilo auricilius*, sugarcane aphid *Melanaphis*

sacchari, scale insect *Melanaspis glomerata* and the root aphid *Tetraneura javensis*. The DNA barcodes generated for *M. glomerata* and *T. javensis* are the firsts in the world as there are no barcodes for these species in the public domain.

A chromatographic method for simultaneous determination of residues of phorate and its metabolites *viz*., phorate-oxon and phorate-sulfone in sugarcane juice has been developed for the first time using a highly sensitive gas chromatography-mass spectrometric (GC-MS) method. Acetonitrile-based extraction followed by primary-secondary amine (PSA) clean-up provided more than 80% recovery for all the three compounds and the method is in compliance with the European Commission's Regulations for Trace Residue Analysis (2010).

Biochemical characterization of 10 symbiotic bacteria isolated from *G. mellonella* infested with entomopathogenic nematodes (EPN) was carried out. Molecular characterization of symbiotic bacteria using primers specific for 16s rDNA and sequencing studies indicated that *Xenorhabdus* isolates had maximum similarity with *Xenorhabdus stockiae* and *Photorhabdus* had similarity with *P. luminescens* sub sp. *akhurstii*. Bacterial cell and cell free culture filtrates of *P. luminescens* sub sp. *akhurstii* (SBIPL78) and five *Xenorhabdus stockiae* caused mortality in different instars of *G. mellonella.*

A methanol fraction of *X. stockiae* (SBIXS52) caused variable mortality in different instars of white grub *Holotrichia serrata* and *G. mellonella* at two different temperatures. Four different fractions of *P. luminescens* sub sp. *akhurstii* (SBIPL78) caused mortality in second and third instars of *G. mellonella.*

Statistics & Economics

The pedigree database on parentage of 'Co' canes and other varieties/ genetic stocks was updated. Database on AICRP- Sugarcane trials were compiled for more in-depth analysis using Analysis of Means (ANOM) and ranking based on mean-stability variance. The Agricultural Knowledge Management Unit (AKMU) has been maintaining the Institute's website as per the ICAR guidelines under a domain name www.sugarcane.res.in through periodical updates.

Extension

The outreach programs included one model training course, five national level training programs, two state level training programs and four one-day training programs. Six frontline demonstrations were conducted in farmers' fields.

The institute participated in four exhibitions: Agri-Intex 2014 at CODISSIA Trade Fair Complex, Coimbatore; Agri-Horti Tech 2014 at Vijaya Fair Grounds, Coimbatore; Farmers Day at NRC for Banana, Tiruchirapalli; State level Farmers' Day at Tamil Nadu Agricultural University, Coimbatore.

Survey based study was conducted on technology dynamics of mechanical harvesting in sugarcane. Surveys were conducted in Dharmapuri, Vellore, Ambur, Karur and Tirunelveli districts to identify the training needs of cane growers. Adoption pattern of sugarcane technologies was studied in Kumbakonam, Dharmapuri, Vellore and Ambur districts, Tamil Nadu.

5. RESEARCH ACHIEVEMENTS

5.1 DIVISION OF CROP IMPROVEMENT

5.1.1 BREEDING

Breeding sugarcane varieties for tropical region

Selection of varieties for AICRP varietal trials

For Initial Varietal Trial (IVT) in Peninsular zone, 18 clones proposed were selected at the Biennial Workshop of AICRP on Sugarcane held in November 2014 of which four are early maturing and 14 are mid-late maturing. Ten clones were selected for IVT in East Coast zone, of which three are early maturing and seven are mid-late maturing.

Selection of 'Co' canes

(K. Mohanraj)

One hundred and twenty nine clones were evaluated with four standards in Pre Zonal Varietal Trial (PZVT) for cane yield, juice quality, field stand and red rot resistance. From this, 22 superior clones were assigned 'Co' numbers, of which seven are early (Co 15001 to Co 15007) and 15 are mid-late (Co 15008 to Co 15022) (Tables 4 and 5). Three of these Co canes were with the parentage Co 86032 x Co 86011. Co 86011 and Co 86032 proved their worth as one of the parents by contributing seven and six 'Co' canes, respectively. The information on Co canes from Karnal is given in Tables 6 and 7.

Early 'Co canes' showed an improvement of 22.26 to 74.98% over standards for CCS yield, 19.73 to 80.12% for cane yield and 2.05 to 12.12% for sucrose % juice, whereas for the mid-late clones, it ranged from 10.28 to 50.48% for CCS yield, -2.32 to 30.84 % for cane yield and -2.98 to 15.89 % for sucrose % juice (Fig. 2). Co 15007 (early); Co 15011, Co 15014, Co 15017 and Co 15021 (mid-late) Co canes had higher cane yield as well as sucrose content.

Table 4. **Performance of 'Co' selections (Early) at Coimbatore**

'Co' Number	Parentage	Cane yield (t/ha)	CCS (t/ha)	At 10 months			NMC ('000/ ha)	Red rot (Nod-al)
				Brix	Sucrose (%)	CCS (%)		
Co 15001	CoM 0265 x Co 86011	133.80*	18.52*	21.05	19.56	13.84	86.11	R
Co 15002	1148-S4-242-4 PC	143.52*	19.65*	21.66	19.58	13.69	110.18	R
Co 15003	CoM 0265 x Co 89003	106.48*	14.85*	21.30	19.73	13.94	74.07	R
Co 15004	(Co 740 x Co 2000-03) x (Co 86002 x Co 88039)	102.80*	14.09	21.84	19.65	13.71	87.59	R
Co 15005	(Co 8371 x ISH 69) x (Co 86032 x Co 99006)	127.80*	19.10*	22.53	21.06	14.94	111.2	R
Co 15006	CoM 0265 x Co 89003	100.00*	13.73	22.00	19.72	13.73	103.79	-
Co 15007	ISH 100 x Co 0209	95.40	15.27*	23.52	22.39*	16.01*	85.27	R
Standards								
CoC 671		79.68	11.23	21.58	19.97	14.11	62.59	
Co 86032		103.33	12.93	19.88	17.93	12.52	85.74	
CD(0.05)		17.35	3.05	1.31	1.15	1.06	14.44	
CV		11.39	11.54	3.20	2.95	3.11	8.00	

* Significantly superior to the standard at P=0.05

Table 5. **Performance of 'Co' selections (Mid-late) at Coimbatore**

'Co' Number	Parentage	Cane yield (t/ha)	CCS (t/ha)	At 10 months			NMC ('000/ ha)	Red rot (Nodal)
				Brix	Sucrose (%)	CCS (%)		
Co 15008	Co 86011 GC	100.93	15.66	23.89	22.11*	15.62*	82.40	R
Co 15009	CoSi 6 x BO 92	130.56*	19.52*	22.92	21.18*	14.95*	79.63	R
Co 15010	Co 99006 x CoH 70	130.56*	17.02*	21.28	18.87	13.07	102.77	R
Co 15011	Co 86002 x Co 94008	123.61*	18.91*	23.32	21.63*	15.29*	102.78	R
Co 15012	Co 86032 x Co 05001	148.10*	20.56*	21.07	19.60	13.88	93.15	R
Co 15013	Co 86002 x Co 0320	141.70*	21.07*	22.38	20.95*	14.88*	85.74	R
Co 15014	Co 94012 x Co 86011	121.30	18.76*	23.16	21.75*	15.47*	115.83	R
Co 15015	CYM 08-903 x Co 94008	126.40*	17.82*	21.63	19.98	14.10	88.05	R
Co 15016	Co 86032 x Co 86011	124.50	18.44*	22.66	20.96*	14.80	117.68	R
Co 15017	Co 94012 x Co 86011	135.20*	21.36*	24.79	22.54*	15.80*	110.27	R
Co 15018	(CoC 671 x IG 91-1100) x Co 94008	129.80*	18.02*	22.06	19.89	13.89	85.28	MR (Plug)
Co 15019	Co 86032 x SP 80185	144.90*	19.35*	21.39	19.18	13.36	90.83	R
Co 15020	Co 86032 x Co 86011	143.50*	20.86*	22.18	20.56	14.54	109.35	R
Co 15021	Co 86032 x Co 86011	138.89*	19.60*	23.33	21.58*	15.24*	120.96	R
Co 15022	Co 86032 X Co 05001	134.96*	19.37*	23.26	20.69	14.35	106.60	R
Standards								
Co 86032		103.33	14.20	21.15	19.45	13.70	85.74	
CoM 0265		115.14	15.35	20.58	18.96	13.37	75.46	
Co 99004		104.81	14.40	21.36	19.61	13.80	70.74	
CD(0.05)		21.48	2.89	1.31	1.47	1.14	11.14	
CV		15.24	14.87	4.48	5.44	6.01	10.26	

* Significantly superior to the standard (Co 86032) at P=0.05

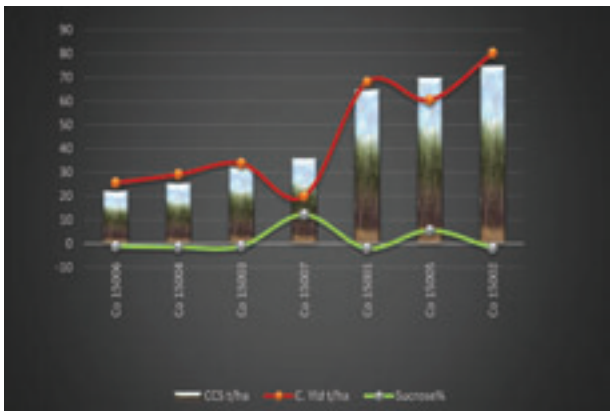
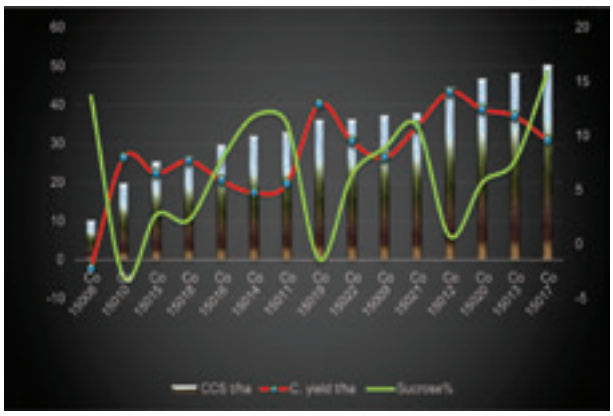


Fig. 2. a. Improvement in early maturing Co canes (2015 series) for CCS, cane yield and sucrose content over the standard CoC 671



b. Improvement in mid-late maturing Co canes (2015 series) for CCS, cane yield and sucrose content over the standard Co 86032

Table 6. **Performance of 'Co' selections (Early) at SBIRC, Karnal**

'Co' Number	Parentage	Cane yield (t/ha)	CCS yield (t/ha)	At 10 months			Pol in cane (%)	Fibre (%)	RR rating
				Brix	Sucrose (%)	CCS (%)			
Co 15023	Co 0241 x Co 8347	128.7	16.97	20.9	18.89	13.19	14.84	12.42	R
Co 15024	Co 0124 x Co 94008	144.4	18.60	20.7	18.54	12.90	15.56	12.13	MR
Standards									
Co 0238		154.9	19.80	20.1	18.24	12.80	15.89	12.09	
CoJ 64		91.0	11.00	19.0	17.0	11.82	15.01	12.4	
CD (0.05)		34.85	5.6	0.72	1.25	0.92			
CV (%)		14.25	18.2	1.73	3.73	3.97			

Table 7. **Performance of 'Co' selections (Mid-late) at SBIRC, Karnal**

'Co' Number	Parentage	Cane yield (t/ha)	CCS yield (t/ha)	At 12 months			Pol in cane (%)	Fibre (%)	RR rating
				Brix	Sucrose (%)	CCS (%)			
Co 15025	Co 0241 x Co 8347	144.4	20.08	22.3	19.9*	13.90	15.89	12.51	MR
Co 15026	Co 0124 x Co 8347	152.3	19.86	20.7	18.7	13.04	14.91	12.70	MR
Co 15027	Co 0331 x Co 0218	141.0	19.09	21.3	19.3*	13.54	15.26	13.09	R
Standards									
CoS 8436		123.4	15.8	20.6	18.2	12.60	14.57	13.29	
CoS 767		128.7	16.2	19.9	18.0	12.80	14.38	12.96	
CD (0.05)		34.85	5.6	0.46	0.94	0.80			
CV (%)		14.25	18.2	15.04	2.53	3.20			

* Significantly superior over the best standard at P=0.05

Hybridization

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

A total of 163 crosses were made utilizing proven parents, genetically diverse clones based on pedigree and molecular diversity, disease resistant lines, new and improved interspecific and intergeneric hybrids and genetic stocks for different agronomic traits. The fluff collected is stored for sowing during August- September 2015.

Ground nursery

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

A total of 24,300 seedlings from 195 crosses, including 140 experimental crosses, 23 proven crosses and 32 GCs were planted in ground nursery.

First Clonal Trial (Plant crop)

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

A total of 1165 clones were evaluated in augmented

design II with four standards *viz*., CoC 671, Co 86032, Co 99004 and Co 85004. The HR Brix of the clones varied from 16.0 to 23.0, the number of millable stalks from one to 20/clump and cane thickness from 2.0 to 3.7 cm. The clones were screened for the presence of spines on leaf sheath, erectness of cane and clasping of leaf sheath. Among 1165 genotypes, 196 superior clones were selected and planted in II clonal trial in augmented design II. The number of clones selected was more from the parentage Co 11015 x Co 86011 (17), Co 8371 x Co 86011 (13) Co 2000-10 x Co 97005 (11) Co 0209 x Co 8341 (9), Co 11020 x Co 06002 (10) and Co 86032 PC x (CoC 671, Co 99006, CoN 10072) (11). Fifteen clones registered juice sucrose comparable to the standard Co 86032 (19.7%) and three clones *viz*., EB 1231048 (23.2%), EB 1201072 (22.3%) and EB 1231045 (21.9%) recorded higher or eqivalent sucrose compared to the best standard CoC 671 (21.9%). The top five crosses from which more number of selections was effected are given in Table 8. The trial is ratooned to make final selection.

Table 8. **Crosses with higher number of selection in first clonal trial**

Cross	Number of selections
Co 0209 x Co 8341	9
Co 0403 x 2006-118	7
Co 2000-10 x Co 97005	11
Co 8371 x Co 86011	13
Co 2011-15 x Co 86011	17

First Clonal Trial (2013-15)

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

Combined evaluation of 2804 clones for cane yield and juice quality traits in the plant and ratoon crop was conducted during 2013-15. Among these, 980 clones had high number of millable stalks (≥ 8.00 / clump) and cane diameter (≥ 2.80 cm) with a moderate HR Brix of 20.0, while 301 clones combined moderate number of millable stalks (≥ 4.00 / clump) with high HR Brix (≥ 23.0). Based on overall performance of both plant and ratoon crops, 873 clones were advanced to II clonal trial. The cross CoM 0265 x Co 99006 gave the highest percentage of selection (36.5%), followed by Co 8371 x Co 85002 (33.3%). The crosses Co 86032 x Co 0403, Co 0327 x Co 0218, Co 0240 x Co 0214 Co 0217x Co 0209, Co 86002 x 88A162, Co 94012 x Co 86011, Co 0314 GC and Co 11015 GC also were promising.

Second Clonal Trial

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

This trial had 832 clones in augmented design along with four standards (Co 86032, Co 0403, CoM 0265 and CoC 671). The best selections for yield and quality traits are given in Table 9.

Table 9. **Performance in II clonal trial**

Character	Best selections (values)
Sucrose % at 240 days	2010-390 (18.98%), 2010 -171 (18.28%)
Sucrose % at 330 days	EB 0850029 (21.95 %), EB 0850029 (21.95 %) >20% : 46 clones
Brix at 330 days	EB 0954098 (23.42), EB 0949062 (23.38)
Single cane weight (kg)	EB 09117579 (2.8 kg), >2.0 kg : 14 clones
Cane diameter	EB 0991422 (3.66 cm) >3.0 cm : 43 clones
Best cross combinations and the top entries	
Co 8371 x Co 99006	2014-110, 2014-130, 2014-102, 2014-101, 2014-124, 2014-108
Co 94012 x Co 94008	2014-278, 2014-280, 2014-279, 2014-282
CoM 6806 x Co 94008	2014-211, 2014-209, 2014-205
Co 86011 x Co 1148	2014-142, 2014-146, 2014-143

Sixty eight clones were found to be better for quality traits, of which 11 clones were superior to Co 86032. Three clones performed well for quality at 240, 300 and 360 days. Red rot resistance of the cones was assessed and based on yield, quality, resistance and field stand, 81 clones were promoted to PZVT (2015 series).

PZVT (2015 series)

(P. Govindaraj)

A total of 172 elite clones selected from different experiments and projects were promoted to PZVT (2015 series). The clones were planted for multiplication for trials in 2016-17.

Botanical description and DNA fingerprinting

(G. Hemaprabha)

Thirty three 'Co' canes of 2014 series were described based on 34 botanical descriptors. Flowering behaviour and pollen fertility of the flowering clones were recorded; 12 clones were non flowering. The cross combinations Co 99006 x Co 94008 and Co 86032 x Co 86011 produced a higher proportion of non-flowering clones. DNA fingerprints were generated for Co 06034 and included in the varietal notification proposal. Eighty four elite drought tolerant clones were finger printed with 15 primers and genetic diversity was quantified to identify new and diverse parental combinations for economic breeding programme. Fingerprints of elite varieties from EID Parry (India) Ltd., and Sugarcane Research Station, Anakapalle were generated on service basis.

Adaptive trials in sugar mills

(G. Hemaprabha, S. Alarmelu, R.M. Shanthi)

At Sakthi Sugars Ltd., Appakoodal, 24 clones were selected out of 58 clones under evaluation in collaboration with the factory R&D personnel based on their superior performance over Co 86032 and were planted in larger plots. The clone 2012-150 had excellent crop stand followed by 2012-204 (Co 14027). At Sree Ambika Sugars. Ltd., Thuhili, where the main emphasis was to select red rot resistant and non flowering clones with thick canes suitable for the deltaic region, 12 best performers were selected and planted in larger plots. Five best entries were identified and brought to the notice of the factory.

In order to identify location specific elite clones combining red rot resistance with yield and quality suitable to delta region, a new set of 62 clones of recent origin and in pipeline were field planted at Sree Ambika Sugars Ltd., Thuhili.

Ethanol and fibre

(C. Palaniswami and A. Vennila)

Ethanol yield from juice of 30 PZVT clones ranged from 7.15 to 10.52% on volume basis, the highest being in the clone 2013-119. Ethanol production potential ranged from 3464 to 6065 l/ha, the highest being in the clone 2013-59 followed by 2013-175 (5983 l/ha) and 2013-213 (5823 l/ha).

The fibre content of the PZVT clones ranged from 9.63 - 17.82%, the lowest being in the clone 2013-90 and the highest in the clone 2013-171.

All India Coordinated Research Project on Sugarcane

Initial Varietal Trial (Early)

(Adhini S. Pazhany)

Thirteen entries *viz*., Co 11001, Co 11004, Co 11016, Co 11017, Co 11018, CoM 11081, CoM 11082, CoM 11083, CoM 11084, CoN 11071, CoN 11072, CoT 11366 and PI 11131 were evaluated along with three standards (CoC 671, Co 85004 and Co 94008). The entry Co 11016 recorded the highest CCS yield of 14.97 t/ha while the best standard Co 85004 recorded 12.29 t/ha. Three entries *viz*., CoM 11083 (130.55 t/ha), Co 11018 (123.35 t/ha) and Co 11016 (110.50 t/ha) performed significantly better than the best standard Co 85004 (90.37 t/ha) for cane yield. The test entries CoM 11084 (20.19%) and Co 11004 (20.18%) were numerically better than the best standard CoC 671 (20.15%) for juice sucrose at 300 days.

Initial Varietal Trial (Mid-late)

(G. Hemaprabha)

Fourteen entries were evaluated with two standards in RBD in two replications. At harvest, both the standards exhibited almost similar performance for cane yield and CCS yield. The entries CoM 11085, Co 11019, Co 11005 and Co 11007 were on par with the standards but recorded numerically better performance for CCS yield. The best entry for cane yield was Co 11019 (117.18 t/ha) and for sucrose it was Co 11007 (20.74%). The entries Co 11021, Co 11023, CoM 11087 and CoN 11074 were inferior to Co 86032 for CCS yield. For juice quality, Co 11024, CoM 1108, CoN 11023 and CoN 11024 were inferior to both the standards. Based on yield, quality and field stand at Coimbatore, seven entries *viz*., Co 11005, Co 11007, Co 11012, Co 11019, Co 11020, Co 11022 and CoM 11085 were found to be promising.

Advanced Varietal Trial (Early)

(K. Mohanraj)

Three test entries *viz*., Co 09004, Co 09007 and CoN 09072 were evaluated along with three standards for cane yield and juice quality traits at 240 and 300 days. The results showed that the entry Co 09004 recorded the highest sugar yield (15.42 t/ha) followed by CoN 09072 (13.85 t/ha) compared to the best standard Co 85004 (11.84 t/ha). It also recorded the highest cane yield of 102.03 t/ha and sucrose of 21.26%. Based on cane yield and juice quality parameters, Co 09004 was found to be promising.

Exchange of seed material

(R.M. Shanthi, A. Anna Durai and S. Alarmelu)

Twenty eight new IVT clones (Early:8, mid-late:20) accepted for testing in Peninsular zone during the AICRP workshop held during 2013 were multiplied. Seed material of these 28 clones was supplied to eight AICRP(S) centres of Peninsular zone (Mandya, Perumalapalle, Powarkheda, Pugalur, Rudrur, Sameerwadi, Sirugamani and Thiruvalla) for multiplication.

Red rot

(R. Viswanathan)

Out of 39 IVT entries evaluated for resistance to red rot against Cf671 pathotype under field conditions along with two susceptible standards Co 94012 and CoC 671, 32 entries were resistant / moderately resistant to red rot under plug method of inoculation.

Smut

(A. Ramesh Sundar)

Out of 41 IVT clones (13 early, 14 mid-late and 14 Co selections) evaluated for smut resistance, three (Co 11012, Co 13030 and Co 13026) were rated as 'R' and nine as 'MR' (Co 11001, CoM 11082, CoN 11072, Co 11020, Co 11022, CoN 11073, Co 13022, Co 13027 and Co 13031). For the current season, IVT clones representing early and mid-late types were planted in February 2015 and are being evaluated for smut resistance.

Jaggery characters

(A. Bhaskaran and A. Vennila)

Jaggery of the AVT (early) clones were of A1 grade based on NR value. The standards Co 94008 and CoC 671 yielded golden yellow jaggery while CoN 09072 yielded brownish yellow jaggery. The jaggery colour of Co 09004, Co 85004 and Co 09007 were yellow. Clones CoN 09092 and Co 09004 gave higher jaggery recovery (14.75 and 13.89%, respectively) on par with the best standard CoC 671 (14.09%).

Fibre, nutrient uptake and nutrient use efficiency

(C. Palaniswami and A. Vennila)

The mean fibre content of the AVT (early) clones ranged between 12.08 and 13.96%. There was no significant difference among clones and standards. Potassium content in the green leaves and dry leaves ranged from 0.37 to 1.74 and 0.12 to 0.55% on dry weight basis, respectively. Potassium uptake ranged from 89.93 to 324.32 kg/ha.

Ethanol production

(C. Palaniswami and A. Vennila)

Ethanol production in AVT (early) clones ranged from 8.33 to 11.90 ml per 100 ml juice. Significant

difference (p=0.05) in ethanol production potential was observed. The ethanol production in CoN 09072 and Co 09004 were on par with the standard CoC 671 but significantly higher than the standards Co 85004 and Co 94008. Ethanol yield ranged from 4918 to 6824 l/ha. The ethanol yield of the clones CoN 09072 (6526 l/ha) and Co 09004 (6823 l/ha) were on par but significantly higher than the standards CoC 671 and Co 94008.

Screening AVT clones for salinity tolerance

(S. Vasantha)

Four AVT clones (Co 09004, CoN 09072, Co 09009 and Co 09007) were screened for salinity tolerance in micro plots. Based on cane and sugar yield at harvest, Co 09004 and CoN 09072 were found to be tolerant and Co 09009 and Co 09007 were sensitive to soil salinity, at soil EC of 8 dS/m.

Screening AVT clones for drought tolerance

(R. Gomathi)

Four AVT clones of 2009 series (three early and one mid-late) were planted in split plot design along with two resistant standards (Co 86032 and Co 99004). Drought stress was imposed by withholding irrigation during formative phase of the crop (60-150 DAP). The percentage of soil moisture depletion was worked out at 30, 60 and 90 days after drought treatment through gravimetric method as 28.5, 39.5 and 57.0 over control, respectively. No rainfall was received during the treatment period. Among the clones screened for drought tolerance, Co 09004 was rated as tolerant (T), Co 09007 as moderately tolerant (MT) and CoN 09072 and Co 09009 as susceptible (S) for drought. During this planting season, 18 AVT clones of 2010 series were planted for multiplication.

Screening for red rot

(P. Malathi)

In 2014, 129 PZVT clones of 2013 series were planted in the field and screened by plug and nodal method of inoculation, of which 62 clones by plug and 71 clones by nodal methods were found to be R/MR.

Screening for smut

(A. Ramesh Sundar)

During the season, PZVT 2013 series were screened for smut and 37 entries were identified as resistant. The resistant standard Co 6806 remained resistant to smut whereas the susceptible standard Co 96007 behaved as highly susceptible.

Fluff supply and National Hybridization Programme

(A. Anna Durai and Adhini S. Pazhany)

Five hundred and ninety nine parental clones including 19 new introductions (CoPb 09181, CoPb 12181 and CoPb 12182 from PAU, Faridkot; CoSe 01434 from Seorahi; LG 05302, LG 05403, LG 07408, LG 07482, LG 07501, LG 07560, LG 07615, LG 07671, LG 07672, LG 07951, LG 07953 and LG 08422 from IISR, Lucknow and CoA 12321, CoA 12322 and CoA 12323 from ANGRAU, Anakapalle) were planted in NHG 2014.

The existing database on 599 parental clones in NHG was revised by adding the data on pollen fertility, smut reactions and reaction to different abiotic stress and was uploaded in the Institute website. Data on different phases of flowering of these clones *viz*., short blade, tip emergence, bulk tip emergence and anthesis were collected and hosted in the website with weekly updates during September - December 2014. Among the 599 parental clones, 514 clones (85.81%) flowered during 2014.

Twenty three participating centres of fluff supply programme other than Nayagarh and Bethuadahari took part in the hybridization programme. Four hundred and fifty four station crosses and 15 selfs were made. Apart from these station crosses, 56 proven crosses were made for four zones - Peninsular zone (14), East Coast zone (13), North West zone (13) and North Central and North East zones (16). Besides these bi-parental crosses, 21 poly-crosses and 295 general collections were also done for these centres. Maximum number of station crosses were made by Shahjahanpur (33 crosses) followed by Seorahi (29) and Padegaon (28).

Fluff weighing 37.28 kg of the crosses made at Coimbatore was supplied to the 23 participating centers. Number of crosses / selfs made and quantity of fluff supplied to different participating centers of fluff supply programme during 2014-15 are given in Table 10.

Table 10. **Number of crosses made and quantity of fluff supplied during 2014-15**

Centre	Station crosses and selfs		Zonal crosses		Poly-crosses		General collections		Total quantity of fluff (g)
	Number	Fluff weight (g)	Number	Fluff weight (g)	Number	Fluff weight (g)	Number	Fluff weight (g)	
Peninzular zone									
Mandya	19	431.0	14	150.5	13	406.5	-	-	988.0
Navasari	16	295.5	14	144.5	13	383.0	11	387.5	1210.5
Padegaon	28	797.5	14	146.0	13	390.0	13	291.0	1624.5
Perumalapalle	16	322.5	14	143.0	13	386.5	14	339.5	1191.5
Powarkheda	15	251.5	14	136.5	13	428.5	14	516.5	1333.5
Pune	15	342.5	14	153.0	13	370.0	7	322.5	1188.0
Rudrur	26	591.0	14	147.0	13	391.5	5	173.0	1302.5
Sankeshwar	15	271.5	14	150.5	13	418.5	4	273.5	1114.0
Thiruvalla	17	307.5	14	141.5	13	409.0	18	379.0	1237.0
Total	167	3610.5	14*	1312.5	13*	3583.5	86	2682.5	11189.0
East Coast zone									
Anakapalle	33	746.0	13	308.0	13	418.0	52	587.5	2059.5
Cuddalore	20	471.5	13	318.0	13	415.0	18	650.0	1854.5
Vuyyuru	31	732.5	13	325.0	13	381.0	18	397.5	1836.0
Total	84	1950.0	13*	951.0	13*	1214.0	88	1635.0	5750.0
North West zone									
Faridkot	16	435.0	13	152.5	8	388.0	34	1014.7	1990.2
Kapurthala	22	460.0	13	151.0	8	312.0	21	733.5	1656.5
Uchani			13	148.0	8	402.5	41	1573.5	2124.0
Lucknow	13(10)	458.5	13	146.0	8	325.0	62	1003.0	1932.5
Karnal	17	426.0	13	150.5	8	342.0	1	65.5	984.0
Shajahanpur	33	690.0	13	142.0	8	388.5	29	1232.7	2453.2
Pantnagar	24	599.0	13	135.5	8	317.0	10	357.0	1408.5
Total	125(10)	3068.5	13*	1025.5	8*	2475.0	198	5979.9	12548.9
North Central and North East zone									
Burlikson	15	399.5	16	352.1	8	317.0	5	160.0	12228.6
Motipur	15	433.6	16	355.5	8	314.5	25	1241.5	2345.1
Pusa	19(5)	556.0	16	333.5	8	356.5	51	1186.5	2432.5
Seorahi	29	656.0	16	318.5	8	354.5	15	453.5	1782.5
Total	78(5)	2045.1	16*	1359.6	8*	1342.5	96	3041.5	7788.7
NHG, CBE	454 (15)	10674.1	56	4648.6	21	8615.0	295*	13338.9	37276.6
NDHF, Agali	74	1264.0	-	-	-	-	25	650.5	1914.5
Grand total	528 (15)	11938.1	56	4648.6	21	8615.0	320	13984.4	39191.1

Values in parentheses indicate number of selfs; * excluding duplicates

Testing of seed germination

(N Rajendra Prasad)

The germination potential of fluff from 1000 crosses/selfs/open pollinated collections from National Hybridization Garden was tested. In general, the seed set was good. The crosses CoJ 82315 x SP 80-185, CoS 96268 x Co 62198, Co 05011 x ISH 176, Co 99006 x 85 R 186 and 97R401 x Co 775 gave more than 400 germinants per gram of fluff.

DUS testing (at Coimbatore)

(M.N. Premachandran and C. Jayabose)

For maintenance breeding, 183 reference varieties were clonally replanted and maintained in the field. The varieties were maintained free of pests and diseases and the growth parameters were monitored. Two farmer's varieties were planted along with the reference varieties. Three candidate varieties were planted along with seven reference varieties as per the DUS test guidelines for DUS testing during 2015-16.

Breeder seed production

(N. Rajendra Prasad)

Two seed crops were planted in April and November 2014. The newly notified varieties Co 06027 for Peninsular zone and Co 06030 for East Coast zone are introduced in the seed chain along with other varieties Co 86032, Co 0403, Co 99006, Co 99004, Co 2001-13 and Co 2001-15. A total of 137 tonnes of breeder seed was supplied to farmers and sugar factories of Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu. Seedling nurseries were raised using bud chips of varieties Co 86032, Co 99006, Co 06027 and Co 06030 in seedling trays and about 24,200 transplants were distributed.

Micropropagation and production of tissue culture plants

(D. Neelamathi)

Out of 31,122 tissue culture plants produced through apical meristem tip culture, 28,122 plants of varieties Co 86032, Co 99006, Co 06030 and Co 0403 were supplied to various sugar factories and progressive farmers in Tamil Nadu, Karnataka, Maharashtra and Kerala. Three thousand tissue culture plants of varieties Co 86032 and Co 0403 were used for planting in breeder seed plot of the Institute. Besides, 87 virus free mother culture flasks of Co 86032, Co 0403 and Co 06030 were supplied to different tissue culture laboratories.

Breeding sugarcane varieties for high biomass and total sugars

(P. Govindaraj)

Identification of new energy canes: Six new potential energy canes (SBIEC 14001 to SBIEC 14006) were identified with high harvestable biomass and fibre content. Among the 11 entries evaluated for fibre content and harvestable biomass at 330 days, the fibre content varied from 27.24 to 17.19%. SBIEC 14006 recorded the highest harvestable biomass of 233.65 t/ha (Table 11).

Table 11. **Yield and quality attributes of selected energy canes**

Clone	Cane Dia (cm)	SCW (kg)	Sucrose (%)	Brix	Harvestable biomass (t/ha)	Fibre (%)
SBIEC 14001	2.02	0.70	3.49	8.88	132.12	26.65
SBIEC 14002	2.10	1.30	13.25	17.38	186.92	20.41
SBIEC 14003	2.17	0.97	15.87	18.70	158.08	21.98
SBIEC 14004	2.21	0.73	10.79	14.36	136.15	25.24
SBIEC 14005	1.69	0.80	10.97	14.90	143.08	26.50
SBIEC 14006	2.25	1.20	5.87	9.92	233.65	27.24
CD (0.05)	0.48	0.27	1.77	1.66	32.04	2.86
CV (%)	11.73	13.65	9.31	6.01	12.23	5.97

Evaluation of energy clones under drought condition: Out of 10 energy canes (SBIEC 11001 to SBIEC 11010) evaluated under drought condition at the Research Farm of M/s. Nava Bharat Ventures Ltd., (Power Division), Dharmavaram, SBIEC 11002 was found to be vigorous and non-lodging in first ratoon. At nine months, juice Brix of more than 15 was observed in the clones SBIEC 11003 (15.26) and SBIEC 11008 (15.66). The moisture condent in bagasse ranged from 39.00 (SBIEC 11007) to 54.73% (SBIEC 11003). The tallest cane was observed in SBIEC 11008 with 392 cm. Based on field performance and juice quality, SBIEC 11002, SBIEC 11003, SBIEC 11008 and SBIEC 11010 were identified as the best Type I energy canes and SBIEC 11001, SBIEC 11006 and SBIEC 11007 as Type II energy canes.

Identification of superior sugarcane varieties for Tamil Nadu

(C. Appunu, A. Anna Durai and R. Karuppaiyan)

Varieties proposed for release in Tamil Nadu through CAE programme: The variety release proposal of clone Co 99006, an early variety, and Co 0212, a mid-late variety, was submitted for release and commercial cultivation in Tamil Nadu. Release of these varieties was deferred for want of additional data including Big Mill test.

2012-14 season trial: In Early trial with five test entries and two standards, 06 Si 021 was found to perform well for yield and quality in Coimbatore region. Co 0314 recorded higher CCS % of 13.42 than the best standard Co 86032 (12.52%). Under mid-late category, out of seven entries evaluated with standards Co 86032, Co 0320 and Co 0209 recorded the highest cane yield (151.5 t/ha) and CCS% (13.69), respectively compared to standard Co 86032 with cane yield (129.8 t/ha) and CCS% (12.97) in this region.

2013-15 season trial: Out of five early entries and five mid-late test entries evaluated for two plant and one ratoon crops, the clone Co 06015 was found to perform well for yield and quality across locations tested in Coimbatore region. Co 06015 recorded high average cane yield (141.5 t/ha) and CCS yield (19.13 t/ha) compared to standard Co 86032 with 119.4 t/ha and 15.92 t/ha, respectively. None of the entries from mid-late category performed better than the standards for yield and quality parameters.

2014-2016 season trial: Early trial with five test entries and mid-late trial with four test entries were planted in first plant crop during 2014-2015 at Bannari Amman Sugars Ltd, Sathyamangalam, Sakthi Sugars Ltd, Appakudal (Bhavani) and Ponni Sugars (Erode) Ltd, Erode. The clone Co 06022 recorded significantly higher cane yield in first plant crop at Appakudal (170.5 t/ha) and Sathyamangalam (165.8 t/ha) compared to the best standard CoC 24 for cane yield (143.6 and 155.8 t/ha, respectively).

2015-2017 season trial: Seed cane material of elite clones Co 07015 (early) and Co 08009 (mid-late) were supplied to CAE trial conducting factories for evaluation during 2015-2016 season. Two promising clones Co 08016 and Co 08020 were field planted for multiplication to be supplied for 2016-2018 trial.

Identifying location specific varieties for tropical region

(P. Govindaraj and C. Appunu)

Three early (Co 13023, Co 13024 and Co 07013) and seven mid-late (Co 13025, Co 13027, Co 13028, Co 13029, Co 13030, Co 13031 and Co 13032) maturing clones selected form Chagallu were proposed and accepted for inclusion in AICRP on Sugarcane, ZVT at East Coast zone.

Selections at M/s. Sakthi Sugar Mills Ltd. Appakoodal: Among the 40 clones evaluated, 21 clones viz., EB 09004, EB 09052, EB 09156, EB 09395, EB 09473, EB 09475, EB 09561, EB 09569, EB 09586, EB 09592, EB 09785, EB 09797, EB 09839, EB 09842, EB 08184, EB 08261, EB 10011, EB 10077, EB 10080, EB 10122 and EB 10127 were selected based on high sucrose content in juice, non-flowering type, high NMC, no splits, no spines in the leaf sheath and free from natural incidence of major pests and diseases. These clones were planted in RBD with five standards for final evaluation.

Selections at Sree Ambika Sugar Mills, Kottur: Two sets of trials were planted at Shree Ambika Sugar Mills, Kottur. The first trial was laid out with 16

entries selected based on juice sucrose % and cane traits (EB 09194, EB 09030, EB 09040, EB 09111, EB 09163, EB 09194, EB 09569, EB 09567, EB 09561, EB 09589, EB 09716, EB 09901, EB 08014, EB 08219, EB 08226, EB 08259) with six standards (CoA 92081, Co 86032, CoV 92012, Co 94008, CoC 671 and Co 99004). Another multiplication cum observation trial was planted in four rows of six meters length with 24 test clones.

Sugarcane varieties with *S. spontaneum* or *Erianthus arundinaceus* cytoplasm

(M.N. Premachandran and Adhini S. Pazhany)

Among 19 entries evaluated at Coimbatore, the highest cane yield was form CYM 11-518, a 5th generation BC hybrid with sugarcane of *S. spontaneum* x *E. bengalense* hybrid and CYM 11-511 had high sucrose % and high cane yield. Out of 116 clones tested for red rot reaction under controlled condition testing, 86 clones were R or MR to red rot. The red rot resistant clones CYM 11-84, CYM 12-406 and CYM 12-509 were selected for PZVT trial. A total of 97 entries along with three standards (Co 86032, Co 99004 and CoC 671) were clonally evaluated in replicated trial at SBIRC, Agali. Six elite clones *viz*., CYMA 10-2428, CYMA 10-1989, CYMA 10-2362, CYMA 10-2071, CYMA 10-7, and CYMA 10-1040 were selected for PZVT. CYMA 09-525 with *E. arundinaceus* cytoplasm with high cane yield of 126.4 t/ha and 19.98 sucrose % juice was assigned 'Co' number Co 15015. From fifteen crosses made using hybrids with *S. spontaneum* or *E. arundinaceus* cytoplasm, 868 seedlings were transplanted to ground nursery.

A new cpDNA specific primer tested could differentiate the chloroplast DNA of *S. spontaneum* and *S. officinarum*. It was found that all the interspecific/ intergeneric hybrid clones with *S. spontaneum* type cpDNA had *S. spontaneum* type mtDNA, hybrid clones with *S. officinarum* type cpDNA had *S. officinarum* type mtDNA and those with *E. arundinaceus* type cpDNA had *E. arundinaceus* type mtDNA only.

Disease free biotized tissue culture plants through direct regeneration

(D. Neelamathi)

Virus free tissue culture plants produced through apical meristem culture and shoots regenerated from leaf segments of virus free source material by direct regeneration method were multiplied for further virus indexing and testing for genetic purity. Bacterial cultures of *Bacillus subtilis*, *Pseudomonas fluorescence, Gluconacetobacter diaztrophicus* and *Mehylobacterium* species were inoculated in tissue culture plants prior to hardening as root dipping and soil application. Root dipping of *Gluconacetobacter diazotrophicus* showed significant increase in plant growth 30 days after transplanting in terms of leaf length, root length, shoot and root weight. This was followed by *Pseudomonas fluorescence, Bacillus subtilis, Mehylobacterium* and uninoculated control. To confirm the growth promoting effect of the beneficial bacteria, physiological and enzyme analysis are in progress.

5.1.2 BASIC AND STRATEGIC RESEARCH FOR SUGARCANE VARIETAL DEVELOPMENT

Development of high sucrose genetic stocks through recurrent selection

(R.M. Shanthi)

Genetic improvement for juice sucrose content was assessed in 220 sucrose clones generated through simple recurrent selection from selection cycles I-IV. A large proportion of the clones recorded HR Brix above 23.0 at 240 days. Juice analysis at 300 days indicated that 28 clones recorded 22.0% and eight clones recorded more than 23.0% sucrose. Eleven clones registered more than 10.0 % improvement for juice sucrose over the standard CoC 671 (Fig. 3). Two clones, 05-0234 and 05-0257, with high sucrose and less flowering intensity have the potential to be exploited as short duration varieties. Overall performance of the clones indicated that cycles III and IV showed a corresponding increase in the frequency of high sucrose clones. Out of 80 clones evaluated for red rot by CCT method, 13 high sucrose clones were found to combine resistance to red rot.

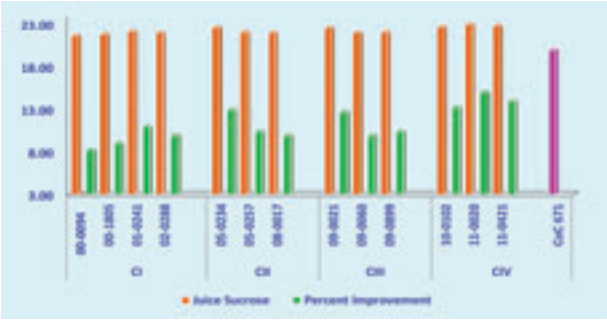


Fig. 3. Improvement for juice sucrose over four selection cycles

Genome characterization of *Saccharum* using molecular markers

(N. Vijayan Nair and A. Selvi)

Identification and characterisation of Erianthus specific TRAP markers: Screening of *Erianthus*, *Saccharum* species clones and confirmed intergeneric hybrids with 150 TRAP primer pairs revealed that 25 primer pairs were very consistent in identifying hybrids. The *Erianthus* specific markers that were distinctly amplified by these primer pairs were eluted, reamplified, purified and sequenced. Good quality sequences were obtained for 21 markers. The size of the sequences ranged from 120 – 700bp. The sequences of the *Erianthus* specific TRAP markers showed similarities with gene sequences that are involved in stress responses in an array of crop species. These include similarity to gene products expressed in response to oxidative stress in rice, homology to chromosomal segment containing *Sorghum bicolor* genes that are orthologous to the *Zea mays* Rp1 disease resistance (R) gene complex, similarity to *Saccharum* hybrid cultivar R570 serine/threonine protein kinase sequences that are conserved motifs of disease resistance genes, homology to *Oryza sativa* Japonica group genomic DNA sequences similar to putative Zinc transporter zupT, similarity to *Saccharum* hybrid cultivar R570 retrotransposon, complete sequence, etc. Other *Erainthus* specific fragments that were characterized also showed similarities to candidate genes that are often involved in stress responses including transcription regulation, heterochromatin expansion, reterotransposan, SSR and SNP that lie in the vicinity of disease resistant genes in sugarcane, sorghum, wheat and cotton. The similarity results may serve as important pointers to the functions the *Erianthus* specific markers may be involved in. These markers could be developed as potential candidate gene markers for monitoring the introgression of important stress resistance traits from *Erianthus*.

Population improvement for yield and quality through recurrent selection

(S. Alarmelu, G. Hemaprabha and R.M. Shanthi)

Evaluation of cycle I, II, III and IV hybrids for yield (Ax A): Among the 60 hybrids of A x A population, 12 clones were promising for quality and 38 clones recorded sucrose condent of 20.0% and above. The clone C4-22 recorded the maximum sucrose of 23.66%. Cane yield ranged from 75.21 to 138.13 kg in the population. Among cycle four hybrids of A x A population, 11 hybrids were promising and three hybrids recorded the maximum sucrose of 20.1% at 300 days. Variability was high for yield parameters in the developed population. Among the C3 and C4 hybrids evaluated for juice and yield traits at 360 days, 13 hybrids were promising of which C4 -66 recorded the maximum sucrose of 23.66% followed by C3- 41 with 22.84% and C3 -12 with 22.85% in comparison with CoC 671 (23.17%). Among the hybrids tested for red rot by CCT, 36 were MR, 20 R and 30 MS types.

There was a substantial improvement for cane weight in four cycles of selection. C1 and C 2 hybrids showed substantial improvement for cane height. Cycle three hybrids showed an improvement of 12.21, 13.01, 20.09 and 9.36% and C4 hybrids showed an improvement of 6.13, 9.19, 22.21 and 11.02% for cane height (cm), cane thickness, cane weight and stalk number respectively in comparison with the base population (Fig. 4).

Recurrent selection cycle in population A x B: Among the 300 hybrids (A x B) evaluated, cane yield ranged from 50 to 125 kg /row. Twenty hybrids were promising for both yield and quality parameters. Among the 120 clones in A x B population, five clones combined good yield, quality and were non-flowering types and 19 had juice sucrose above 20.00%.

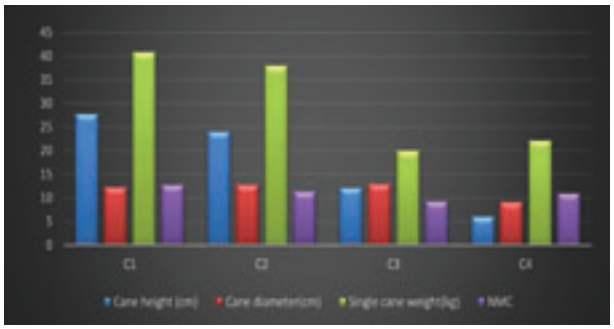


Fig. 4. Generation-wise improvement (%) for yield traits in comparison with the base population (Co) over four cycles of recurrent selection in A x A

Recurrent selection cycle in population B x B: Among the 170 Cycle III hybrids of B x B, 81 clones recorded high NMC (11-25/clump), cane thickness (2.58-.3.39 cm) and Brix (18.0-25.0). One hundred and fifty promising clones from A x B and B x B populations were planted for further evaluation.

Two clones 2013-42 (Co 15004) and 2013-23 (Co 15005) were promoted to Co status. Seventeen clones were proposed for PZVT testing.

Identification of candidate genes and markers for red rot resistance

(A. Selvi, P. Malathi and P.T. Prathima)

Cloning and sequencing of RGAs associated with resistance and susceptibility: A set of 10 RGA primer pairs were shortlisted from 137 primer pairs developed. RGAs developed for sugarcane were screened on a set of 88 sugarcane cultivars that are resistant and susceptible to red rot disease for confirmation of their associations with red rot disease. Five R specific sequences that showed associations with red rot resistance and one susceptible specific fragment that was associated with susceptibility were sequenced and characterized. Introns and exons and promoter sequences were predicted.

In order to check the abundance and diversity of the resistant gene analogues, 32 primer pairs that amplify resistant gene analogues in sugarcane were amplified on *S. officinarum, S. robustum, S. spontaneum, S. barberi, S. sinense* and related genera *Erianthus,* sorghum, maize and rice. Thirty primer pairs amplified in all the related species and genera whereas two primer pairs failed to amplify. Ten primer pairs (31.25%) amplified all the species and genera with similar fragment size whereas 20 primer pairs amplifying all species and genera showed abundance in the RGAs amplifies as well as variability in size of the products in the different species and genera..

Whole transcriptome sequencing of sucrose regulating genes in sugarcane

(P.T. Prathima)

Saccharum spontaneum 'Coimbatore', *Saccharum officinarum* 'Black Cheribon' and a sugarcane hybrid cultivar CoC 671 were selected for transcriptome sequencing. Total RNA extracted was reverse transcribed to complementary DNA and cDNA templates were then amplified by long-distance PCR (LD-PCR) using SMARTer ultra-low input RNA for Illumina Sequencing- HV (Clontech Labaratories, CA, USA) kit. The paired-end cDNA sequencing libraries were prepared using illumina TruSeq Nano DNA HT Library Preparation Kit as per the described protocol. Library quantification and qualification was performed using DNA High Sensitivity Assay Kit. The three pair-end libraries were prepared using SMARTer ultra-low input RNA for Illumina Sequencing- HV followed by illumina TruSeq Nano DNA HT Library Preparation Kit. The means of the library fragment size distributions were 543 bp, 569 bp and 523 bp for *S. spontaneum*, CoC 671 and *S. officinarum*, respectively. The libraries were sequenced using 2 X 150 PE chemistry on NextSeq-500 for generating ~6 Gb of data per sample. The raw data were obtained and sequence analysis for novel transcripts identification using BLASTx results is in progress.

Isolation and characterization of invertase inhibitor genes from sugarcane

(P.T. Prathima, R. Manimekalai and S. Vasantha)

A 650 bp invertase inhibitor gene was cloned and characterized from *S. spontaneum*. The sequence was found to have 92.0% similarity with *Zea mays* invertase inhibitor gene (NM_001157609.1). The open reading frame (ORF) of the cloned gene encodes 193 amino acid residues, a complete protein with start and stop codons,. Its subcellular

location and *in-vivo* function were characterized in silico using various online bioinformatics resources. Sequence was deposited in NCBI-GenBank database (accession no. KP055631). Sugarcane invertase inhibitor gene sequence showed highest identity with *Sorghum bicolor* invertase inhibitor sequence. This is the first report of invertase inhibitor gene isolated from sugarcane.

Genes involved in lignin biosynthesis pathway of sugarcane

(K. Lakshmi)

Sub-cloning of Caffeic acid O Methyl transferase (COMT) gene into prokaryotic expression vector pET22b: A full length of COMT (1089) has been cloned from *Sacharrum officinarum* (PIO 00 809) and submitted in NCBI genebank (NCBI ID: KM370990). The sugarcane full-length COMT cDNA consists of an 1181-bp fragment with the translational start site of the major open reading frame (ORF) at nucleotide 26 and the TAA stop site at nucleotide 1141 which codes for a 362-amino acid polypeptide with a calculated molecular mass of 39.56 kDa and predicted isoelectric point of 5.23. The G+C content of the coding region was 66.85% which proves it for a typical graminaceous monocot. Comparison of this protein with maize COMT gives an identity of 91.16% over the entire amino acid sequence. The seven characteristic motifs (Fig. 5) of plant OMT-II S-adenosyl-L-methionine-dependent methyltransferases and the distances between them are well conserved as well as it consisted of a single dimersation domain from position 31-85 therefore it belongs to the plant OMT-II superfamily. The full length COMT was amplified with gene specific primers designed with EcoRI and HindIII restriction

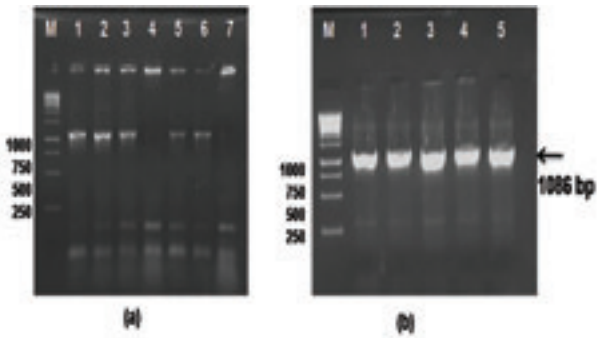


Fig. 6. Confirmation of the transformants by PCR with COMT specific primers

sites and sub cloned into pET expression vector and transformed into appropriate BL21 host for protein expression analysis. All colonies were confirmed through colony PCR and plasmid PCR with gene specific primers (Fig. 6).

5'RACE PCR for the full length gene isolation of PAL: The conserved region of Phenylalanine ammonium lyase (PAL) gene sequence (~650 bp) cloned earlier was used for primer designing in 5' and 3'RACE. The sequences from the sense and anti sense strands served as a template for the designing of primers named S1, S2, A1 and A2. RNA isolation was done from the *Erianthus* clone IK 76-81 and the cDNA conversion was done. S1 and A1 primers were used for primary PCR, which was followed by a secondary PCR where the template is the product of primary PCR. Finally the products were verified on 1% agarose gel electrophoresis. The product size of ~1.5 kb was obtained. The sequence results showed that it consists of 520 amino acids which gave 93% similarity with the 5' region of PAL gene reported in other crops. The protein sequence of PAL was analyzed through Protein Feature View of PDB (Fig. 7).

Fig. 5. Amino acid sequences showing the motifs of O' Methyl transferase Class-II

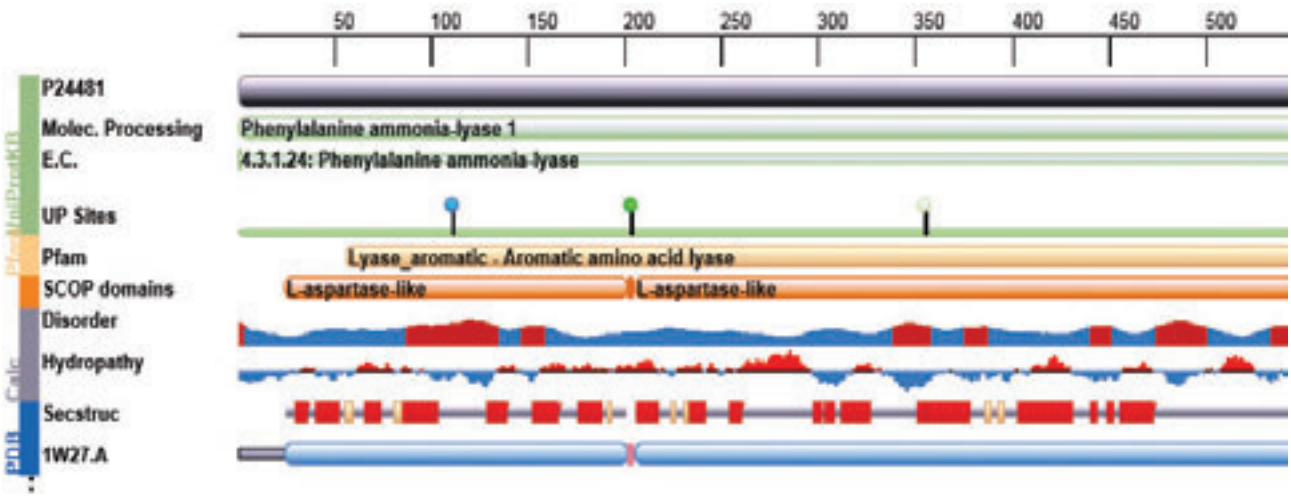


Fig. 7. Conserved domain identified for the gene PAL involved in lignin biosynthesis pathway

Protein homology by domain architecture of PAL showed specific hits to Lyase class I superfamily which contains the histidine ammonia-lyase and phenylalanine ammonia-lyase, which catalyze similar beta-elimination reactions of ammonia from histidine and phenylalanine, respectively. The secondary structure of the PAL protein consists of 50% α Helix, and 43% Coil as well as the 3D structure of the protein showing a single domain. The results showed that it consisted of two L- Aspartase like SCOP domain, belonging to the aromatic amino acid lyase family. Two vital sugarcane genes involved in lignification which might open up the possibility of producing plants with lower and/or modified lignin by genetic engineering means were cloned and characterized.

Mechanism of chromosome elimination and allelic variation in centromeric region in sugarcane

(V.P. Sobhakumari and P.T. Prathima)

A total of 13 progenies of a cross which involves commercial sugarcane, *S. officinarum* and *Erianthus*, *i.e.* Co 7201x (28 NG 210 x IK 76-78) were cytologically analyzed and stable and unstable clones were identified. In the hybrid, IGH 43, with 2n=110, the expected 2n chromosome number was identified and other progenies with different levels of chromosome elimination were also identified (Fig. 8). The somatic chromosome numbers of the progenies are : IGH-84 (2n=96), IGH-87(2n=102), IGH-75(2n=90), IGH-4(2n=96), IGH-5 (2n= 96), IGH-39 (2n=92), IGH-77(2n=98), IGH-8 (2n=88), IGH- 86 (2n=96), IGH-43 (2n=110), (IGH 56 (2n=96). Comparative study showed that among the progenies there is a gradual reduction in cane diameter with reduction in chromosome number. The progenies were showing intermediate characteristics when compared with the parents (Fig. 9).

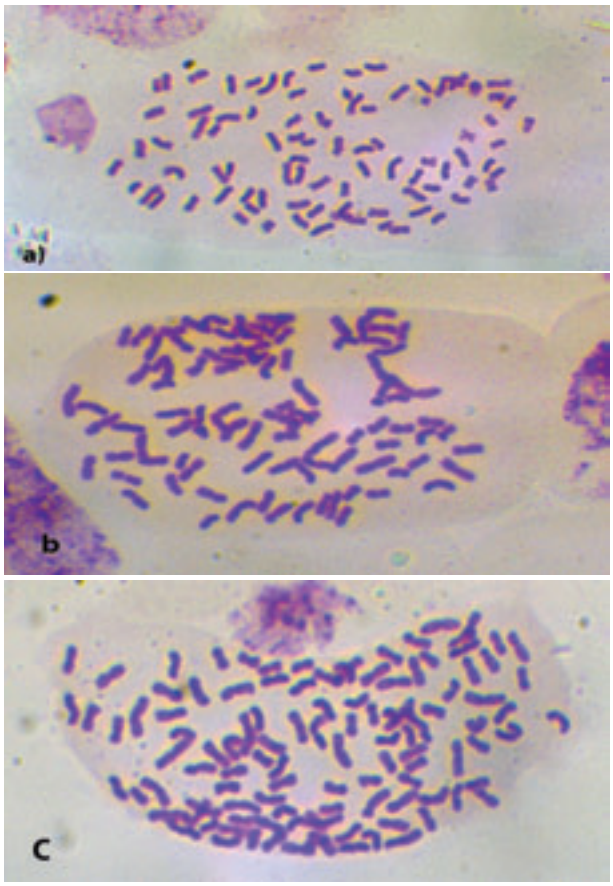


Fig. 8. Somatic chromosome number of (a) IGH-8 (2n=88), (b) IGH-86 (2n=96), (c) IGH-43 (2n=110)

Fig. 9. Parents and progenies of Co 7201 x (28 NG 210 x IK 76-78). a) Co 7201 (2n=110), b) IGH-8 (2n=88), c) IGH-86 (2n=96), d) IGH-43 (2n=110). e) 28 NG 210 x IK 76-78 (2n=110).

A CENH3 gene was identified and cloned from sugarcane. Upon sequencing, it showed 96% homology with *Sorghum* CENH3 sequences and 91% with *Zea mays* CENH3 sequences. Subsequently, differential expression of these genes in clones with different levels of chromosome elimination has been studied. Amplification of CENH3 has been obtained in all the parents and four progenies of Co 7201x (28 NG 210 x IK 76-78). The expression analysis is in progress.

Transcript-SSR markers for sucrose synthesis and WRKY transcription factors

(R.M. Shanthi and G. Hemaprabha)

For microsatellite search 1,50,000 non-redundant transcript assemblies from TIGR database of *S. officinarum* were used. Using a special UNIX C program 18,275 transcript SSRs in the ORFs, 3′ UTR & 5′ UTR were retrieved. These SSR motifs represented genes associated with important metabolic processes such as photosynthesis, carbohydrate metabolism, sugar transport and amino acid metabolism, biotic & abiotic stresses.

Thirty two primers specific to the eight major enzymes in sucrose metabolism (soluble acid invertase, cell wall acid invertase, neutral invertase, fructokinase, sucrose phosphate synthase, pyrophosphate dependant phospho-1-fructokinase, di-phosphate fructose-6-phosphate-1-phosphotransferase, fructose1,6-bi-phosphatase) were designed. The WRKY gene family plays important roles in the regulation of various physiological programs that are unique to plants, various biotic and abiotic stress factors (drought, pathogen defense response *etc*). Twenty one primers specific to WRKY protein and putative disease resistance response protein were designed for WRKY transcription factors. Fifty clones with more than 19.0% sucrose and 50 clones for WRKY transcription factors were identified for this study.

The annealing temperature (Tm) of 22 SSR primers specific to eight major enzymes in sucrose metabolism was optimized. The standardized Tm for sucrose synthase and sucrose phosphate synthase enzymes specific primers was 56^{0}C. The SSR primers for Neutral Acid Invertase were optimized at 60^{0}C.

Genetic engineering of sugarcane for enhanced salinity stress tolerance

(K. Lakshmi and C. Appunu)

The gene construct pCAMBIA 1302:: GLY I & II (Fig. 10) for salinity stress tolerance was procured from ICGEB, New Delhi. This was eluted in the TE buffer and transformed into *E. coli* DH5α for maintenance. Gene specific primers for Glyoxalase I & II were designed and the gene construct received was confirmed through PCR for both the genes which produced an amplicon of 558 bp for GLY I and 1008 bp for GLY II (Fig. 11). After confirmation, the gene construct was mobilized into *Agrobacterium* host, by which *Agrobacterium* strain LBA 4404 was inoculated and the gene construct pCAMBIA 1302 :: GLY I & II was transformed through freeze thaw method.

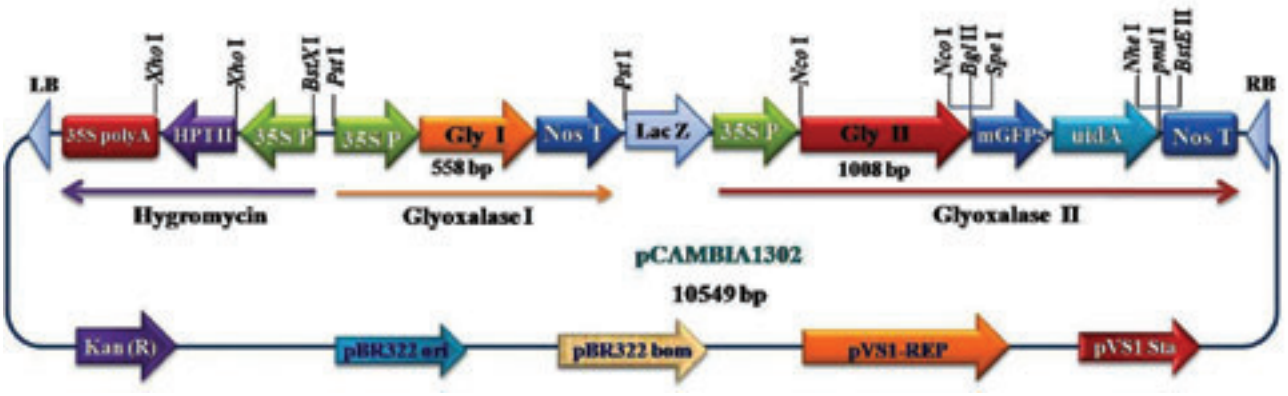


Fig 10. Map of the gene construct pCAMBIA 1302 :: GLY I & II

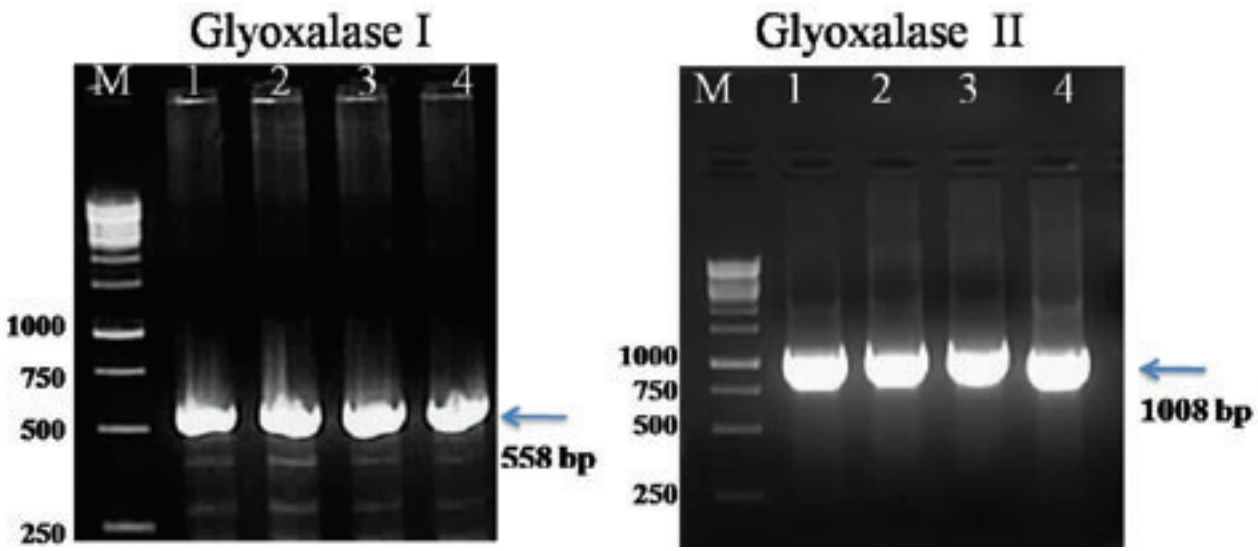


Fig 11. Confirmation of the gene construct by PCR with GLY I & II specific primers

Embryonic calli developed from leaf whorls of sugarcane clone Co 86032 were selected, co-cultivated with pCAMBIA 1302 :: GLY I & II along with acetosyringone. After two days of infection the calli were placed on callus proliferation medium for a 30 days and calli wee separated from the explant and placed on primary selection medium with hygromycin as the plant selection marker.

Isolation and characterization of low temperature tolerance genes from *Saccharum spontaneum*

(C. Appunu)

Nine *Saccharum spontaneum* clones from high altitudes of Arunachal Pradesh along with two *Erianthus arundinaceus* clones were used to study growth during winter at SBI-Research Centre, Karnal. The *S. spontaneum* clone IND 00-1037 had the highest growth rate in winter season followed by clone IND 00-1043. The clone IND 00-1037 was selected and multiplied for isolation and functional characterization of low temperature tolerance responsive genes. Total RNA was isolated from leaves of 90 days old plants after exposing to cold stress (10±2^{0}C) for 24 h and cDNA library was prepared for identification of differentially expressed genes under cold stress.

Genetic engineering of sugarcane for water deficit stress tolerance

(N. Subramonian, C. Appunu and M. N. Premachandran)

Twenty five transgenic events from different transgenics using EaDREB2, EaHSP70, PDH45, and

EaDREB2 & PDH45 were screened for tolerance to soil moisture stress at the V1 generation in the formative phase (120 days of growth) by withholding irrigation for 10 days and the recovery of the plants after stress was studied with subsequent irrigation. In general, the transgenics showed increased photosynthesis rate, stomatal conductance and transpiration rate compared to untransformed control plants. There was a significant increase in relative leaf water content in transgenics under water stress compared to that of control plants. Over expression of EaDREB2 and/or EaHSP70 were able to impart high level of drought tolerance in the transgenics. A total of 18 promising events (4-5 events/construct) from each of the transgenics were selected for further screening for drought tolerance and studying the water use efficiency. Total RNA from these promising transgenics was isolated to confirm the stability of transgene expression in V2 generation through RT-PCR.

PDH45 sequences were amplified using gene specific primers with flanking restriction sites that were not present in the gene sequences. Primers were designed in such a way that PDH45 sequence with NcoI (CCATGG) restriction site is anchored to the forward primer and NheI (GCTAGC) in the reverse primer. Sugarcane variety Co 0238 was transformed with PDH45 gene through *Agrobacterium* mediated transformation. The differentiated plantlets were rooted, hardened and transferred to pots in the transgenic green house. Nearly 14 transgenic events were obtained and transgene presence was confirmed with transgene-promoter fusion primers (Fig. 12) and also by amplification of marker gene. All these events are being pot planted for further multiplication.

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

(A. Suganya and R. Karuppaiyan)

Twenty backcrosses were effected with the progenies of cytotypes 2n=40, 60, 64 and 88. Germination of the crosses ranged from 2-355 seedlings per cross with the highest germination in backcross involving the cytotype 2n=40.

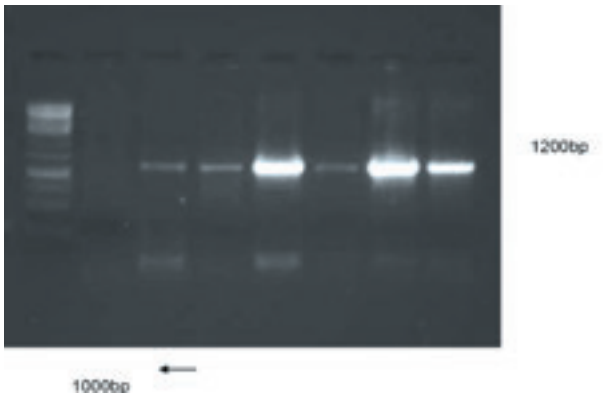


Fig. 12. PCR analysis for PDH45 gene in putative transgenics of sugarcane variety Co 0238. M - 1 KB ladder; lane 1 - negative control; lanes 2, 3, 4, 5, 6 - PDH 45 transgenics; lane 7 - positive control

In ground nursery, backcrosses involving '2n' transmission and other crosses were evaluated for NMC, plant height, thickness, single cane weight and HR Brix at 12th month. Among the crosses with '2n' transmission, high mean value of 263.4 cm was observed for height and 598.0 g for single cane weight in the cross of [(04 - 2153, Co 89029 x IND 82- 321) x (04 - 244, Co 89029 x IND 84 -394)]. The progenies of 04 - 2153 x Co 0453 had higher variability for Brix, NMC and single cane weight. A backcross progeny of Co 0233 x (Co 8371x *S. spontaneum*) possessed single cane weight of 1.25 kg. In the BC2 of 06-225 x CoC 671, four hybrids had Brix value of more than 23.0. About 60 selections were made from these crosses for further studies and utilization.

Meiotic studies in 22 hybrids derived with the cytotype 2n=40, 56, 60, 64, 72 and 112 revealed predominance of bivalents with 1-6 univalents. Mean chiasma/ bivalent ranged from 1.35 in 04-1873 (Co 89029 x IND 84-394, 2n=112) to 1.87 in the hybrid 04-2208 (Co 1148 x IND 84-337, 2n=56). The hybrids derived with 2n=40 had mean chiasma as 1.58. Trivalents were observed in two hybrids derived with 2n=40 and 2n=112. The hybrids derived from the cytotype 2n=56 and 72 exhibited abnormalities with laggards, bridges and micronuclei. The hybrid 04-2208 possessed 34.6 bivalents, 5.7 univalents with unevenly distributed 3-12 laggards, 1-6 bridges and 4.8 micronuclei/ microspore.

Instrument for on-field fibre content measurement in sugarcane

(P. Govindaraj, K. Hari, RavindraNaik and Nachiket Kotwaliwale)

A basic prototype of digital penetrometer was fabricated by integrating mechanical components designed by ICAR-CIAE and electronic components by ICAR-SBI. The mechanical component consists of a needle attached to a piston like arrangement. The end of the piston lands on a force sensor which is interfaced with a microprocessor. Standardization of length and diameter of the puncturing needle, fine tuning of force measurement and different methods of integrating mechanical and electronic components was carried out to make a workable prototype. Suitability of this prototype was evaluated in 63 genotypes consisting of Co canes, nobilized canes and interspecific and intergeneric hybrids and genetics stocks for rind hardiness. Consistency among the replications and variability among the genotypes were observed. In general, the digital readings from prototype were higher in bottom portion followed by middle and top.

Correlation coefficient was worked out between the digital readings in top, middle and bottom of the cane and the fibre %. The correlation between fibre content and the digital readings in the middle portion of the cane was positive and significant (0.6287) and comparatively higher than the correlation between fibre content in top (0.4036) and bottom (0.4785) positions of the cane. Fibre analysis and recording of rind hardiness in 150 clones with manual and digital penetrometers was carried out. Relationship between the manual rind hardiness instrument and newly developed digital hardiness meter was estimated. The digital readings in bottom portion of the cane had significant positive relationship (0.5098) with the manual penetrometer. Further refinement of the instrument to improve the accuracy and working out appropriate algorithm to convert the observed value into the fibre units are in progress.

5.1.3 GENETIC RESOURCES

Sugarcane germplasm: Collection, maintenance, evaluation, documentation and utilization

Maintenance of wild sugarcane germplasm

(S. Karthigeyan and Adhini S. Pazhany)

A total of 1459 wild germplasm clones comprising *Saccharum spontaneum*, *Erianthus* spp, allied genera, improved *Erianthus* and other *Saccharum* clones (cane forming types) were replanted during December 2014 for field maintenance. True seeds of 25 *Saccharum spontaneum* accessions have been submitted to NBPGR, New Delhi for long term conservation.

Maintenance of commercial hybrids and genetic stocks

(K. Mohanraj and T. Manjunatha)

A total of 1667 clones comprising 1305 'Co' canes, 22 'Co' allied canes, 41 foreign clones and 204 ISH clones were maintained in the field for further utilization. All the clones were treated with aerated steam before planting to eliminate seed borne diseases.

Maintenance of NATP collection at Coimbatore and Wellington

(S. Karthigeyan)

A total of 458 clones were replanted in the field at Coimbatore during December 2014. Forty seven clones of *S. spontaneum*, and *E. procerus* collected from Arunachal Pradesh were maintained at IARI-Regional Station, Wellington, The Nilgiris.

National Active Germplasm maintenance

(C. Jayabose)

NAGS clones available in the quarantine have been verified for germination. Index number was assigned to 18 accessions received from different parts of the country. One hundred and ninety five notified and registered genetic stocks were planted in the field for maintenance.

Characterization and evaluation

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

Thirty morphometric traits have been recorded for the Nagaland collections of *S. spontaneum*. Among

the six 2n=40 cytotypes, the only clone IND 09-1520 (Himachal) alone flowered during the period of evaluation. There was increase in leaf lamina length in accordance with the altitude in all the 2n=40 cytotypes except IND 09 -1509. The clone IND 09- 1527 (Himachal Pradesh) collected at an altitude of 532 AMSL recorded 63.2 cm, IND 09-1520 from an altitude of 1035 AMSL expressed 93.7 cm and the clone collected from an altitude of 1950 AMSL (IND 09-1544, Uttarakhand) expressed 137.3 cm. The 2n=60 types occurred only in 1000 metres of AMSL. The HR Brix of the three clones of 2n=60 cytotypes *viz*., IND 09-1538, IND 09-1525 and IND 09-1545 was found to be more than 12. These clones did not flower at Coimbatore. The lamina midrib width was recorded as higher than other cytotypes (0.30, 0.33, 0.40 mm). Similarly mean internodal length and dewlap width was found to be more uniform for all the three clones (IND 09-1545 Uttarakhand, IND 09-1538 (Uttarakhand) and IND 09-1525 (Himachal Pradesh).

Phytolith extraction was carried out in *Erianthus* clones. Four class of phytolith characters *viz*., panicoid class eupanicoid sub family phytolith, cylindric sulcate tracheid (tracheid) type, festucoid class - circular crenate and elongate class elongate spiny and elongate concave were observed in *Erianthus* spp.

Selfing was done in 46 accessions of *S. spontaneum* and germination of fluff collected from open pollinated and selfed arrows was studied. Very poor seed set and germination was observed in selfed seeds. Pollen fertility of all the accessions was studied and no correlation was found between pollen fertility and selfed seed set.

Cataloguing

(C. Jayabose)

A catalogue on NATP collections was published.

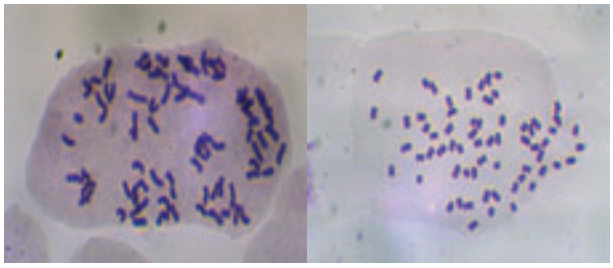
Cytological analysis of *Saccharum spontaneum*

(V.P. Sobhakumari)

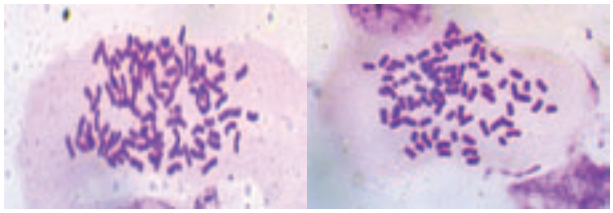
The somatic chromosome number of *S. spontaneum* clones collected from North West and North East regions of India and some clones collected from Indonesia were determined (Table 12, Fig. 13).

Table 12. **Chromosome number of *S. spontaneum* accessions**

Chromosome number (2n)	*S. spontaneum* accessions
From Nagaland and Manipur (2011)	
64	IND 11-1652, 1700, 1699, 1691,1624
56	IND 11-1625, 1597, 1683
54	IND 11-1536
80	IND 11-1650
72	IND 11-1623,1579
From West Bengal (2010)	
60	IND 10-1567, 1595, 1574
74	IND 10-15v85
72	IND 10-1577
From Rajasthan (2008)	
64	IND 08-1495, 1496
From Meghalaya, Manipur and Nagaland	
80	IND 89-653, 682
64	IND 89-640, 676
62	IND 89-745
From Indonesia	
92	IS 76-196
80	IS 76-222, 217
64	IS 76-192



IND 89-682 (2n=80) IS 76-192 (2n=64)



IS 76-196 (2n=92) IS 76-222 (2n=80)

Fig. 13. Somatic chromosomes of different cytotypes of S. spontaneum accessions

Floral biological studies and cytological characterization of *E. arundinaceus*

(A. Suganya)

The earliest flowering among *E. arundinaceus* clones was Mythan B in August and flowering in other clones was observed up to January. Sixteen clones had synchrony with sugarcane flowering duration. Anthesis occurred after 5-11 days of panicle emergence in the flowered clones studied. It was found to have dual anthesis in morning (5.30 -7.00 a.m.) evening (4.30 - 6.00 p.m.) and night (8.00 - 10.30) pm. The clone IMP 1547 had prolonged anthesis time from 8.00 - 10.30 p.m during rainy days. Chromosome number of 40 clones was confirmed (Table 13).

Table 13.* Chromosome number of clones of *E. arundinaceus

Clone	Place of collection	Chromosome number (2n)
SES153 and 288	India	30
SES 3, 7, 17, 75, 79, 89,136, 149 and 293.	India	40
SES 133	India	60
IK 76- 05, 22, 27, 55, 80, 81, 88, 91,92, 93, 99, 101, IS 76- 220, 126, 134, 145, 169 and 163	Indonesia	60
ERI 2385	-	60
US 57-03-01	Vietnam	60

Utilization of germplasm resources for broadening the genetic base

(K. Mohanraj and A. Suganya)

Hybridization: During 2014 flowering season, 32 crosses were made in the following categories: a) Eight backcrosses using interspecific hybrids involving *S. spontaneum* from Arunachal Pradesh; b) Twelve BC2 crosses involving BC1 hybrids of E. procerus *viz.*,GU 12-18, GU 12-35, GU 12-15; c) Six backcrosses involving *E. arundinaceus* GU 04(6) OE-3; d) four intercrosses among BC1 progenies involving *Erianthus procerus;* and e) two back crosses involving sorghum x *Saccharum* hybrids.

Fluff sowing and raising seedlings: A total of 2014 seedlings were raised from 17 crosses and transplanted in the field for evaluation. The seedlings were mostly from intergeneric hybrids involving *Erianthus*. High number of 382 seedlings were obtained from the back cross GU 04(28) EO-2 self x Co 0314 followed by GU 04(42) RS-2 x GU 10-103 (311 seedlings) and GU 04(50) RE-6 x Co 94008 (284 seedlings).

Evaluation of elite clones for yield, juice quality and red rot resistance: Thirty six clones involving improved *S. officinarum* and *Erianthus* were evaluated in two replications for yield, juice quality and red rot resistance. Twelve clones recorded more than 20.0% sucrose in juice compared to 20.2% in the standard Co 86032 at 360 days. The controlled condition testing for red rot reaction revealed that only 10 clones were resistant to red rot. One clone developed from the cross (CoC 671 x IG 91-1100) x Co 94008) with high yield, quality and red rot resistance was assigned 'Co' status as Co 15018.

Evaluation of BC1 hybrids involving Erianthus procerus*:* A total of 32 BC1 hybrids from the cross GU 04 (28) EO-2 involving *E. procerus* were evaluated for HR Brix at 7th month and it ranged from 8.0 (GU 12-34) to 20.4 (GU 12-23) in the cross GU 04 (28) EO-2 x Co 06027 and 11.0 (GU 12-41) to 18.2 (GU 12-49) in the cross GU 04 (28) EO-2 x Co 775.

Intergeneric hybrids involving Erianthus *with 2n+n transmission:* Three intergeneric hybrids of *Erianthus viz.*, GU 04(85) CoE-9 (CoC 671 x IMP-1547), GU 04(72) CoE-1 (CoC 671 x IK 76-91) and GU 04-157 (PIR 98-635 x IK 76-93) were found to be the products of 2n+n transmission. Cytological studies in 47 hybrids of intergeneric crosses and backcrosses revealed n+n transmission, 2n+n

transmission and induction of androgenic plants (Table 14).

BC1 hybrids involving E. procerus*:* The confirmed intergeneric hybrid GU 04(28) EO-2 backcrossed with both commercial canes and *E. arundinaceus*. When it was crossed with *Erianthus*, only five seedlings (GU 12-6,7,8,9,10) were obtained which were morphologically similar to *Erianthus* and had chromosome number of 2n=60. While the backcrosses of this hybrid with Co 06027 (2n=108) indicated their hybridity with 2n=86-94, the expected number was 2n=94. Meiosis of the clones from the cross GU 04(28) EO-2 x *Erianthus* was normal while the clones of GU 04(28) EO-2 x Co 06027 had shown abnormalities with laggards (1-12) and bridges (1-3). In the hybrid GU12-30, 90.3 % of the microspores possessed 1-5 micronuclei.

Improved robustum *x* Erianthus*:* The chromosome number of hybrids from the cross PIR 98-635 (2n=110) x IK 76-91 (2n=60) ranged from 2n=90-106. In the cross PIR 98-63 (2n=110) x IK 76-93 (2n=60), out of six clones analyzed, the hybrid GU 04-157 possessed 2n=136 with 2n+n transmission. Other hybrids had chromosome number ranging from 2n=84-86, whereas the expected number was 2n=85.

Development of genetic stocks utilizing improved *S. officinarum, S. robustum* and *S. barberi*

(S. Alarmelu, C. Jayabose, Adhini S. Pazhany and T. Manjunatha)

Hybridization : Fifty six back crosses involving commercials, improved *S. officinarum* and improved *S. robustum*, *S. barberi* were made during 2014 flowering season.

Ground nursery : Seedlings from 50 experimental crosses involving Co 94008, Co 0403, Co 11004, Co 11021, Co 11024, Co 12001, Co 12009, Co 13010,PIR 96-305 , PIR 0034, PIR 0039, PIR 001157, PIR 001174, PIR 001176, PIR 003-Co 12009, Co 13019 x PIR 96-305 as parents were screened and 900 selections were forwarded to first clonal trial.

Evaluation of clones in first clonal stage: A total of 700 clones selected based on Brix and field stand were planted in first clonal trial along with four improved *officinarum* and *robustum* parents. The crosses PIR 96-285 x Co 09014,PIR 96-285 x CoC 671 and PIR 03107 x PIO 96-475 yielded high tillering progenies. HR Brix at 240 days ranged from 11.25 to 19.20 in the hybrid population and 20 clones recorded H.R Brix in the range of 18-19.20. The crosses PIR 96-285 x Co 09014, PIR 001188 x CoC 671, 99 -269 x Co 0209 yielded high quality progenies.

Table 14. **Chromosome number of intergeneric/ back cross hybrids**

Clone	Cross	Chromosome No. (2n)
Improved robustum x *Erianthus arundinaceus*		
GU04-348, 349, 350, 352, 353,355, 358, 360, 361	PIR 98-635 (2n=110) x IK 76-91 (2n=60)	94, 94, 92, 90, 94, 104, 94, 94, 106
GU 04-153,157,158, 159, 160, 162	PIR 98-635 (2n=110) x IK 76-93 (2n=60)	86, 136, 86, 84, 86, 85
BC1 hybrids involving *E. procerus*		
GU 12-06 ,08, 07	GU04 (28) EO-2 (2n=80) x IK 76-99 (2n=60)	60, 60, 60,
GU 12-55, 28, 15, 16, 18, 19, 20, 22, 26, 27, 30, 33, 29, 32, 37, 38, 39, 41, 23	GU 04 (28) EO-2 (2n=80) x Co 06027 (2n=108)	86, 88, 90, 90, 90, 90, 90, 90, 90, 90,90, 90, 92, 92, 92, 92, 92, 94
Commercial cane x *Imperata*		
GU 12- 04	CoLk 8102 (2n=98) x *Imperata* (2n=20)	88

Hybrid derivatives with improved S. robustum, S. barberi as female parent: One hundred and ten clones from *S. barberi, S. sinense* and commercials were evaluated for yield and quality parameters and hybrids were significantly superior for yield and quality parameters. At 300 and 360 days, this group showed juice sucrose above 18.01% and 21.00% respectively. Among the 200 *S. robustum* hybrid derivatives evaluated for juice parameters at 300 days, 28 clones recorded juice Brix in the range of 21-22.0 and sucrose of 19.01 -19.14%. Sixty interspecific hybrid derivatives involving *S. barberi* were evaluated for juice parameters at 300 days. Eighteen clones registered juice sucrose in the range of 17.00 to 19.57%. Clone 2011-70 and 2011-55 recorded juice sucrose of 19.57 and 19.13% respectively. The clone IOR 360 showed significant improvement for cane yield and sucrose followed by IOR 396, 258, 1100, 1136 and 1128.These clones were resistant to red rot also.

Maintenance of genetic stocks: A total of 560 breeding stocks of improved *S. officinarum, S. robustum, S. spontaneum, S. barberi, S. sinense* hybrids and 83 back cross progenies involving Arunachal *S. spontaneum* were maintained.

Evaluation of recombinants from one cycle of recurrent selection in Population B: Out of 360 cycle I hybrids, 33 hybrids were promising for Brix (17.25-19.10) at 240 days. For yield traits, 103 hybrids were promising. Cycle II hybrids recorded HR Brix in the range of 21.0 -25.23 at 300 days. Cycle III hybrids had an overall mean Brix above 24.0. A total of 100 hybrids were forwarded for further evaluation. There was a steady increase of Brix from cycle 0 (20.18) to cycle 1 (22.21).

Evaluation of recombinants from recurrent selection cycles in Population (AxB): One thousand five hundred seedlings (Cycle III) were screened for NMC, cane diameter and HR Brix. NMC ranged from 5 to 23/clump and cane diameter 1.65-3.29 cm. Brix at eight months ranged from 13.0 to 20.2. One hundred and twenty one clones were promising for both yield traits and quality parameters. Fluff of Cycle IV hybrids was sown and 3000 seedlings from 23 crosses were raised. Cycle I and II hybrids from this group are under evaluation for yield and quality attributes.

Improvement over four cycles of recurrent selection was recorded for the yield and quality traits in this population. There was a substantial improvement for cane weight in four cycles of selection. Cycle 1 and Cycle 2 hybrids showed substantial improvement for cane height. Cycle three hybrids showed an improvement of 12.21, 13.01, 20.09 and 9.36% and C4 hybrids showed an improvement of 6.13, 9.19, 22.21 and 11.02% for cane height, cane thickness, cane weight and stalk number respectively in comparison with the base population (Tables 15 and 16).

Table 15. **Mean and CV for Cane yield and CCS yield**

Cane yield	C0	C1	C2	C3	C4
Selected mean	97.12	84.09	112.28	96.54	78.51
Selection differential	10.54	2.88	14.98	11.28	6.94
CV (%)	11.53	10.25	13.14	9.98	7.08
CCS yield					
Selected mean	13.01	14.38	19.83	15.12	13.00
Selection differential	1.38	1.01	2.13	2.38	1.04
CV (%)	13.00	13.24	13.58	11.29	7.84

Table 16. **Generation wise improvement (%) for yield traits in comparison with the base population (Co) over four cycles of recurrent selection in A x A**

	C1	C2	C3	C4
Cane height (cm)	27.85	24.12	12.21	6.13
Cane diameter(cm)	12.32	12.89	13.01	9.19
Single cane weight (kg)	40.95	38.14	20.09	22.21
NMC	12.85	11.42	9.36	11.02
Brix	11.88	12.13	11.45	13.18
Cane yield	10.53	13.33	15.76	12.78
CCS yield	13.01	14.38	15.12	13.00

Evaluation of improved *E. arundinaceus* clones for biomass and paper industry

(C. Jayabose)

Five high fibre / high biomass clones of *Erianthus arundinaceus* were evaluated in a replicated trial for estimation of biomass and fiber yield. At eight months, the clones IK76-81 and GC04-9 exhibited high dry biomass yield of 262.82 t/ha and 220.01 t/ha respectively. Maximum force required to compress the *Erianthus* canes varied from 9.04 kN to 3.86 kN for canes with rind and 9.04 kN to 2.67 kN for the canes without rind. The clone IK76-93 x SF 06-48 required high compressive force of about 9.04 kN and had the maximum displacement value of 16.59 mm, confirming the hardiness of the cane. Minimum compressive load of 2.67 and 3.86 kN was required to crush the *Erianthus* clone IK76-81 / GC04-09 probably due rind character, which could be of trifling fibers and soft pith in cane and accumulation of less mature fibers in the stem.

The *Erianthus* clone IK76-93/SF 06-48 yielded maximum compression load and a maximum displacement force of 9.04 kN was required to compress the stem with rind which can be classified as hard cane among the identified high fibre clones. Minimum displacement force was enabled at 5.13 kN for the clone IK76-81/GC04-09 and at 3.86 kN for the clone IK76-81/GC04-09 which can be categorized as soft canes.

5.2. DIVISION OF CROP PRODUCTION

5.2.1 AGRONOMY AND MICROBIOLOGY

Agronomic evaluation of promising sugarcane genotypes

(P. Gopalasundaram, P. Rakkiyappan, A.S. Tayade, A. Bhaskaran and P. Govindaraj)

The experiment was continued with the I plant crop of new set of four promising varieties (Co 08009, Co 08016, Co 08020 and Co 09004) with Co 86032 and CoC 671 as check with three replications. Graded levels of N at 75%, 100% and 125% of the recommended dose of N (225 kg/ha) is being applied. Experimental field was low in available N and high in available P and K. Germination and Initial crop growth are satisfactory.

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

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

This project was initiated during January 2015 with the objectives of estimating the recyclable biomass available in sugarcane production system; characterizing the biochar from sugarcane dry trash, tops, bagasse and stubbles and exploring the options of its practical utility as a manure and amendment. An un-detrashed seed multiplication field with five plots of seven rows (3 ft x 6 m) each planted with the variety Co 86032 during January 2014 was harvested during January 2015 and the dry biomass yields were recorded. The trash + tops,

bagasse and stubbles dry biomass yields were 13, 12 and 8 t/ha, respectively. Biochar was produced by pyrolysis process at the Department of Bio-Energy, Tamil Nadu Agricultural University, Coimbatore. The biochar yield from dry leaves and tops (Fig. 14) varied between 10 and 13% . The flame oxidizable matter content ranged from 78.52 to 80.82%.

Fig. 14. Biochar derived from leaves and tops

Water management with composted coirpith and trash for sustainable sugarcane production

(R. Dhanapal, A.S. Tayade and P. Geetha)

The experiment was started during 2013 in split plot design with irrigation in main plots and conservation measures, spacing and planting material in the subplots. Ratoon crop was raised during 2014-15. The field capacity (FC), permanent wilting point (PWP) and available soil moisture (ASM) of the experimental soil were 30.5%, 9.82% and 20.14%, respectively. The crop was harvested during February 2015. In the main plots, 137.54 lakh litres (1375.40 mm) and 103.16 lakh litres (1031.58 mm) of water was irrigated in 100% and 75% irrigation levels (Fig.15). In addition to irrigation water, 537 mm of rainfall was received during the cropping period. At 100% irrigation level, composted coir pith (CCP) treatment had 11% higher soil moisture (41% soil moisture) than control (30% soil moisture) while in trash incorporated plots, the soil moisture content was 33%. At 75% irrigation level, CCP treatment registered 7.5% higher soil moisture than control (Fig. 16 &.17).

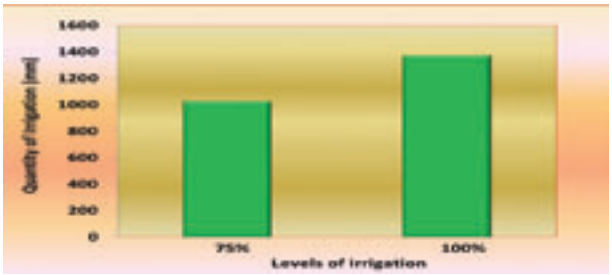


Fig.15. Irrigation levels and quantity of water

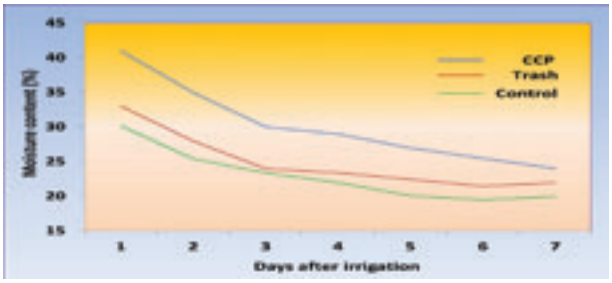


Fig.16. Soil moisture content in 100 % irrigation level as influenced by water conservation measures

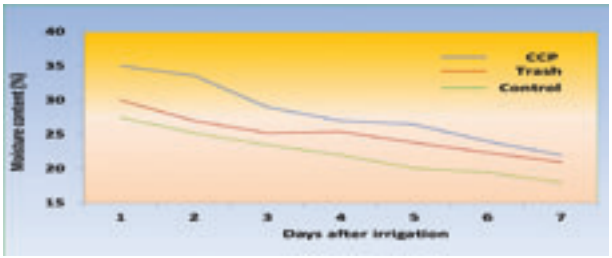


Fig. 17. Soil moisture content in 75 % irrigation level as influenced by water conservation measures

Soil moisture content estimated after eight days of irrigation revealed 4% higher moisture in CCP plots than control at both 100% and 75% irrigation levels. The soil moisture in CCP plots were 68% and 58% of ASM in 100% and 75% irrigation levels, respectively while in control, it was 49% and 39%, respectively.

The mean cane yield of first ratoon crop in 100% and 75% irrigation levels were on par indicating 25% savings in irrigation water. The interaction between irrigation levels and water saving measures was not significant (Fig.18). The cane yields varied significantly between water saving measures, spacing and planting materials. CCP applied plot under 150 x 45 cm spacing with bud chip settling planting gave on par yield (98 t/ha) with CCP applied and setts planted at 90 cm row spacing (109.7 t/ha) and trash applied plot (100.7 t/ha) but significantly higher than other treatments.

The lowest yield was obtained in control plots. The two budded setts planting at 90 cm spacing performed better with higher yield than 150 cm bud chip planting except in 150 x 45 cm spacing under CCP treatment.

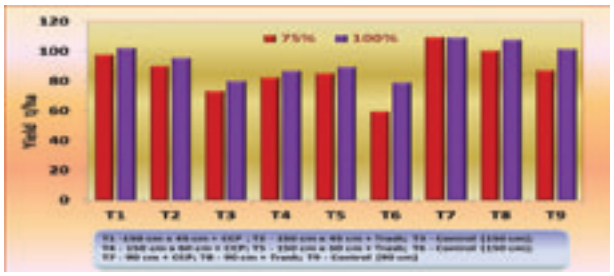


Fig. 18. Effect of irrigation levels, soil moisture conservation measures, spacing and planting

Effect of trash management on sugarcane production under wide row planting

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

This experiment was planted in wide row during January 2014 with sugarcane variety Co 86032 to study the effect of trash management on growth, development and juice quality of sugarcane. The plant crop yielded 15.67 t/ha of trash, which was used as trash mulching and incorporated *in-situ* at different stages of crop growth. Trash mulching and *in-situ* incorporation substantially recorded higher soil moisture content by 0.70 to 5.92% in various treatments over control. Microbial biomass carbon studies carried out at 180 DAP indicated that *in-situ* trash mulching combined with green manuring recorded significantly higher microbial biomass carbon (112.25 µg/g of soil) than control (86.91). *In-situ* trash mulching had pronounced effect on buffering the soil temperature at 5 cm depth which fluctuated between 25.1 and 27.2°C. *In-situ* trash management coupled with microbial consortia application resulted in higher single cane weight (1.48 kg), cane height (211 cm) and cane girth. It had significantly higher NMC and cane yield (106.15 t/ha) over the rest of the treatments.

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

(P. Geetha and A.S. Tayade)

The experiment was initiated during February 2013 to work out the productivity and economics of sugarcane based intercropping systems with three N levels (100, 75 and 50% of RDF) as main plot treatment and six intercrops (ragi, soybean, blackgram, sesame, amaranthus and sunhemp) as sub plot treatments under wide row spacing to evaluate the possibility of reducing the N application rates by synergetic action of intercrops on sugarcane. The growth of intercrops such as amaranthus, ragi, sesame and sunhemp was good whereas the performance of soybean and blackgram was not satisfactory. The sugarcane crop planted in 2014 was harvested during February 2015. The highest NMC was recorded in 100% N (92932/ha) followed by 75% N application (88084/ha) and 50% N application (79506/ha). There was no significant difference among the intercropping system followed. The juice quality parameters at harvest were not significantly influenced by the treatments. The cane yield was higher in the 100%N plot (76.82 t/ha) than 75% and 50% N plots (64.41 and 52.71 t/ha).

A new experiment with same set of treatments was planted during February 2015. The intercrop amaranthus gave the highest yield (3.7 t/ha fresh weight) in 100% N treatment followed by 75% N (3.0 t/ha). Sunnhemp was harvested and incorporated *in-situ* in respective plots. Fresh biomass yield of sunhemp ranged between 8844 and 6770 kg/ha.

The total light interception was measured by using LI COR radiation sensor in different intercropping system. Amaranthus intercropping system intercepted more light (13533 µmol/s/m^2) followed by sunnhemp (9043 µmol/s/m^2) and sesame (8631 µmol/s/m^2) at 30 DAP.

Developing new technologies for processing sugarcane juice

(K. Hari, G.S. Suresha, K. Sivaraman and T. Arumuganathan)

Spray dried sugarcane juice powder (SJP): Raw sugarcane juice had a pH of 5.40 to 5.95, viscosity 0.0224 to 0.0294 Pas, total soluble solids 16.5 to 22.4% and water activity 0.974 - 0.987 aw and the colour varied from greyish green to yellow. Highest powder yield of 74 g/l was obtained. The powders were highly hygroscopic and the moisture content

ranged from 2.2 to 2.9%, water activity from 0.366 to 0.466 aw, total microbial plate count was <5.0 x 10^3 colony forming units (cfu g^{-1}) and no coliforms were detected. As spray drying was done at >100°C which is above the Tg value of sugars (40°C) in juice, sugar and organic contents became sticky. Addition of food additives / carrier agents having Tg values > 100°C like maltodextrin commercial grade, maltodextrin DE 20, lactose (101°C), gum acacia, soluble starch and others individually and in combinations gave higher SJP yield and better quality powder (Fig 19). The highest yield was obtained with 20% maltodextrin (187 g/l).

The SJP collected with carrier agents recorded moisture content of 1.80 to 2.44%, water activity of 0.146 to 0.266 aw. Differential scanning colorimetric analysis indicated that powders without carrier agents showed a Tg value of 47.42°C and were unstable at 140°C, but carrier agents added powders recorded Tg values of >60°C and stable beyond 140°C. Diffraction analysis indicated average particle size ranging from 0.58 to 4.81 µm. Scanning Electron Microscopy (SEM) of SJP without carrier showed uneven particles while with carrier agents formed even smooth particles (Fig. 20 & 21). Total plate count was <300 cfu g^{-1} and fungi, yeast and pathogenic coliforms were absent. Chemical analysis of powders showed significant variation. Heavy metal contents *viz.*, chromium, lead, cadmium and nickel were insignificant.

Rotary vacuum concentration (RVC) of sugarcane juice: Parameters for RVC of Co 86032 juice were optimized. Concentration could not be at temperatures from 50 to 70°C at -400 to -500 mm Hg but achieved at 80°C and -500 mmHg with a constant rotary speed of 100 rpm. RVC of juice of Co 86032, Co 86249, Co 95020, Co 0218, Co 97009 and Co 92005 was done at -600 mmHg and 80°C for 30 min. The raw juice had a water activity of 0.986 to 0.988 aw and moisture content of 77.62% to 79.05%. The concentrates recorded a moisture content of <16.8% and water activity of <0.720 aw. All the concentrates formed crystals after 15 days of storage at ambient condition. Microbial analysis showed <2.0 x 10^2 cfu g^{-1} total plate count and coliforms were absent.

Freeze drying of sugarcane juice: Freeze drying process was standardized using juice from Co 86032, Co 86249, Co 95020, Co 0218, Co 97009 and Co 92005 using laboratory scale freeze driers at -40°C and ~0.2 mTorr vacuum and glistening flake powders were obtained (Fig. 22). The water activity ranged from 0.290 to 0.348 aw and moisture content from 3.2% to 3.3%. Powder colour varied between varieties. DSC analysis showed Tg value of 45°C and powders were unstable above 144°C. SEM image showed flaky powder (Fig 23). Microbial analysis showed 2.0 x 10^4 to 5.0 x 10^3 cfu g^{-1} total plate count and absence of coliforms.

Fig. 19. Spray dried juice powder

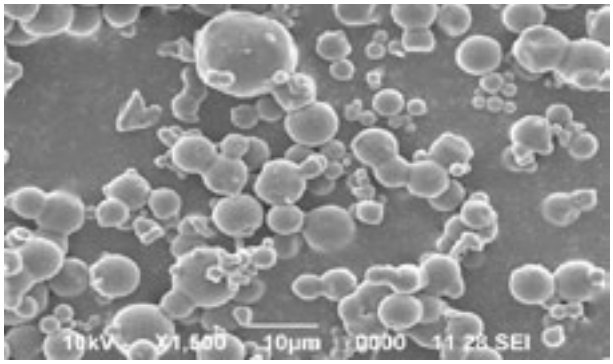


Fig. 20. SEM image of spray dried raw juice powder

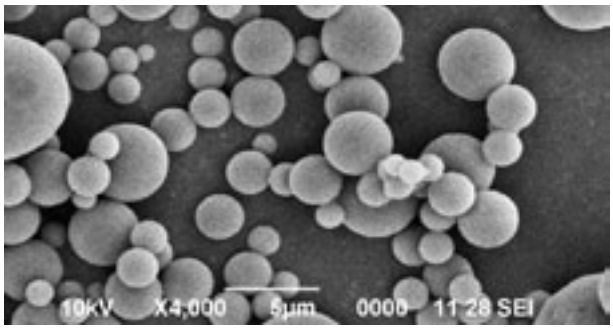


Fig. 21. SEM image of spray dried carrier agent added juice powder

Fig. 22. Freeze dried juice powder

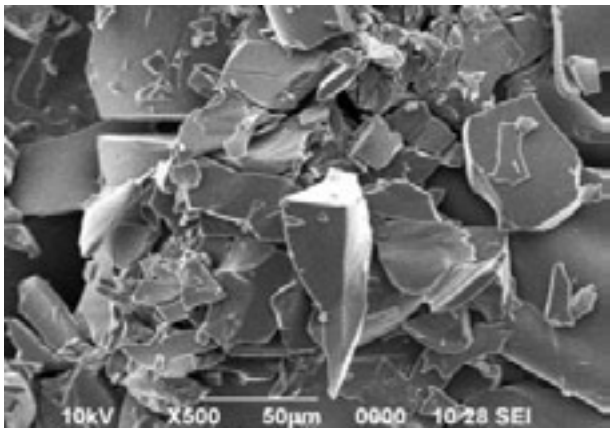


Fig. 23. SEM image of freeze dried juice powder

5.2.2 PLANT PHYSIOLOGY

Induction and synchronization of flowering in Saccharum species and commercial hybrids for utilization in breeding programme

(P.N. Gururaja Rao and S. Venkataramana)

I*nduction of flowering in non- flowering/rare flowering varieties:* Eighteen non-flowering/rare flowering clones were given photoperiod of 13 h 05 min starting from August 1 with a differential rate of declination during the induction and developmental phases. Four out of 18 varieties (CoBLN 04-174, CoC 671, MS 68141 and CoS 8436) flowered in control and light treatment while CoLk 97154 flowered only in light treatment.

Twelve late flowering clones were given an initial photoperiod of 12 h 45 m starting 25 July and declined at 60 s/day to advance flowering. None of the clones flowered in photoperiodic treatment as well as in control.

Synchronization of flowering in early flowering varieties: Ten early flowering varieties were given post-inductive constant day length by extension of dusk and dawn by artificial lighting under field conditions to synchronize flowering with late flowering varieties. The effective delay in flowering varied from 5 days (CoS 8436 & CoSe 92423) to 17 days (CoLk 94184). This facilitated crossing of subtropical with local varieties in NHG programme.

Energy production potential of sugarcane

(S. Venkataramana and S. Vasantha)

A field experiment was conducted in RBD with three replications in 43.2 m^2 plots using six sugarcane varieties (Co 86032, Co 94008, Co 99004, Co 62175, Co 0218 and Co 0314) during 2014-15 to evaluate the energy production capabilities of leaf, sheath and stem at different growth phases and to integrate over the cropping season. Plant characteristics, biomass, juice quality and yield were recorded. The energy production was quantified in selected *Erianthus* types.

Plant growth: The average germination at 45 days was 38.22%. Varieties Co 62175, Co 0218 and Co 94008 recorded good germination per cent of 48.8, 47.6 and 45.6, respectively. At formative stage, varieties Co 86032, Co 62175 and Co 0314 recorded high main shoot and tiller heights. Number of leaves/plant was high in Co 0218 (13.8), Co 94008 (13.1) and Co 62175 (13.0). At grand growth stage (240 days), variety Co 62175 reached the maximum plant height of 203cm followed by Co 0218 (201.9 cm). Co 86032 exhibited the maximum tiller height of 157.3 cm, followed by Co 0218 (152.7 cm). The average tiller number was 1.8/plant. The total number of leaves ranged from 19.7/clump in Co 99004 to 23/clump in Co 62175.

Biomass: Leaf biomass production was high in Co 94008 (266.4 g/m^2) and Co 62175 (225.2 g/m^2). The sheath dry mass varied from 93.7 g/m^2 in Co 0314 to 146.1 g/m^2 in Co 86032. The stem formation was rapid in Co 86032 producing about 202.5 g/m^2. The total dry mass production was high in Co 86032 (573.6 g/m^2). The average total dry mass

production at this stage of sampling was 483.75 g/m^2 and the partitioning per cent was 45.54, 25.64 and 28.82, into leaf, sheath and stem, respectively. At grand growth phase, the biomass production was high in variety Co 94008 (1.945 kg/m^2), followed by Co 0314 (1.881 kg/m^2). The average partitioning percent of total biomass into leaf, sheath and stem was 17.34, 11.39 and 71.27, respectively. At harvest, the average biomass production was 2.925 kg/m^2 and it was partitioned into leaf, sheath and stem in the proportion of 11.34, 5.89 and 82.77%, respectively. The biomass content in green leaf and sheath tissues in fully matured crop was considerably low, while cane contribution was high (>2.00kg/m^2) in all varieties.

Energy: At formative phase, the energy production in the leaf tissue of Co 0314 was higher (3815 kcal/kg biomass) than other varieties. The stem of Co 94008 produced maximum energy of 3726 kcal/kg biomass. Energy production potential at grand growth stage was high in the leaf of Co 0314 (4094 kcal/kg dry mass) followed by Co 94008 (3769 kcal/kg dry mass. The energy in stem was >3500 kcal/kg in all the varieties. The stem of Co 86032 recorded the maximum energy of 3917 kcal/kg. At maturity, the energy production potential in the stem of Co 62175 was high (4552 kcal/kg dry mass). All other varieties produced >4000 kcal/kg biomass. The leaf of Co 0218 and sheath of Co 94008 recorded high calorific value than other varieties. The integrated energy production at harvest was high in Co 62175 (14,877 kcal/m^2), followed by Co 99004 (13,332 kcal/m^2). All other varieties produced >10,000 kcal/ m^2.

Germplasm: Seven *Erianthus* clones (IS 76-219, IJ 76-358, IK 76-48, IK 76-44, IK 76-45, IM 76-257 and IK 76-91) at SBI-RC, Agali with good vegetative growth were selected and evaluated for energy production. Among the tested clones, IK 76-44 produced maximum energy of 3562 kcal/kg and 3897 kcal/kg in the leaf and stem tissues, respectively. Clones 76-219 and IM 76-257, IK 76-91 also produced appreciably high energy.

Juice quality and yield: The sucrose in juice ranged from 17% in Co 62175 to 20.1% in Co 99004. Other varieties such as Co 86032, Co 94008, Co 0218, and Co 0314 recorded more than 18% sucrose in juice. The juice purity was ~90% in all these varieties and the average CCS was 12.7%. The average cane height was 179.5 cm with 19.2 internodes and the number of millable canes was the highest (95.89 '000/ha) in Co 62175, followed by Co 0218(83.97 '000/ha). However, among the varieties, cane yield was highest in Co 94008 (136.56 t/ha), followed by Co 0314 (133.02 t/ha).

Interactive effects of salinity and drought on nutrient status of sugarcane

(S. Vasantha and R. Gomathi)

Two trials were planted during 2014-15 in split plot design for testing the interactive effect of drought and salinity with six genotypes that are tolerant/sensitive (Co 86032, Co 99004, Co 2001-13, Co 8021, Co 97010 and Co 85019). Nutrient formulations (P and micro nutrients- in three doses) were evaluated in these trials, for mitigating the stress.

Leaf area index and biomass: After formative phase the mean reduction in leaf area in drought stressed plants was 37% with nutrient spray while it was 52% without nutrient spray. Nutrient spray @ 2% concentration improved the leaf area by 23% over control (water spray) in saline soil, while @ 1.0 and 1.5% nutrient spray, there was a reduction of 4 and 6%, respectively over control.

The total dry biomass at formative phase (150DAP), varied from 391g/m^2 (Co 97010) to 891g/m^2 (Co 2001-13) with a mean of 632 g/m^2, in control. In 1.0% nutrient spray, it varied from 580g/m^2 (Co 86032) to 898 g/m^2 (Co 99004) with a mean of 714g/m^2. In 1.5% nutrient spray, it ranged from 145g/m^2 (Co 97010 to 895 g/m^2 (Co 99004). The highest dry biomass was observed in 2% nutrient spray which ranged from 495 g/m^2 (Co 97010 & Co 8021) to 1261 g/m^2 (Co 2001-13). The mean improvement in biomass was 12% for 1.0% nutrient spray and 10% for 2.0% nutrient spray while 1.5% nutrient spray was on par with control.

Yield :Nutrient spray recorded an improvement of 20 and 25% in 1.0 and 2.0 spray in saline soil over control. In drought treatment, the nutrient spray improved cane yield by 26% over control.

Response of sugarcane to high temperature stress

(R. Gomathi, S. Vasantha and K. Lakshmi)

A pot culture experiment was conducted using ten commercial varieties *viz*., Co 86032, Co 99004, Co 2001-13, Co 2001-15, Co 06015, Co 06022, Co 0218, Co 0315, Co 0403 and Co 8021 with five replications to study the adaptive response of sugarcane to elevated temperature by subjecting plants at 5°C above ambient temperature (~42°C day temperature) in environmental growth chambers along with a control at ambient temperature during grand growth phase (150 to 240 DAP).

The sucrose phosphate synthase (SPS) & sucrose synthase (SS) activities were assayed at 180 DAP. The variation in SPS activity was 6.80 (Co 86032) to 9.45 µmol/g/h (Co 06022) for control, while in elevated treatment it varied from 4.58 (Co 8020) to 7.50 µmol/g/h (Co 06015) with mean reduction of 16.40% over control. Reduction in SS activity was 11.5% in elevated temperature treatment over control.

A reduction of 19.5% in PEP carboxylase activity was observed due to elevated temperature treatment over control in all the varieties studied (Fig. 24). The reduction was less in Co 99004, Co 06015 and Co 06020. Free radical scavenging activities (POX, APX and SOD) were enhanced upon elevated temperature particularly in Co 0315, Co 99004, Co 06015 and Co 06020 indicating their nature of adaptation under elevated temperature condition.

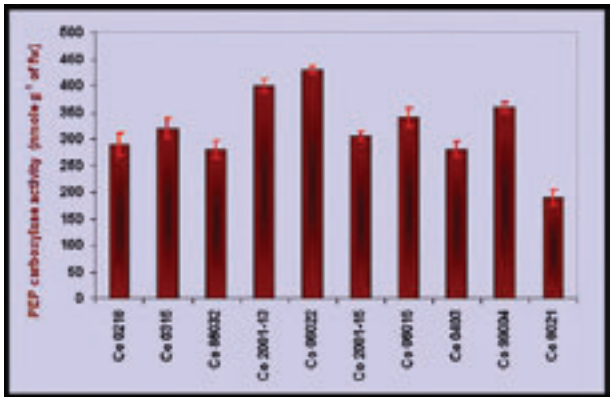


Fig. 24. Varietal variation in PEP carboxylase activity (nmole/g of fw.) in response to elevated temperature

Proteomic study on 2-Dimensional gel electrophoresis was performed in Co 06022 at 90 days treatment. The elevated temperature treated sample showed over expression of heat shock protein spots (HSPs) with different molecular weight and density compared to control. In treated samples, 15 more spots with molecular weight of 30 KD (hsp 27 and hsp 86) were noticed compared to their respective controls. Over expression of protein spots with molecular weight of 34.42 to 48 KD (hsp 40 and hsp 60) was noticed compared to control. The results will be further confirmed through sequence analysis.

Transcript analysis-semi quantitative RT-PCR: Heterologous primers (10 nos.) were designed using sequence information available in the public domain for sugarcane and related species like sorghum, maize and wheat. Changes in gene expression patterns in response to elevated temperature were studied through semi quantitative RT-PCR. Transcripts that are involved in the heat stress tolerance *viz*., hsp 70 (511 bp), hsp 100 (555 bp), hsp 90 (557 bp), hsp 22(585 bp), LEA protein (577 bp) and PEPcase (522 bp) were isolated from samples of Co 06022, Co 99004, Co 0403 and Co 8021. Up-regulation of transcripts encoding heat shock protein *viz*., hsp 90, hsp 70, hsp 100 and hsp 22 was noticed at elevated temperature in adapted varieties *viz*., Co 06022, Co 99004 and Co 0403 while its expression was absent in the non-adapted variety Co 8021 and all controls. Unlike other transcripts, expression level of PEPC was lesser in treated samples than controls except Co 99004 which showed higher PEPC transcripts accumulation under elevated temperature.

Two sets of pot experiments have been initiated using six varieties (Co 86032, Co 8021, Co 0315, Co 06015, Co 06022 and Co 99004) with four replications in CRBD at different time intervals to assess changes in sucrose synthesis accumulation under elevated temperature. A set of plants are being subjected to elevated temperature in growth chambers during formative phase of the crop (120 DAP). The experiment is in progress.

5.2.3 SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Precision farming in sugarcane: Evolving site specific management practices for increasing the sugarcane productivity

(C. Palaniswami, A. Bhaskaran, P. Gopalasundaram, P. Rakkiyappan and R. Viswanathan)

Sugarcane yield variability was studied using geostatistics module of IDRISI in two farmers' fields. Grid-wise fertilizer recommendations were derived using the variable rate fertilizer module developed and the economics of fertility management was studied. The yield variability in field 1 ranged from 65 to 175 t/ha while in field 2, it was 78 to 198 t/ha. Due to variable rate of fertilizer application, the fertilizer cost in field 1 increased by Rs. 1960 /ha while in field 2, there was a saving of Rs.1700 /ha (Fig. 25). Due to the variable rate fertilizer application, the cane yield increased by 70 t/ha and 20 t/ha in field 1 and field 2, respectively.

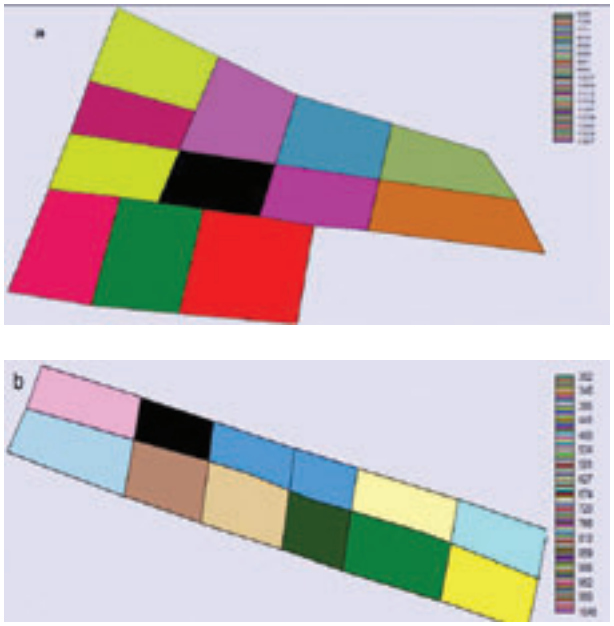


Fig. 25. Fertiliser cost (Rs.) a) Field 1 and b) Field 2

Studies on sulphur nutrition of sugarcane

(A. Bhaskaran, C. Palaniswami and P. Rakkiyappan)

A field experiment with nine treatments comprising 50, 100, 150 and 200 kg S/ha in the form of gypsum and elemental sulphur + *Thiobacillus thiooxidans* culture and a control with three replications was planted during January 2014 with Co 86032 as the test variety and harvested during the first week of February 2015. Application of S @ 200 kg/ha in the form of gypsum and elemental sulphur + *Thiobacillus thiooxidans* culture gave on par yield of 124 t/ha each, which was 28.5% higher than control where no S was applied (96.48 t/ha) (Fig. 26). Sulphur application at lower doses both in the form of gypsum and elemental sulphur + *Thiobacillus thiooxidans* culture gave on par yields but were significantly higher than the control.

A pot culture experiment with five different soils and five levels of S in the form of elemental S + *Thiobacillus thiooxidans* culture with Co 86032 as the test variety was harvested during March 2015. The cane weight varied significantly among different soils. Increasing doses of S increased the cane weight significantly. The highest cane weight of 1.86 kg/pot was obtained in S @ 200 ppm treatment while in control it was 0.89 kg/pot. The interaction effect of different sulphur doses in various soils was not significant.

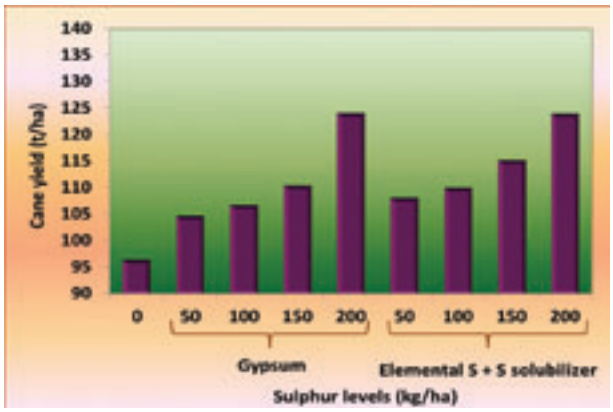


Fig. 26. Effect of sulphur fertilization on cane yield

Delineation of sugarcane soils for micronutrients status and screening sugarcane varieties for tolerance to iron and zinc deficiency

(A. Bhaskaran, C. Palaniswami and P. Rakkiyappan)

A field experiment was conducted to identify chlorosis tolerant sugarcane clones and the basis of tolerance. Twenty seven genotypes were tested with and without application of Zn and Fe in a split plot design with two replications. Based on

the visual observations at 300 DAP, among the genotypes tested, 15 genotypes (Co 01-13, Co 0238, Co 0240, Co 0403, Co 06022, Co 06027, Co 06030, Co 8021, Co 8338, Co 86032, Co 91010, Co 92005, Co 99004, Co 99006 and CoM 0265) were found to be tolerant to chlorosis while 12 genotypes (Co 01-12, Co 01-15, Co 0218, Co 0314, Co 62175, Co 6806, Co 7219, Co 85019, Co 86249, Co 87025, Co 94008 and Co 97010) were found to be susceptible for chlorosis (Fig. 27). Except Co 6806, the other susceptible varieties responded to micronutrients (Zn and Fe) fertilization in terms of chlorophyll content and leaf greenness.

The crop was harvested during March 2015. Application of micronutrient fertilizers (Zn and Fe) gave 30.27% higher average yield (96.31 t/ha) than control (73.93 t/ha). All the genotypes responded positively to the application of micronutrient fertilization in terms of cane yield but the magnitude of response varied widely from 1.75% in Co 8338 to 77.0% in Co 85019. In Co 0238, Co 0430, Co 06022, Co 8338, Co 92005 and Co 99006, the yield responses for micronutrient application were less than 10% but all varieties were tolerant to chlorosis in terms of visual observation of leaf greenness at 300 DAP. The pot culture experiment was harvested during March 2015. The root biomass values recorded in the varieties Co 95020, Co 99004 and Co 94008 were 38.33, 37.00 and 35.33 g/pot, respectively, which were significantly higher than the other varieties.

Development of a Decision Support System for sugarcane soil management

(A. Bhaskaran and C. Palaniswami)

This new project was initiated during October 2014. The soil profile database of sugarcane growing soils of Coimbatore, Erode, Tiruppur, Karur, Tiruchirappalli and Villupuram districts were collected from their respective Soil Atlas and incorporated in the Soil.sol file of the DSSAT crop growth model. The knowledge base on sugarcane soil constraints management including soil test based fertilizer recommendation, fertility grading based blanket recommendation *etc*. were collected and a database has been created. The Decision Support System was developed in Visual Basic and tested for its stability and compatibility on Windows Vista, Windows 7 and Windows 8 platforms.

Development and promotion of tools and machinery for sugarcane mechanization

(T. Arumuganathan, C. Palaniswami and K. Sivaraman)

An improved sugarcane de-trashing tool was designed using the design software SOLID WORKS. The tool weighed 290 g whereas the early model weighed 430 g. This tool has two stainless steel knives of 3" length and 1.5" width fitted in a 'U' shaped stainless steel flat with tension and welded with a 4" stemmed 12 x 3 mm stainless steel flat. The flat gives tension and the knives are stiff enough to detach the leaves. At the bottom of

Fig.27. Genotype variation in chlorosis tolerance / susceptibility

the `U' shaped steel flat, a stainless steel pipe of 25 mm diameter with 30 mm length is attached and provided with a wooden handle for convenience. A movable 3 mm SS ring is placed to adjust the knives to the diameter of cane. De-trashing angle of 5° with varying approaching/ cutting width ranging from 25 to 50 mm is provided to ease the de-trashing process (Fig. 28). This tool was field tested in fifth and seventh month crop. The field capacity of the tool is 0.3 acre per day and the cost of the tool is Rs. 480 for stainless steel and Rs.180 for mild steel.

Fig. 28. Detrashing tool

5.3 CROP PROTECTION

5.3.1 PLANT PATHOLOGY

Screening of sugarcane progenies and germplasm for disease resistance, disease survey and surveillance and impact of climate changes on sugarcane pathogens

Screening for red rot resistance under controlled conditions

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

A total of 3046 clones were tested for red rot resistance under controlled conditions and among them 1170 clones were identified as resistant / moderately resistant.

Field tolerance to red rot: Field tolerance to red rot in 39 genotypes which were susceptible to red rot by plug method was assessed against grain inoculum along with susceptible, tolerant and resistant checks (Fig. 29). To assess field tolerance to red rot in elite clones, 62 entries were planted under disease endemic location, Tuhuli, Thanjavur District, Tamil Nadu. In additon, 12 clones exhibiting field tolerance in previous trials are being multiplied in large plots for further observations.

a. Susceptible

b. Resistant

Fig. 29. Field tolerance in sugarcane clones to red rot

Yellow leaf disease (YLD): Population dynamics of YLD vector *Melanaphis sacchari* were assessed during different growth stages in different varieties maintained at NHG, VPT and ECC. Some genotypes recorded maximum aphid population of up to 621 per plant in NHG. However, it ranged from 742 to 920 per plant in severely infested varieties at VPT farm. Only few parental clones maintained at ECC had shown aphid infestation as compared to NHG where many of them recorded higher population of the vector. Impact studies of YLD on a set of varieties revealed decline in cane growth and final yield parameters due to the disease in sugarcane.

Fig. 30. Epidemic occurrence of YLD in CoV 09356 in East Godavari Dt, Andhra Pradesh

Similar studies conducted in different factory areas of Tamil Nadu and Andhra Pradesh also revealed severe impact of the disease in sugarcane (Fig. 30).

Fig. 31. YLD-free crop of Co 86032 raised from virus-free tissue culture derived nurseries

For effective management of the disease, YLD-free seed nursery programmes have been found to be successful (Fig. 31) in different factory areas.

Characterization of red rot pathotypes

Differential host studies (AICRP)

(N. Prakasam and V. Jayakumar)

Red rot incidence on differential hosts indicated that among four isolates, Cfv09356 (Elanganur) exhibited more virulence followed by Cf91017 (Nellikuppam). The isolate Cfv09356 behaved differently from the standard isolate Cf671 for the second consecutive year. It has produced intermediate (I) reaction on CoS 767 and BO 91, R reaction on CoS 8436, Baragua, SES 595, CoSe 95422 and Co 86032, and S reaction on all other sugarcane differentials. The isolate Cf91017 also behaved differently from standard isolate on 11 differentials and the other two isolates Cf0323 & Cf92012 behaved more or less similar to the standard isolate.

Identification of new differentials

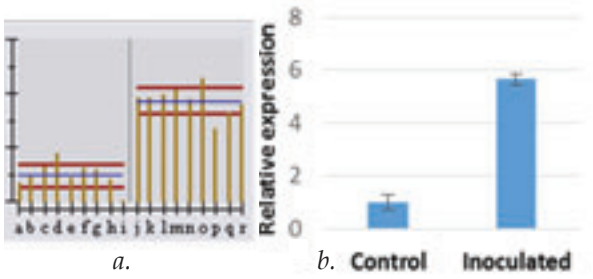
(R. Viswanathan)

Twenty six *C. falcatum* isolates collected from 18 different varieties in the states of Tamil Nadu, Andhra Pradesh, Orissa and Gujarat were tested on 26 varieties to assess their relative virulence. Among them, the isolate Cf94012 was the most virulent followed by Cfv09356 Elanganur, Cfv09356 Keerangudi, Cf91017 NKM, Cf86032 Bari and Cf92012 Naga. Many of the isolates including the standard isolate Cf671, CfROC Chandhupur, Cf86032 Kallakurichi, Cf95020 Sakthinagar, Cf0323 Petta and Cf92012 Kanjanur were less virulent.

Mapping pathogenic and molecular variability of sugarcane smut in India

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

Defense proteomics to understand compatible/ incompatible interactions involving sugarcane and the smut pathogen: A *Saccharum* specific custom-made amino acid sequence file was generated by translating all the available ESTs (Plant-GDB derived unique transcripts), to be used as a reference database to perform MASCOT search of the obtained mass data from compatible interaction study. Expression of candidate defence/stress responsive genes like phenylalanine ammonia lyase, L-Ascorbate peroxidase, Caeffoyl-CoA-methyl transferase, etc. were validated by quantitative real time PCR in the compatible interaction study (Fig. 32).



a. *b.*

Fig. 32. a. Representative histogram of a differentially expressed protein spot showing normalized spot volumes of all the technical replicates representing samples of control and inoculated tissues

b. Gene expression analysis by QPCR to validate the differential expression

In vitro secretomics of the smut pathogen: From the *S. scitamineum* whole genome dataset, coding sequences were predicted to derive corresponding amino acid sequences by AUGUSTUS web server. This amino acid sequence file was used as a reference data set for analyzing Mass Spectometry (MS) data output. This facilitated identification of host signal-responsive secretory proteins of *S. scitamineum*. As part of characterizing the virulence coding genes in the sugarcane smut pathogen, gene sequences of CMU, TIN, PIT2, STP, SRT, etc. (functionally characterized effectors of *Ustilago maydis*) were retrieved by blast search against *S. scitamineum* genome. Primers were designed for targeting the identified candidate secretory proteins/ orthologous effectors and conditions optimized for the gene expression analysis.

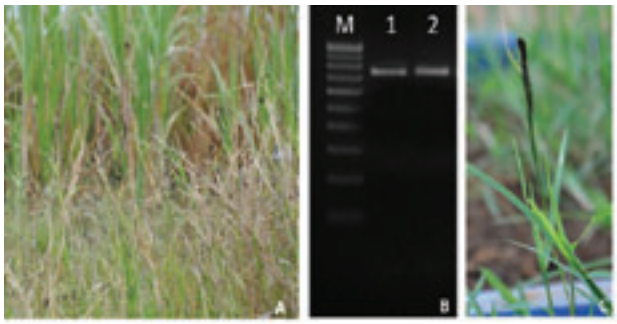


Fig. 33. Prevalence of smutted Cynodon dactylon in vicinity to sugarcane fields B. PCR amplification of ITS region (M-Marker, 1-Weed smut pathogen, 2-Sporisorium scitamineum (gDNA templates) C. Proving Koch's postulate - smutted inflorescence of C. dactylon

Identification of weed smut pathogen: Critical observation of the smut incidence in weeds at close proximity to sugarcane experimental fields indicated that *Cyanodon dactylon* - the Bermuda grass is the predominant host for the weed infecting smut fungus. Identity of the weed smut fungus was confirmed as *Ustilago cynodontis* through ITS sequencing and was validated by proving Koch's postulate on its grass host - *Cynodon dactylon*. However the weed smut fungus could not produce any whip smut symptom in sugarcane on cross-inoculation (Fig. 33).

Exploitation of endophytic bacteria for the management of sugarcane diseases

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

Pot experiment to assess antagonistic potential of endophytic bacteria: In the red rot trial, the least incidence of red rot was noticed in setts treated with ESR 3 (30.8%) followed by ESR 21 and ESR 24 (46.2%), when compared to 76.9% red rot incidence in pathogen inoculated control. In the smut experiment, the plants developed from the setts treated with endophytes ESS 9, ESR 3, ESR 7 and ESR 21 did not show any smut incidence until 8 months after planting. In the other endophyte treated plants also only least incidence of smut was recorded when compared to 25% incidence in control.

Field trial to assess antagonistic potential of endophytic bacteria: The endophyte strain ESR21 (*B. pumilus*) treated sugarcane setts recorded highest germination (62%) followed by ESR3 (*B. amyloliquefaciens*) treated setts. Challenge inoculation of pathogen on endophyte treated setts under field condition showed varying degree of disease incidence. In pathogen inoculated control, the disease initiated from germination onwards causing reduction in germination/drying of germinated seedlings, production of mid rib lesion followed by yellowing and drying. The least incidence of red rot was recorded in ESR3 (43.4%) treated plants followed by ESR 21 (55.8%) when compared to 91.2% disease incidence in control. The same trend was noticed in production of number of millable canes and yield, i.e., ESR3 treated plants recorded highest yield followed by ESR 21.

Identification and characterization of genes / proteins related to *Colletotrichum falcaum* pathogenicity

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

Characterization of pathogenicity gene homologs in C. falcatum causing red rot in sugarcane: In continuation of earlier studies, totally about 28 pathogenicity gene homologs under 14 different functions were referred from other *Colletotrichum* spp. and amplified in *C. falcatum*. The specific amplicons were sequenced to confirm their identity. Results of the study revealed that the sequences have both intra- and interspecific variations among phylogenetically identified virulent and least virulent isolates. The key gene PKS1 involved in melanin biosynthesis was found to show variation in *in vitro* and *in vivo* among the isolates varying in virulence. The gene responsible for appressorium penetration RPK1 was found amplified only in virulent isolate and not in the least virulent. Similarly, another gene APH involved in appressorium penetration was highly expressed during host pathogen interaction in the virulent isolate. Our results confirm the role of selected pathogenicity related genes during pathogenesis of *C. falcatum*. Among these genes,

PKS1 is being studied in detail for functional analysis to prove its role in melanin biosynthesis.

Identification of pathogenicity related genes in C. falcatum*:* To identify and characterize pathogenicity related genes, phylogenitically differentiated virulent (Cf671) and least virulent (Cf92020) isolates were inoculated on susceptible variety by plug method and 10 days after inoculation, tissue samples near inoculated position were drawn and extracted RNA from two samples along with mock. The RNAs were subjected to cDNA synthesis and Suppressive Subtraction Hybridization (SSH) as per CloneTech subtraction kit manual. The subtracted products were sent for NGS analysis. Similarly, subtracted products from virulent isolate (Cf671) inoculated on susceptible (CoC 671) and resistant (Co 93009) hosts and also products from sporulating virulent (Cf671) and non-sporulating virulent (Cf89V74) isolates inoculated on susceptible host have been sent for NGS analysis and being sequenced. Reaction of virulent (Cf671), least virulent (Cf92020) and non-sporulating virulent (Cf89V74) isolates on susceptible cultivar and virulent (Cf671) isolate on resistant host (Co 93009) shown in the figure (Fig. 34) indicates types of tissue used for SSH process.

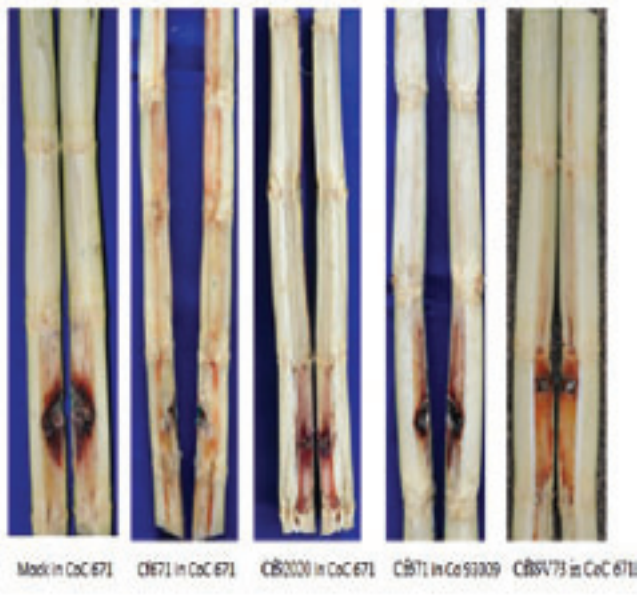


Fig. 34. Behaviour of C. falcatum isolates varying virulence in response to host susceptibility/ resistance

Structural characterization and evaluation of toxin produced by *Colletotrichum falcatum* for sugarcane red rot disease management

(V. Jayakumar)

Column chromatography and fractionation of toxin: Elution of five crude samples *viz*., culture filtrate, fungal mat extract, spore fluid, spore germination fluid and red rot infected cane extract through Silica & C18 column and their bioassay showed that toxin could be eluted well in polar to mid-polar range, *i.e.*, water, water + methanol, methanol and also with diethyl ether. Based on the above results a new protocol for toxin fractionation was formulated *i.e.*, toxin was subjected to fractionation with diethyl ether at acidic, alkaline and neutral pH and 15 fractions of toxin were collected. The bioassay results showed that fraction of toxins eluted at pH 8.5 & 3.5 produced severe symptom and the mild symptom production was observed with fraction eluted at pH 7 (Table 17). Yellowing and browning/scorching of leaves were noticed on toxin inoculated leaves and the browning lesion of >10mm was observed on 10th day after inoculation.

HPLC and mass spectral analysis: The 15 fractions were subjected to HPLC with various combinations of solvents and maximum peaks were observed with water (W): acetonitrile (A) elution. The maximum possible separation of compounds could be done with the mobile phase of W:A in 40:60 ratio with gradient run. Bioassay of HPLC fractions identified 38 active fractions, in that eight produced severe symptom, 13 produced moderate symptom and 17

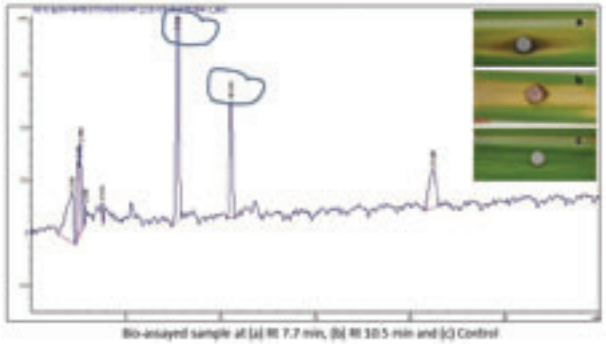


Fig. 35. Chromatogram of HPLC eluted samples showing repeated occurrence of 2 peaks at Rt 7 and 10 min and bioassay of HPLC fractions on sugarcane leaves

produced very mild symptom. In 38 samples, three were selected on the basis of symptom production and analyzed with LCMS. Among 38 samples, 21 samples that were producing severe and moderate symptoms were taken further for HPLC to separate the compounds and elute the active peak/compound. The chromatogram of 21 HPLC eluted samples showed the repeated occurrence of two peaks at Rt 7 and 10 min and bioassay of these HPLC fractions (101 samples) showed that these two were biologically active (Fig. 35). The fractions collected at Rt 7 induced severe necrosis and yellowing whereas the fraction collected at Rt 10 induced yellowing and mild browning on leaves.

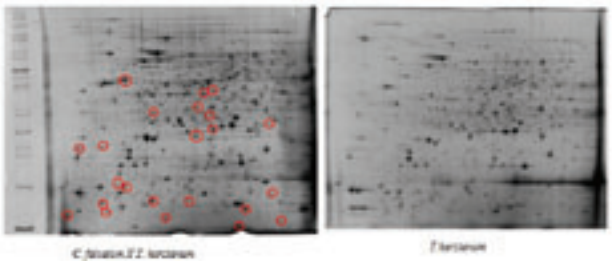


Fig. 36. Identification of antifungal proteins from T. harzianum during its interaction with C. falcatum by 2DGE - Intracellular protein

sent to MALDI-TOF analyses. Results showed that most of the assigned proteins were involved in defense related proteins *viz.,* 14-3-3 protein homolog, triosephosphate isomerase, peroxidase,

***Table 17*. Bioassay of fractionated samples on detached leaves of sugarcane**

Toxin fraction eluted at pH	Culture filtrate				Fungal mat extract				Guttation fluid			
	4th DAI	6th DAI	8th DAI	10th DAI	4th DAI	6th DAI	8th DAI	10th DAI	4th DAI	6th DAI	8th DAI	10th DAI
3.5	(+)	+	++	+++	x	(+)	+	+++	x	(+)	++	++
7.0	x	(+)	+	++	x	(+)	(+)	++	x	+	++	++
8.5	(+)	(+)	++	+++	x	(+)	++	+++	(+)	(+)	++	+++

* Results are mean of 3 replications; DAI- Days after inoculation

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

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

Identification of antifungal proteins from T. harzianum *during its interaction with* C. falcatum*: C. falcatum* and *T. harzianum* were grown individually in complete medium broth and for interaction, *T. harzianum* was grown on *C. falcatum* culture filtrate. Both intra, extracellular proteins were precipitated by 80% of ammonium sulphate and precipitated protein samples were dissolved in phosphate buffer, further purified by filtering through the amicon filter and purified protein samples were separated by 2DGE. Gels were scanned for image analysis with the image master 2D platinum imaging software ver. 7.0. Comparative 2-D gel analyses, in intracellular protein profile 592, 636 and 477 spots were expressed and in extracellular protein profile 691, 446 and 424 spots were expressed in Cf, Cf x Th, Th (Fig. 36) respectively. Among them, 50 unique protein spots (both intra and extra) were

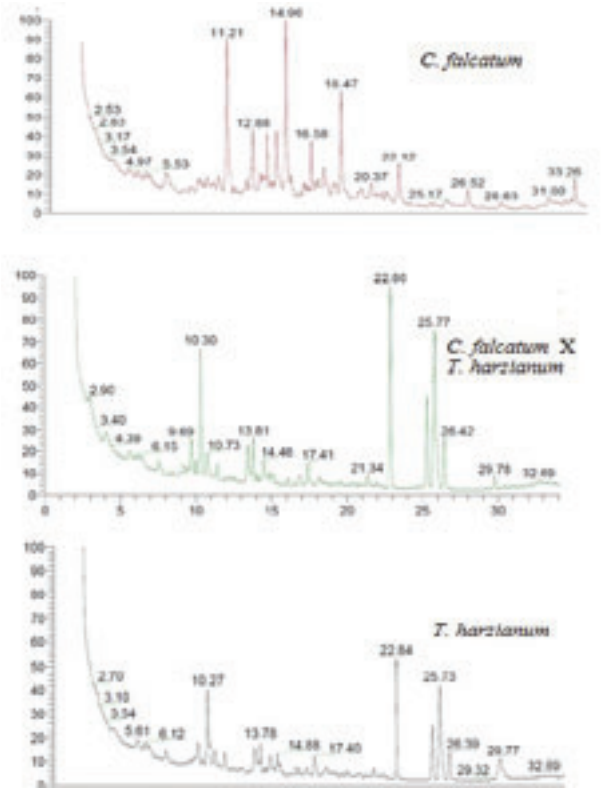


Fig. 37. Separation and identification of volatile compounds from T. harzianum *during interaction with* C. falcatum *by GC-MS analysis*

lon protease homolog, antagonist of mitotic exit network protein 1, hypothetical protein etc., were highly expressed when *T. hazianum* grown on *C. falcatum* culture filtrate.

Identification of secondary metabolites from T. harzianum *during its interaction with* C. falcatum*:* For identification of secondary metabolites, cells were removed from all the samples (Cf, Cf x Th, Th) by centrifugation and filtration. Equal volume of ethyl acetate (EtoAc) was added with culture filtrate and kept at overnight incubation. Secondary metabolites were filtered through the separating funnel and EtoAc was evaporated at 40°C in a rotary evaporator. Dry weights of antifungal metabolites were dissolved in methanol and the samples were analyzed by GC-MS analysis. Results revealed that 57, 59 and 58 volatile compounds were expressed in Cf, Cf X Th and Th respectively (Fig. 37). Among the 59 volatile compounds, 33 were newly expressed in interaction as compared to *C. falcatum* and *T. harzianum*. Based on the chemical structure, the major secondary metabolites expressed were fatty acids (ricinoleic acid, tridecanoic acid etc.) in *C. falcatum* alone, alkane compounds (heptadecane, hexadecane etc.) in *T. harzianum* and antimicrobial compounds (styrene, octadecenoic acid etc.) during interaction of pathogen and antagonist. *Bioassay of secondary metabolites:* Bioassay study with extracted

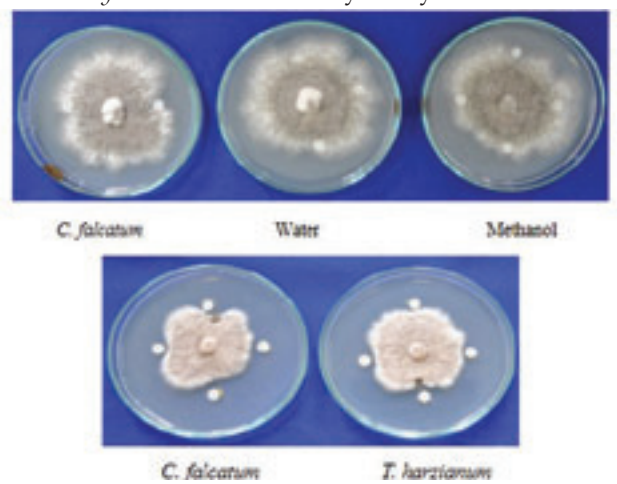


Fig. 38. Bioassay of secondary metabolites from T. harzianum *on* C. falcatum

secondary metabolites/antifungal proteins indicated complete inhibition of *C. falcatum* conidial germination and proved their efficacy (Fig. 38). Further, expression of unique antifungal genes are being validated by Real-Time PCR.

Phytoalexin studies: Induction of phytoalexin compounds during host–pathogen interaction between sugarcane and *C. falcatum* was assayed from ~250 tissue samples of 90 clones varying in red rot resistance after pathogen inoculation under controlled condition testing. HPLC analyses were performed to identify the phytoalexin compounds *viz*., apigeninidin, luteolinidin and cyanidin. In addition few uncharacterized compounds were also detected. The 90 clones exhibited differential accumulation of phytoalexin compounds luteolinidin from 0.00069 to 0.049 μgmg^{-1}; apigeninidin from 0.00087 to 0.123 μgmg^{-1} and cyanidin from 0.00035 to 0.448 μgmg^{-1}. The assays clearly revealed that biochemical induction was higher in resistant clones whereas S types recorded lower induction.

Histological studies to track pathogen progress inside the host tissues: Histological observations in tissue samples of sugarcane cvs Co 93009 and CoC 671 inoculated with GFP transformed *C. falcatum* and wild isolate by plug method revealed progress of fluorescent hyphal structures in both the varieties. After 5 days, fluorescent hyphal structures were observed only in CoC 671 and not in Co 93009. Both wild type *C. falcatum* isolate and GFP tagged *C. falcatum* exhibited similar pattern of virulence on the susceptible cv CoC 671 (Fig. 39).

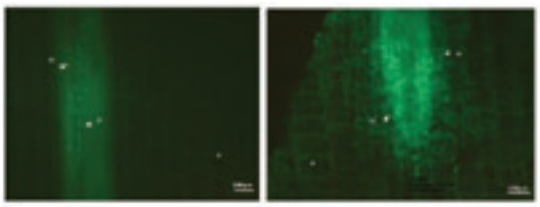


Fig. 39. Progress of GFP tagged C. falcatum *infection in sugarcane: restricted (Co 93009 resistant) and progressive (CoC 671, susceptible)*

Evaluation of delivery methods with chemicals / microbes for the management of major fungal diseases in sugarcane

a. Evaluation of delivery methods

(P. Malathi, A. Ramesh Sundar and T. Ramasubramanian)

Red rot management: Greenhouse studies showed that sett treatment with combination of thiophanate methyl (500ppm) and 5% *Pseudomonas fluroscenes* suspension or sett treatment with 1000 ppm of

thiophanate methyl by different methods *viz*., overnight / mechanized and delivery of bacterial antagonist as soil drench at 1% in pots 30DAP showed that the combined treatments have improved plant growth parameters apart from disease suppression in CoC 671.

Field trial for red rot management in CoV 09356 laid in factory areas at Tuhili indicated that mechanized treatment with thiophanate methyl alone and combination with fungicide spray or drenching with *P. fluorescens* at 1% applied 90 DAP maintained good crop stand as compared to control (Fig. 40). After second treatment, the crop stand was improved in combined treatments compared to

Inoculated control

Mechanized sett treatment with thiophanate methyl+Drenching with *P. fluorescens* 90 DAP

Fig. 40. Evaluation of delivery methods for red rot management at Shri Ambiga Sugars, Tuhili, Kumbakonam

sett treatment alone and they were on par. The yield improvement was 1.4 and 1.2 fold in sett treatment + soil drenching with fungicide (thiophanate methyl – 1000 ppm) and sett treatment + soil drenching with *P. fluorescens* respectively.

Smut management: A trial was laid out with smut susceptible cultivar heavily infected with smut for smut management by various methods of fungicide treatments *viz*., mechanized treatment alone and in

Control – infected seed canes

Mechanized sett treatment of fungicide with infected seed cane and spray (60 DAP) with propiconazole – 100ppm

Fig. 41. Evaluation of delivery methods for smut management at Shri Ambiga Sugars, Tuhili, Kumbakonam

combination with spray and drip irrigation system using propiconazole at 100 ppm. Results showed that the treated plants remained healthy and maintained a good crop stand compared to control; germination was above 80% in all mechanized treated blocks were as in control it was below 30% (Fig. 41). The addtional delivery of propiconazole at 100 ppm given throw drip system and foiar spray on 60 DAP indicated a high disease suppression as compared to sett treatment alone. Finally, yield data indicated that the treated plots showed increased yield with reduced smut incidence. Among the different treatments, combination of sett treatment and fungicidal delivery through drip system was found to be superior.

Wilt management: Mechanized sett treatment with carbendazim at 1000 ppm was found to be equally effective as overnight soaking in maintaining plant survival across the varieties in NHG (Fig. 42). Further addition of *Trichoderma* as soil application helped to reduce the wilt incidence.

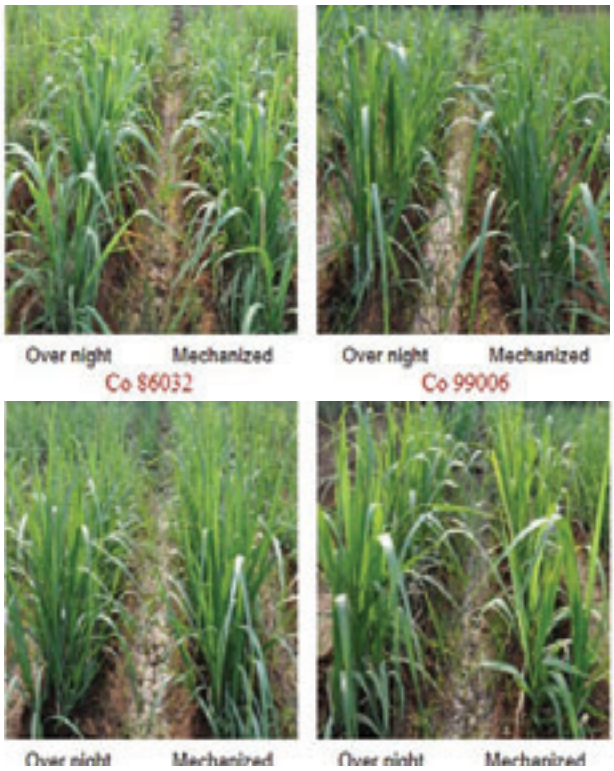


Fig. 42. Equal effect of overnight and mechanized sett treatments across the clones in National Hybridization Garden

b. Validation of mechanized sett treatment device

(R. Viswanathan and P. Malathi)

Validation of mechanized system for the treatment of sugarcane planting material: The newly fabricated unit was validated with selected fungicides *viz.*, thiophanate methyl at 1000 ppm, propiconazole at 100 ppm and carbendazim at 1000 ppm against red rot, smut and wilt respectively under greenhouse and field conditions. Results indicated that the mechanized treatment was found to be equally effective as overnight soaking irrespective of setts or bud chips.

Compatibility of fungicides and insecticides for mechanized sett treatment: Since application of fungicides and insecticides in single treatment will be highly helpful for integrated management of pest and diseases, rapid mechanized sett treatment was tried to take care of sett and soil-borne pest and diseases. Before testing the compatibility, the suitability of insecticides for mechanized sett treatment was evaluated at various concentrations. Results showed that the concentration below recommended dose was found to be better without affecting germination. Hence three insecticides viz., chlorantraniliprole, chloripyriphos and fipronil recommended for soil-borne pests viz., early shoot borer and root borer were tried at their recommended and 50% of recommended dose. Results on compatibility studies indicated that thiophanate methyl at 1000 ppm was highly compatible with fipronil at 50% of its recommended dose compared to other insecticides for mechanized sett treatment.

Mechanized sett treatment for disease management: Mechanized sett treatment with fungicides for red rot, smut and wilt management was evaluated in five field trials including institute and factory

Fig. 43. Validation of mechanized sett treatment for disease management at factory areas – Shri Ambiga Sugars, Tuhili, Kumbakonam

fields during 2014-2015. In institute field trials, evaluation of two units of different size for red rot and smut management showed no difference among them. Further simultaneous evaluation of both the units in factory areas showed that the mechanized treatment (Fig. 43) was able to protect the setts from sett and soil borne inoculum of fungal diseases, significantly improved plant survival and yield without any deleterious effect irrespective of genotype.

Mechanized sett treatment for healthy nursery programme: In factory areas, raising nursery using single bud setts is gaining importance and to get good quality settlings, they treat the cuttings in

a mixture of various inputs for 30 min and plant in trays. Since mechanized treatment is capable of delivering more than one input rapidly and effectively, it was compared with conventional soaking in Ponni Sugars, Oodathurai, Namakkal dt. for drought management in Co 86032.

In mechanized treatment, the input concentrations were lowered by 1/8 (c) and 1/4th (d) level and compared with their normal practice (b) . Results showed that the mechanized treatment with mixture of 0.5% super lime, 0.5% urea and 0.1% carbendazim was highly efficient in producing first quality settlings (Fig. 44) as compared to 2.5% concentration of super lime and urea. This package was highly appreciated by factory personnel and implemented for their regular seed nursery programme. In this connection, a field day has been conducted to popularize the technology on 21.03.2015.

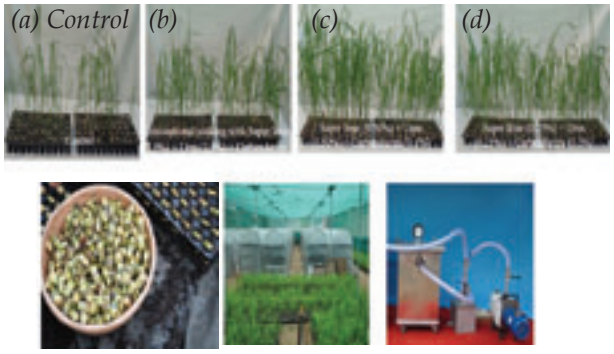


Fig. 44. Impact of mechanized treatment on delivery of different inputs for Healthy Nursery Programme at Ponni Sugars, Namakkal District

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

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

Characterization of viral suppressor genes: P0 gene of Sugarcane yellow leaf virus (SCYLV) from different Indian isolates *viz*. CB86032, CBV92102, CBC671, CB997, CB10033, CB419, CBM10084, CB57NG56, CB10004, CB85019, CBPI10131, CBPant84211, CB09003, CBM10081 was characterized. The P0 genomes were grouped into two major clusters based on the amino acid similarity.

Developing vector constructs for silencing assays: The P0 gene amplicons were amplified from SCYLV-infected cvs CoC 671 and Co 86032, cloned and sequenced. The non-cutter restriction sites were identified and the primers were designed with those restriction sites compatible to the pBINGFP vector. The P0 gene was amplified with the primers containing restriction sites (Xba1 and BsrG1), purified and sticky ends were made with the respective restriction enzymes. Using the same enzymes, the GFP gene present in the vector was removed and the target P0 was cloned into the skeleton (pBIN-P0). This vector construct pBIN-P0 was mobilized into *A. tumefaciens* LBA4404. Similar to P0 vector constructs, another study was conducted to develop vector constructs with P1 and HC-Pro gene of SCSMV. The non-cutter enzymes KpnI and XbaI were selected for both the target genes to clone into the pHANNIBAL vector. P1 and HC-Pro specific primers with flanking restriction sites were designed and cloned into pHANNIBAL vector. Using the NotI octamer enzyme, the cassette harbouring the target gene was moved to the binary vector pART27 and mobilized into the *A. tumefaciens* strain LBA4404.

Assaying the silencing activity of viral RNA silencing suppressor in model plant system: A construct expressing GFP (pBIN-GFP) was co-agro infiltrated with a suppressor-expressing construct (pBIN-P0) into model plant *Nicotiana tabacum* leaves, and GFP expression was compared to the treatment with GFP construct alone. Co-expression of GFP and SCYLV-P0 showed elevated accumulation of GFP as compared to GFP expression without suppressor. GFP imaging and analysis of images of *N. tabacum* young leaf segments co-expressing GFP and the suppressor revealed enhanced and

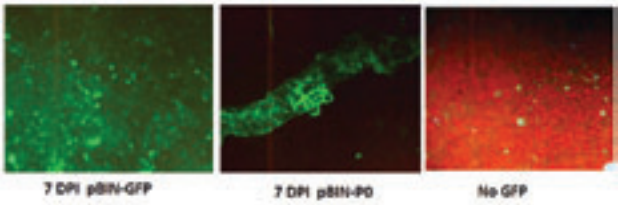


Fig. 45. RSS activity of SCYLV-P0 through Agrobacterium-mediated transient expression system

prolonged GFP expression in the model plant (Fig. 45). Similarly, silencing assays were conducted with vector constructs containing P1 and HC-Pro gene of SCSMV (pHANNIBAL) through agro-infiltration in wild type *N. tabacum*. The GFP expression level increased after 2 dpi and at the 7 dpi the GFP signal was meagre in the GFP, HC-Pro+GFP infiltrated leaves and in the GFP+P1 infiltrated leaf, the expression continued and that confirmed that P1 has the potent suppressor activity. The assay results were further validated in RT-PCR for GFP expression using specific primers (Fig. 46).

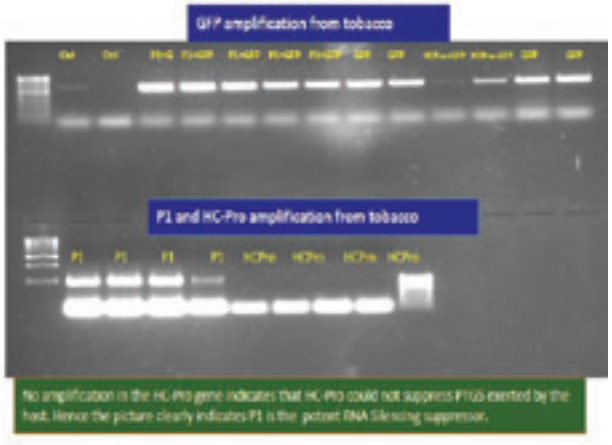


Fig. 46. Confirming Sugarcane streak mosaic virus (SCSMV) P1 as the potent RNA silencing suppressor in model plant through RT-PCR

Construction of the RNAi Expression Vector: A 771 bp fragment spanning 71 - 841 nt of SCYLV genome, which encodes a full length transcript of a suppressor of post-transcriptional gene silencing (PTGS) P0 component of SCYLV-IND, was amplified by RT-PCR and subsequently cloned into pSTARLING vector, which contains Pac1 and Asc1 restriction sites. The transformant with the correct insert (771bp) was positioned in the sense orientation between the restriction sites and in the antisense orientation between the Spe1 and Kpn1 restriction sites on either end of 800 bp fragment of CRE-intron derived from barley. The pSTARLING vector contained constitutive promoter maize ubiquitin gene Ubi1. The inverted repeat gene cassette with the promoter was then sub cloned into Not1 site of binary pART27.

Identifying the most conserved region in SCSMV-P1 for hairpin construct: Ten isolates of SCSMV P1 gene were characterized and comparative sequence analysis of them revealed 83–98% nt sequence identity among themselves and 83–91% identity to other SCSMV isolates. The most conserved region of SCSMV P1 gene was identified from the characterized SCSMV isolates and development of a hairpin construct is in progress to transform into sugarcane through *A. tumefaciens*.

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

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

Standardized the methodology for synthesis of nano particles of chitosan by Ion Gelation technique. The particle size distribution (PSD) of lyophilized Chitosan sample was analyzed in ethanol suspension. Homogeneous dispersion was attained by ultrasonic agitation. It was found that the average size of the major part of the particles is 155, 210 and 245 nm for different concentrations of Chitosan samples. From the particle size analysis it was observed that the particle size decreased when the concentration of Chitosan increased. Zeta potential is defined as the surface charge which can greatly influence the particle stability in suspension through the electrostatic repulsion between particles. Zeta potential of synthesized chitosan nanoparticles was found to be -3mV. Since the expected range of particle size and zeta potential was not obtained, optimization has to be carried out by changing the pH range and the concentrations of chitosan and TPP.

Outreach project on *Phytophthora, Fusarium* and *Ralstonia* diseases of horticultural and field crops

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

Sugarcane wilt: Survey for the diseases and pathogen isolation: Surveys have been conducted in different states in both tropical and sub-tropical regions for wilt and pokkah boeng (PB) infections either alone or in their combination. In addition, clones maintained at NHG were also systematically surveyed for wilt infections (Fig. 47). The samples collected from the surveys were subjected to

Fig. 47. Severe wilt infection in a NHG clone MS901

pathogen isolation. About 53 new isolates were collected from different samples. The cultures are being studied for the variation in cultural and morphological characters.

Simulation of Fusarium *pathogenicity:* Detailed field and greenhouse studies were initiated to simulate wilt development in selected clones at Coimbatore and Karnal. About 19 naturally wilt infected clones were planted in the field along with healthy canes and fungicide treated canes. Similarly, under greenhouse conditions, infected and healthy canes of three varieties were planted in the experimental set up of healthy soil + healthy cane; healthy soil + infected cane; infected soil + healthy cane; infected soil +infected cane. Observations on sett germination and progressive wilt development are in progress.

Virus indexing service

(R. Viswanathan)

A total of 518 batches of tissue culture raised plants from tissue culture production units of M/s RSCL, Theni, Sarvaraya Sugars, Chelluru, Navabharat Ventures, Samalkot and Harinagar Sugars, Harinagar, Bihar, were indexed for three RNA viruses and grassy shoot phytoplasmas by following SOPs. Test reports were prepared and sent to the concerned labs. An amount of Rs 2,55,800/- was realized as indexing charges during the period.

Sugarcane quarantine

(R. Viswanathan)

The clones LG 07595, LG 07650, LG 08478, LG 08865, LG 08866 (Lucknow), Siddhagiri 1234 (Pune), CoS 03261, CoS 08279, CoS 10239 (Shahjahanpur), CoSe 01434 (Seorahi), CoSnk 13104 (Sankeshwar), CoPb 13182, CoPb 13183 (Faridkot), CoA 13321, CoA13322, CoA13324, CoA 13325, CoA 13327, CoA 13328 (Anakapalle) and BO 153, BO 154, BO 155, CoP 09437, CoP 11436, CoP 12436, CoP 13436, CoP 13438 (Pusa) were handed over to NHG after quarantine. Similarly, the clones C 260138, C 260628, CoC 08336 (Cuddalore), CoP 06436 (Pusa), CoN 07072 (GNS-8) (Navsari) and Co 06034 (Karnal) were handed over to NAG after quarantine.

The clones CoLk 07201 (Lucknow), CoS 09231, CoS 08235, S. 301/87 (Shahjahanpur), CoPb 14181, CoPb 14182, CoPb 14183, CoPb 14184, CoPb 14185, CoPb 13181 (Faridkot), CoPant 84211, CoPant 84212, CoPant 90223, CoPant 94211, CoPant 96219, CoPant 97222, CoPant 99214 (Pantnagar), BO 153, BO 154, BO155, CoP 09437, CoP 11436, CoP 12436, CoP 13436, CoP 13438 (Pusa), CoA 13323, CoA 13326, CoA 14321, CoA 14322, CoA 14323, CoA 14324 (Anakapalle) 93 V 297 (Vuyyuru), C 260628, CoC (Sc) 24 (Cuddalore), CoTI 1153 and CoTI 1358 (Thiruvalla) were received for NHG and are in quarantine. The clones CoPb 09181 (Faridkot), CoTI 1153, CoTI 1358 (Thiruvalla), CoVc 99436 (Mandya), VSI/GU 2011-1, VSI/GU 2011-2, VSI/GU 2011-3, CoVSI 08121, CoVSI 08123 (Pune), CoA 13323, CoA 13326, CoA 14321, CoA 14322, CoA 14323, CoA 14324 (Anakapalle) and CoOr 10346 (Orissa) were received for NAG and are in quarantine.

5.3.2 ENTOMOLOGY

Host plant resistance and behavioural studies of sugarcane pests

Screening of Indian hybrid genotypes against internode borer

(P. Mahesh and B. Singaravelu)

Borer incidence: In the second crop season, 186 Indian hybrid genotypes, which include resistant as well as escapes from the previous season, were planted in a replicated trial in the borer endemic M/s Rajshree Sugars factory area at Mundiampakkam for screening against internode borer. These clones were screened and natural incidence and intensity of internode borer were recorded. Of the 186 genotypes, none was totally free from infestation in all the three replications. While the lowest incidence level was recorded in Co 293 (4.50%) and the highest was recorded in Co 1183 (95.00%). In the final observation, 50 genotypes were found to be resistant (R) with less than 15% incidence, 31 genotypes were found to be moderately susceptible (MS) with an incidence range of 15-30%. One hundred and five genotypes were found to be highly susceptible (HS) with an incidence range of 30-95% (Table 18).

Table 18. **Grouping of Indian hybrid genotypes on the basis of internode borer incidence (2014)**

Grade	Status of genotypes	No. of genotypes	Percent of genotypes
I	Resistant (0.0-15.0)	50	26.88
II	Moderately susceptible (15.0-30.0)	31	16.66
III	Highly susceptible (>30.0)	105	56.45

(Figures in parenthesis are percent incidence values)

Borer intensity: Intensity of internode borer was recorded in 50 genotypes which were found to be resistant (R) with less than 15% incidence. The lowest intensity level was recorded in Co 62018 (6.02%) and the highest was in Co 302 (16.25%). A maximum of eight internodes per cane showed bore hole symptoms.

Biological control of sugarcane pests

Exploitation of endophytic *Beauveria bassiana* for the management of *Chilo* spp. of sugarcane

(T. Ramasubramanian, N. Geetha and V. Jayakumar)

Beauveria bassiana isolates NBAII 11, 23, 47, 58 and 61 were confirmed as endophytic to sugarcane. The innovative delivery method of endophytism, as explored in this study for the first time, provides season-long protection against crambid borers of sugarcane. Since a large culture of lab-reared internode borer (INB) larvae is needed for the evaluation of sugarcane plants harbouring endophytic *B. bassiana* isolates, the artificial diet standardized by earlier workers was used for mass-rearing INB in the lab. The diet-reared F1 population was observed to lay a high proportion of unfertile eggs and, therefore, advancement of generations would be difficult. Hence, detailed observations on biology and fecundity of diet-reared INB were made on a fresh batch of neonates emerging from field-collected population. The diet was also found to be contaminated with microbes after two weeks of its preparation. Diet contamination due to microbes has resulted in significant loss of larval recovery. Age-specific fecundity tables were constructed for the diet-reared and shoot-reared populations of INB. The fecundity table statistics were in favour of shoot-rearing as compared to rearing INB on artificial diet. Hence, it was felt necessary to modify the diet so as to make it amenable for the advancement of generations. We are in the process of perfecting the diet with modifications required whenever necessary. Streptomycin sulphate and carbendazim were added to prevent diet contamination from bacteria and fungi, respectively. One of the major

components of the diet has been changed with different proportions of diet ingredients. The modified diets (Diets I, II, III) along with base diet have been evaluated for mass rearing of INB. One of the diets was found superior to others in terms of larval recovery, pupal recovery, sex ratio, weight of the pupae and fecundity.

Evaluation of potential management tools against internode borer

(J. Srikanth, K. P. Salin, R. Jayanthi, M. Punithavalli and P. Mahesh)

Monitoring of internode borer natural enemies: Larval parasitoids of internode borer, particularly the braconid *Cotesia flavipes*, were monitored at Coimbatore from April 2014 to March 2015 through fortnightly sampling of larvae from growers' farms. During April - July 2014, fortnightly parasitoid recovery ranged 0.0 - 6.0%, the highest being in the first fortnight of July 2014 (Fig. 48). Considerably higher activity of *C. flavipes* was observed during the humid months of October – November 2014. The parasitism level reached 15.4% in the second fortnight of October followed by another peak (12.5%) in December second fortnight. The lowest parasitism level (3.03%) was observed in the second fortnight of February 2015 after which there was another unusual peak (9.1%) in the first fortnight of March 2015. The parasitoid activity was, in general, higher than those observed in the previous years or previous studies.

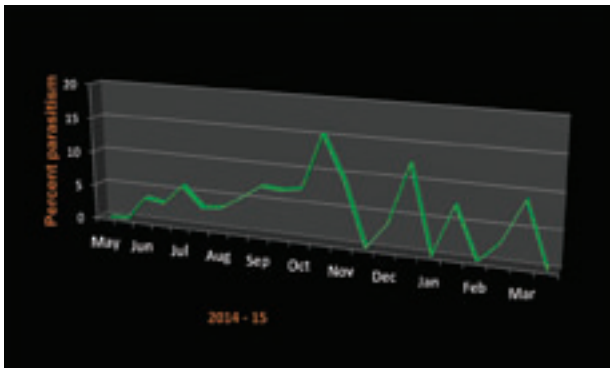


Fig. 48. Pattern of Cotesia flavipes *parasitism in internode borer larvae at Coimbatore (2014-15)*

Natural enemy activity in cane areas: In surveys carried out in a few sugar factory areas during February-March 2014, *C. flavipes* was recovered with parasitism levels of 8.0% at M/s Bannari Amman Sugars, Sathyamangalam, 4.2% at M/s Sakthi Sugars, Aapakudal and 9.1% at M/s Rajshri Sugars and Chemicals, Mundiyampakkam. These parasitism rates were slightly higher than those observed at Coimbatore in the corresponding months. A small batch of internode borer larvae collected from Kannur, Kerala, in November 2014 did not yield *C. flavipes* or any other parasitoid. In January 2015, a sample of borer larvae collected from Mundiampakkam showed a high parasitism rate of 14.3% with percent emergence of 75.0-97.7 and percent males of 18.5-55.6 among the three cocoon masses recovered. A cocoon mass collected from borer infested cane from the same place in March 2015 produced 100% males. In attempts made to collect subtropical populations of the parasitoid, a cocoon mass of *C. flavipes* collected from stalk borer infested cane at Karnal in January 2015 failed to emerge in the laboratory. Stalk borer larvae collected from the field and maintained in the laboratory at Karnal did not produce *Cotesia* but were infected by an unidentified fungus.

Laboratory studies on populations of C. flavipes*:* Parasitization rates of *C. flavipes* populations were examined in diet-reared sorghum borer or internode borer larvae by the standard group-exposure method to assess the suitability of the host. Parasitization rates by Coimbatore population were more or less same in sorghum borer and internode borer larvae. In further studies, an Aapakudal population showed 18.5% parasitization and a Mundiyampakkam population showed 16.0% parasitization on lab-reared internode borer larvae. Despite the difference in the host used, the parasitoid from different geographical areas of Tamil Nadu produced comparable parasitization efficiency. A few consignments of cocoon masses from stalk borer obtained from Lucknow on different dates and maintained in the laboratory either produced only males or only females or no adults.

Field evaluation of C. flavipes*:* Augmentative releases of Coimbatore and Aapakudal populations of *C. flavipes* were made in a grower's farm at a dosage of 500 females/ha. Field releases were made and pre-treatment counts were recorded but

the trial could not be continued due to premature harvest of the crop by the grower. In further three field trials, Coimbatore population was released at 1000 - 2000 females/ha in different growers' plots of 0.20 ha size. Besides, a Mundiampakkam population of the parasitoid multiplied in the laboratory was released in a smaller plot of 0.1ha at 2500 females/ha. Pre-release and post-release internode borer counts have been recorded. In one of the ongoing trials, higher post-release parasitoid activity was observed.

Studies on egg parasitoids: Egg parasitoids of internode borer have been monitored at Coimbatore through fortnightly collections of freshly laid as well as apparently parasitized egg masses from May 2014 to March 2015 (Fig. 49). Two parasitoid species emerged whose identity was tentatively established as *Telenomus* (*dignus* – group) (Hymenoptera: Platygastridae) and *Trichogramma* nr. *chilotraeae* Nagaraja & Nagarkatti (Hymenoptera: Trichogrammatidae). *Telenomus* sp. was the more predominant of the two species occurring in more than 98% of egg masses collected whereas *Trichogramma* sp. was recovered in only two egg masses. Fortnightly parasitism of *Telenomus* sp. ranged 40-100% on egg mass basis. Within egg masses, though 100% individual eggs were parasitized, parasitoid emergence was often less than 100%. Absence of hatching from these egg masses indicated that all eggs were parasitized but some parasitoids failed to emerge. In preliminary laboratory tests, adults of *Telenomus* sp. exposed to freshly laid egg masses of internode borer at random parasitoid: egg ratios

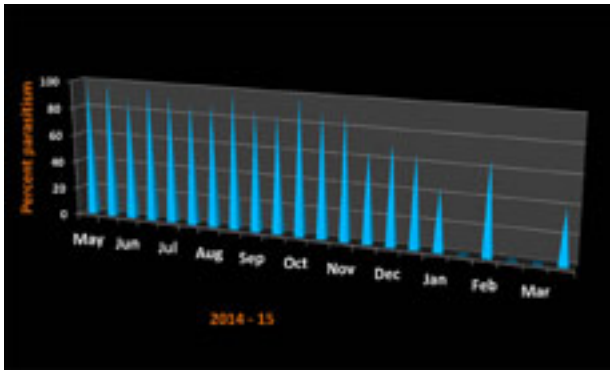


Fig. 49. Pattern of Telenomus *sp. parasitism in internode borer eggs at Coimbatore (2014-15)*

successfully parasitized the borer eggs as evidenced from parasitoid emergence in about 15 days. Parasitism within individual egg masses was 100% and parasitoid emergence from parasitized egg masses ranged 33-100%. The percentage of males in the progeny ranged 10.0 - 23.3%.

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: Work on *M. anisopliae* local isolates in soil samples from different factory zones is continued. Cultures of MTCC (10), MCC (2), ITCC (9) and NAIMCC (9) were obtained, isolated into single spore colony and subcultured. Biological characterization using colony growth, sporulation and germination rate parameters was done on 10 different media and some MTCC, MCC and ITCC cultures were carried forward for persistence studies. Among the nine NAIMCC series, isolates F-01299 and F01300 were better than the others across the media tested.

Viruence of M. anisopliae *isolates:* Infectivity and virulence of six strains of *M. anisopliae* were assessed *in vivo* in the laboratory. Earlier bioassays with *M. anisopliae* isolates against white grub showed 75-90% mortality in first instar but less than 40% mortality in third instar up to 5 months after inoculation. Bioassays of MTCC, MCC and ITCC cultures on *Galleria mellonella* showed that all isolates were entomopathogenic and virulent (>85% mortality). Bioassays conducted with NAIMCC isolates on first instar white grub showed that they were comparable with MTCC, MCC, ITCC cultures (30-90%). However, none of the NAIMCC isolates caused mortality in third instar white grub. When tested on *G. mellonella,* NAIMCC isolates were entomopathogenic and highly virulent (>80% mortality) with lower LC 50 values against fourth instar. Against third and fifth instars also, the results were comparable. When tested against internode borer (INB), NAIMCC-F-02108, NAIMCC-F-01300 and NAIMCC-F-01296 showed more than 90% mortality (Fig. 50). Bioassays with termites were completed with all the isolates including MTCC,

MCC, ITCC and some NAIMCC cultures in four different methods. Among them, MTCC cultures were very effective. Among the ITCC cultures 5489, ITCC 4709 showed more than 90% mortality. Of the NAIMCC cultures tested, NAIMCC-F-02073, NAIMCC-F-01295 and NAIMCC-F-01296 caused mortality in the range of 60-80%.

Fig. 50. Bioassay of NAIMCCF-02108 against INB

Persistence of M. anisopliae *and effect of rhizosphere on isolates:* The isolates of *M. anisopliae*, together with *Beauveria bassiana* and *Beauveria brongniartii,* were inoculated near the root zone in pot culture. A week later, survivability of shoot borer isolate of *M. anisopliae* (SbMa), assessed as mortality of *Galleria* through larval bait studies, was the highest (86.7%). At 30 days the differences were not significantly. After 5 months, the persistence reduced to below 50% and SbMa was the best among the six older isolates. In continuation of these earlier studies on persistence, the rest of the 30 isolates were studied in pot culture. Periodically, samples were drawn and persistence was assessed through *Galleria* traps. In earlier studies, six isolates showed more than 70% persistence (mortality) after 5 months of inoculation. The persistence of *Beauveria* spp. was comparatively low (< 50%). Isolation of *M. anisopliae* was done in case of all the six isolates, though the maximum number of CFU was recorded in MTCC 6060. This was in corroboration with the mortality of the laboratory host Galleria which was used to trap the fungus. In isolate ITCC 4709, though isolation was possible, mortality of larvae due to *M. anisopliae* was below 30%. In case of MCC 1029, despite high mortality, isolation of CFU was yet not possible. Similarly, MTCC 892 showed high persistence even after five months but the isolation into the media and subsequent sporulation were poor. All these isolates showed high virulence against termites, white grub (first instar) and INB besides regular bioassays against *Galleria.*

Effect of rhizosphere and root exudates on isolates: With selected *M. anisopliae* isolates, weekly samples were taken for the first month and later on at monthly intervals at definite depth using augur. Samples were taken from the top, at the point of inoculation and at the bottom. This is to avoid biased sampling and to compare rhizosphere colonization with other areas. Soil suspensions were vortexed and aliquots of 100µl were spread on to selective agar plates. Rhizosphere competence was recorded as CFUs per gram of soil. So far MTCC 6060 has proven to be colonizing the root better than other isolates. Root exudates from sugarcane and two dicots have been collected at different ages (1 week, 1 month, 2 months) and the effect of these on selected isolates has been studied. The growth of some isolates was negatively influenced.

Guttation droplets and mycotoxins of M. anisopliae *isolates:* All the newer isolates collected i.e. 30 isolates from MTCC, MCC, ITCC and NAIMCC were inoculated in 10 different media and incubated at 25°C and guttules from the colonies were collected at different time lapse. Variations in the quantum and coloration of guttules due to the age of the colony, strain as well as medium used were observed. There were associational variations in guttules due to colony morphology. Of the new 30 *M. anisopliae* isolates obtained from MTCC, MCC, ITCC and NAIMCC, guttules were collected from many isolates as some did not produce guttules in any of the media grown after different time lapses. The droplets produced by different strains of *M. anisopliae* were collected using capillary tubes. They were characterized and under different stages of purification. Raw solution of guttules of all the isolates, whichever produced guttules, were bioassayed against *G. mellonella*. In all the guttules, feeding cessation was observed and in 13 isolates mortality was observed in the range of 20-90%. To purify, HPLC protocol was followed and the process is in progress. Methanol extract of the droplet was

filtered through 0.2µm filter and used for analysis. A gradient flow of acetonitrile and methanol was followed and the detection of the compounds was done at 210nm with a PDA detector. The purified components were further fractionalized and fraction A, a high mol. wt. fraction was tested against third, fourth and fifth instar larvae at two dilutions. Third instar larvae showed 100% mortality whereas fourth instar larvae showed 83.3% mortality and fifth instar showed 66.67% mortality. The low mol. wt metabolites were then subjected to HPLC for further purification and identification.

Mycotoxin extraction from the culture filtrates was standardized. Standard bioassay with mycotoxins (mostly destruxins) from 17 isolates has been carried out at five doses against third, fourth and fifth instars of *Galleria*. At the top two doses the target insect suffered 100% mortality in all the isolates in all the instars. In the rest of the doses, four of ITCC, MTCC and MCC have shown more than 80% mortality.

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

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

DNA was isolated from single adult insect of each species. The insect was taken in a sterilized 1.5 mL microcentrifuge tube containing warm CTAB buffer. The insect tissues were homogenized and kept in water bath at 65°C for 1.5 h. The contents were centrifuged at 12,000 rpm for 10 min. at 4°C. The supernatant was collected and equal volume of chloroform: isoamyl alcohol (24:1) mixture was added to it. The microcentrifuge tube was shaken vigorously and the contents were again centrifuged. The top layer was collected carefully, equal volume of ice-cold absolute alcohol was added to the recovered aqueous layer and kept overnight in deep freezer (-20°C). The contents were centrifuged at 12,000 rpm for 10 min under refrigeration and the supernatant was drained with utmost care so that the DNA pellet remained at the bottom of the microcentrifuge tube. The pellet was washed with 70% ethanol and then dried. The DNA pellet was dissolved in sterile Milli-Q water. One µl of RNaseA was added to the isolated DNA and kept at 37°C for 30 min. The enzyme was inactivated by keeping the contents at 65°C for 10 min. The resultant RNA-free DNA was used for PCR. The quality of the DNA was also checked by running the DNA in 0.8% agarose gel. The barcode primers were used to amplify the target fragment. PCR was performed in S 1000 PCR Touch Cycler (BioRad, USA) with 20 µl reaction volume. The PCR mixture consisted of 25-30 ng of template DNA, 0.2 µM of each forward and reverse primer, 0.2 mM each of dNTPs, one unit of Taq DNA polymerase, 1x Taq buffer and sterile Milli-Q water. The PCR thermal regime consisted of one cycle of 4 min. at 94°C; 35 cycles of 30 sec. at 94°C, 45 sec. at 47°C and 45 sec. at 72°C and a final cycle of 20 min. at 72°C. After PCR amplification, the samples were subjected to electrophoresis in 1.5% agarose gel (Fig. 51). The PCR products were purified using GenElute Gel Extraction Kit as per the manufacturer's instruction. The quality of purified PCR products was checked by resolving them in 1.5% agarose gel. The purified PCR products were cloned into the plasmid vector pTZ57R/T using InsTAclone PCR cloning kit as per the manufacturer's instruction. This is followed by transformation of *Escherichia coli* (strain DH5a) competent cells by heat-shock method. The recombinant clones were confirmed by colony PCR and also by the restriction digestion of plasmids isolated from the recombinant colonies. Plasmid DNA was isolated from single recombinant colony. The recombinant plasmid containing target fragment was digested with EcoR1/HindIII. The digestion was done in 20 µL reaction with 4 µL of recombinant plasmid, 2 µL of NE buffer, 2 µL each of EcoR1 and HindIII, 1 µL of 1x BSA and 8 µL of nuclease free water. The release of insert (~700bp in size) confirms the successful transformation. Sequencing of purified plasmids was done through outsourcing. The nucleotide sequences were translated into amino acid sequences using ExPASy (Expert Protein Analysis System) translate tool of Swiss Institute of Bioinformatics and the open reading frames (ORF) were obtained. The well-characterized barcodes of cane pests were finally submitted in the GenBank of NCBI. Molecular diagnostic kits were developed for five important

sugarcane pests *viz*., shoot borer *Chilo infuscatellus*, stalk borer *Chilo auricilius*, sugarcane aphid *Melanaphis sacchari*, scale insect *Melanaspis glomerata* and the root aphid *Tetraneura javensis* during the period under report. The DNA barcodes generated for *M. glomerata* and *T. javensis* are the firsts in the world, as there are no barcodes for the said species in the public domain. The DNA barcodes generated for all the five species are certainly the best and ideal ones, as these are the full length barcodes of *COI* gene fragment with uninterrupted open reading frames. The DNA barcodes developed in this study will serve as ideal diagnostic kits for unambiguous identification of the pest species even by non-insect taxonomists.

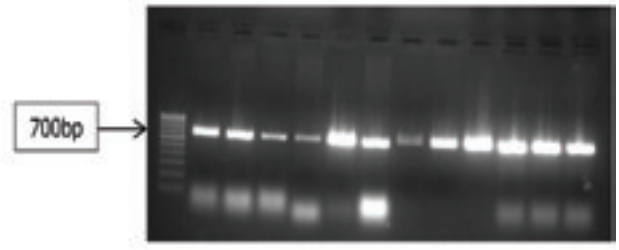
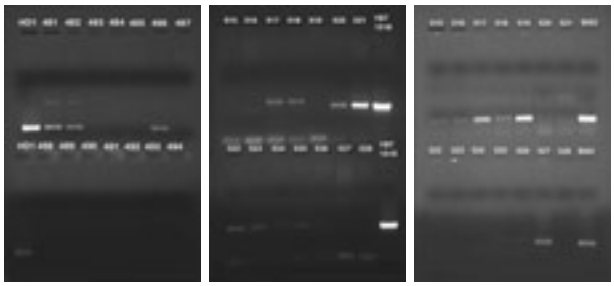


Fig. 51. PCR amplified COI gene fragments of Aleyrodids

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

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

Screening of Bacillus thuringiensis *(Bt) isolates for various crystal toxin (cry) genes:* One hundred and forty three Bt isolates that were collected from different locations and maintained at Sugarcane Breeding Institute, Coimbatore, were screened for cry genes. Primers of *cry1, cry6* and *cry8* were used to detect genes by the size of their PCR products. PCR screening of 143 Bt isolates revealed that 23, 47 and 42 isolates were putatively positive for *cry1, cry6* and *cry8,* respectively. The positive isolates for each *cry* gene amplified a similar band as that of reference standard Bt isolate for each *cry* gene primer (Fig. 52). The reference *B. thuringiensis* serovar. *japonensis*, strain Buibui containing *cry8* gene, amplified a fragment of 373 bp while positive isolates for *cry1* and *cry6* gene amplified bands of 558 and 800 bps, respectively.



52 a *52b* *52c*

Fig. 52 . PCR screening of indigenous Bt isolates with a) cry1 gene positive reference isolate b) cry8 gene positive reference Bt62 isolate and c) cry6 gene positive reference YBT1518 isolate

Pesticide dynamics in sugarcane and its ecosystem

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

Phorate is recommended for the management of white grub and top borer of sugarcane by the Central Insecticide Board & Registration Committee (CIBRC). It is recommended at the rate of 2.5 and 3.0 kg a.i./ha for managing the white grub and top borer, respectively. The indiscriminate use of insecticides due to lack of sufficient knowledge on their usage may lead to unacceptable level of residues in the juice. Hence, it was felt necessary to develop chromatographic method for determination of residues of phorate and its metabolites *viz*., phorate-oxon and phorate-sulfone in sugarcane juice. A highly sensitive gas chromatography-mass spectrometric (GC-MS) method has been developed to determine trace amounts of phorate and its metabolites in cane juice. This is the first report of a novel analytical method for simultaneous determination of phorate, phorate-oxon and phorate-sulfone in sugarcane juice employing GC-MS. The residues of phorate and its metabolites were extracted from the cane juice using acetonitrile and subjected to clean-up with three sorbents *viz*., primary-secondary amine (PSA), octadecylsilane (C18) and graphitized carbon black (GCB) either alone or possible combinations among them. The residues were detected and quantified in Shimadzu GC 2010 Gas

Chromatograph equipped with QP 2010-plus Mass Spectrometer. DB-1MS fused silica capillary column (30 m × 0.25 mm × 0.25 µm; Agilent Technologies, USA) was used for the separation of target analytes. The target compounds were confirmed through similarity match with NIST library. Linearity, which indicates the sensitivity of the GC-MS, was observed to be excellent for all the three compounds under investigation. Among the different clean-up methods employed, PSA alone was found better than other sorbents and their combinations in terms of recovery. Acetonitrile-based extraction followed by PSA clean-up provided more than 80% recovery for all the three compounds and, hence, the method developed in this study is in compliance with the European Commission's Regulations for Trace Residue Analysis (2010).

5.3.3 NEMATOLOGY

Basic and applied studies of sugarcane phytonematodes and entomopathogenic nematodes

Studies on insecticidal molecules of symbiotic bacteria associated with entomopathogenic nematodes

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

Ten symbiotic bacteria were isolated from the greater wax moth *Galleria mellonella* infested with entomopathogenic nematodes (EPN). For identification of all bacterial isolates, biochemical characterization was carried out using 27 tests which included ONPG, lysine utilization, ornithine utilization, urease, phenylalanine deamination, nitrate reduction, H_2S production, citrate utilization, Voges Proskauer's, methyl red indole, malonate utilization, esculin hydrolysis, arabinose, xylose, adonitol rhamnose, cellobiose, melibiose, saccharose, raffinose, trehalose, glucose, lactose, oxidase, sorbitol and catalase. Four symbiotic bacteria were molecularly characterized by analysis of genomic DNA sequences. Primers specific for 16s rDNA, synthesized by Bioserve Private Ltd, were used in the Polymerase Chain Reaction (PCR). Clear bands of 1400-1500 bp appeared for *Photorhabdus* and *Xenorhabdus*. The PCR products were purified and sent to M/s Bioserve Private Ltd for sequencing studies and the 16S rDNA sequences were compared with the database from the sequence gene bank at the National Center for Biotechnology Information (NCBI). While all the *Xenorhabdus* isolates had maximum similarity with *Xenorhabdus stockiae*, *Photorhabdus* had similarity with *P. luminescens* sub sp. *akhurstii*.

Bacterial cell and cell free culture filtrates of *P. luminescens* sub sp. *akhurstii* (SBIPL78) were isolated and utilized for testing insecticidal activity against first and third instar larvae of *G. mellonella.* Culture filtrates showed insecticidal properties and caused mortality levels of 40 - 100% in first and third instar larvae. Similarly, bacterial cell and cell free culture filtrates of five *Xenorhabdus stockiae* cultured on Luria broth were isolated and utilized for testing insecticidal activity against full grown larvae of *G. mellonella*. All the bacterial isolates showed insecticidal properties and caused mortality in *Galleria*. Among the isolates, *X. stockiae* (SBIXSCBE10) recorded maximum mortality (96.6%) followed by *X. stockiae* (SBIXS52) (83.3%).

Purification of insecticidal metabolites from cell free supernatant of *X. stockiae* (SBIXS52) and *X. stockiae* (SBIXSD4) was done using ethyl acetate. Methanol fraction of *X. stockiae* (SBIXS52) caused 60-80% mortality of first and second instar larvae of white grub *Holotrichia serrata* at 25°C and 40-60% mortality at 30°C. Against first, second and third instar larvae of *G. mellonella*, the fraction caused mortality ranges of 47-100% at 25°C and 36-74% at 30°C. Purification of *P. luminescens* sub sp. *akhurstii* (SBIPL78) carried out by sephadex column resulted in four different fractions. In bioassays against second and third instar *G. mellonella* larvae, all the four fractions caused mortality in the range of 50-80%. HPLC analysis was carried out for further fraction identification.

5.4 STATISTICS AND ECONOMICS

Computerization and development of information systems in sugarcane

Creation of databases for sugarcane research

(R. Balakrishnan)

Database on parents of 'Co' canes and AICRP-Sugarcane trials were updated. Analysis of the multi-location variety evaluation trials under the AICRP system for 2013-14 using ANOM technique was effective in delineating the performance of entries and test locations and their interaction. The analysis of the data indicated that the criteria in selecting high yielding entries by ANOM can be improved by further supplementing with Shukla's stability variance by suitably adjusting the grading of entries based on the statistical significance of stability variance and Safety-first Index. Though ANOM technique is useful in identifying superior entries on mean values, it lacked a stability component. A procedure known as Analysis of Mean Variance (ANOMV) for incorporating the stability variance (Shukla's stability variance) of the entries was attempted to identify entries that have high mean and low stability variance. Database on Personnel Information System (PERMISNET) was periodically uploaded.

Economic impact assessment of cane varieties and technologies in sugarcane production system

(P. Murali, T. Rajula Shanthy, D. Puthira Prathap, C. Karpagam and R. Balakrishnan)

A survey was conducted in 15 sugar mill areas of Tamil Nadu to know the extent of area under Co 86032. Primary data on varietal scenario, cane area under different varieties, yield and varietal characteristics were collected by interviewing 200 progressive farmers and evaluated by tabular method. The area under Co 86032 is stable during 2014-15 when compared to 2013-14. The analysis on yield and sugar recovery improvement revealed that Co 86032 recorded more than 1% improvement. The yield improvement was not factored out due to drought and varietal degeneration. Study on the varietal adaptability for wide row and drip irrigation showed that Co 86032 has better yield than others. It is concluded that Co 86032 has significantly improved the economic status of the sugarcane farmers.

The economic impact study was done using Dynamic Research Evaluation for Management (DREAM) Model developed by IFPRI Washington. The secondary data of Co 86032 were collected and modified as per model specifications. The varietal adoption log period was considered as eight years; real discount rate was judged as 5.95% and 22 years data were used to generate the economic benefits. The closed economy model was used to study the impact. Spread of Co 86032 had taken place owing to breakdown of the previous ruling varieties due to disease. Hence, after its release, the varietal developmental cost remained zero as it was released for the benefits of the sugarcane farmers.

The results showed that the flow of BC ratio started in the year 2000. The total net present value of Co 86032 to the producers was US$ 16 million. The consumers benefit was US$ 25.6 million and the government earned about US$ 3.2 million as tax and levy. The variety has totally generated about US$ 45 million Net Present Value (NPV) benefits since its release. The BC ratio of Co 86032 was about US$ 19.6 million in 2012-13. The yield and sugar recovery improvement was significantly higher than the earlier varieties cultivated. The study concluded that Co 86032 has increased the total factor productivity of the sugarcane in the tropical zone and has significant economic impact on sugarcane cultivation in Tamil Nadu.

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, C. Karpagam and V. Venkatasubramanian)

Sugarcane Research and Development Workers meeting

Northern Karnataka: The 16th meeting of Northern Karnataka was held at Belgaum, Karnataka during 18-19 July 2014.The meeting was hosted by M/s. Ugar Sugar Works Ltd. Dr. N. Jayaram IAS., Deputy

Commissioner, Belgaum, inaugurated the meeting. Dr. N.V. Nair, Director, SBI, delivered the Theme Address. About 200 delegates comprising scientists from ICAR-SBI and University of Agricultural Sciences Dharwad, S. Nijalingappa Sugar Institute, Joint Directors of Agriculture, Development personnel from Agricultural Department, sugar factories of northern Karnataka and other Cane Development organizations in the region participated in the meeting (Fig. 53). The major topics discussed were mechanization in sugarcane farming and intercropping in sugarcane.

Fig. 53. Release of compendium during the sugarcane R&D workers meeting of northern Karnataka

Tamil Nadu: The 45th meeting of Tamil Nadu and Puducherry was conducted during 26-27 August 2014 at Tiruchirappalli. M/s.Kothari Sugars & Chemicals Ltd., hosted the meeting. Shri A. Sankaralingam, Additional Director of Sugar, Govt. of Tamil Nadu delivered the Inaugural Address. Dr. N.V. Nair, Director, SBI delivered the Theme Address. About 350 delegates comprising scientists from ICAR-SBI, Tamil Nadu Agricultural University, Coimbatore, Development Department personnel from various sugar factories, officers from the Department of Agriculture, Directorate of Sugar and other Cane Development Organizations in Tamil Nadu & Puducherry participated in the meeting (Fig. 54). The major topics discussed include pest management in sugarcane and soil health management for sustainable cane production.

Fig. 54. Release of compendium during the sugarcane R&D workers meeting of Tamil Nadu

Training programmes organized

Model Training Course

A Model training course on 'Recent technologies for increased sugarcane productivity' sponsored by the Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India was organized during 17-24 September 2014 (Fig. 55 & 56). Fourteen participants from Nagaland, Haryana, Uttar Pradesh, Tamil Nadu, Chattisgarh, Odisha and Kerala participated. The training consisted of lectures, practical sessions, field visits and outdoor visit to farmers' fields and M/s. Ponni Sugars (Erode) Ltd., Erode.

Fig. 55. A practical session in progress

Fig. 56. Trainees at Ponni Sugars, Erode

National level programmes organized

The following five programs sponsored by the Ministry of Agriculture were organized:

- 'Scientific sugarcane cultivation' for 22 cane development personnel from Tamil Nadu, Maharashtra and Karnataka during 18-19 December 2014 (Fig. 57).

Fig. 57. Participants of the training: 18-19 December 2014

- 'Recent advances in sugarcane cultivation' for 19 participants from Tamil Nadu, Karnataka and Maharashtra during 20-21 January 2015 (Fig. 58).

Fig. 58. Participants of the training: 20-21 January 2015

- 'Sugarcane technologies for increased productivity' for 18 cane development personnel from Tamil Nadu, Maharashtra and Karnataka during 28-29 January 2015 (Fig. 59).

Fig. 59. Participants of the training: 28-29 January 2015

- 'Sugarcane technologies' for 17 cane development personnel from Tamil Nadu, Maharashtra, Gujarat and Karnataka during 19-20 February 2015 (Fig. 60).

Fig. 60. Participants of the training: 19-20 February 2015

- 'Advances in sugarcane cultivation' for 12 cane development personnel from Telengana, Tamil Nadu, Karnataka and Maharashtra during 3-4 March 2015 (Fig. 61).

Fig. 61 Participants of the training: 3-4 March 2015

State level programmes organized

- A three-day training programme on 'Scientific jaggery production' for 22 farmers from Marayoor and Kanthaloor Panchayat of Idukki district, Kerala during 17-19 March 2015 (Fig. 62).

Fig. 62. Dr Bakshi Ram, Director, ICAR-SBI discussing with trainee farmers

- A six-day training programme on 'Scientific sugarcane cultivation' for 16 farmers from Lal Bahadur Shastri Ganna Sansthan, Lucknow, Uttar Pradesh during 21-26 March 2015 (Fig. 63 & 64).

Fig. 63. Dr Bakshi Ram, Director, ICAR-SBI apprising farmers on sugarcane technologies

Fig. 64. Farmers from Maharashtra visiting farmers' fields

One day training programmes: Four one-day training programmes on 'Sugarcane agriculture' were organized:

- Nineteen farmers from Department of Agriculture, Government of Nagaland on 9 May 2014.
- Twenty five farmers from Department of Agriculture, Karamadai Block, Mettupalayam, Coimbatore district on 14 May 2014.
- Seventy farmers from Nikhil Sugars, Harda, Madhya Pradesh on 31 July 2014.
- Twenty eight farmers from Jharkhand on 26 February 2015.

Exposure visits: Three exposure visits were conducted:

- Four delegates from LANTRA, UK on 16 October 2014.
- Fifteen students from Cornell University, USA on 12 January 2015 (Fig. 65).

Fig. 65. Students from Cornell University at the Institute's Technology Park

- Fifteen delegates from Fiji, Laos, Indonesia, Myanmar, Bangladesh, Nepal and Afghanistan organized by Kothari Research Management Centre, Coonoor on 16 January 2015 (Fig. 66).

Fig. 66. International delegates with Director, ICAR- SBI

Institute Industry Interface: An 'Institute Industry Interface Meet' was conducted on 10 December 2014 under the Chairmanship of Dr. Bakshi Ram to discuss the issues faced by sugarcane farmers and sugar industries in Tamil Nadu and to chart out a road map for up-scaling sugarcane productivity. Cane personnel from 23 sugar factories participated (Fig. 67).

Fig. 67. Interface Meet in progress

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 :

- Nineteen students of II semester during 9-18 May 2014
- Twenty one students of IV semester during 14-18 May 2014
- Seventeen students of I Semester students during 7-16 October 2014
- Eighteen students of III Semester during 15-24 November 2014

Frontline demonstration

A one acre frontline demonstration trial on the variety Co 99006 with Co 86032 as control was planted in 5 feet row spacing in Chundakamuthur village of Coimbatore district during August 2013 and harvested on 22 July 2014. The yield realized was 144.75 t/ha in Co 99006 as against 116.10 t/ha in the check variety Co 86032. Farmers' feedback indicated good crop stand and lush growth. Presence of spines on the leaves was expressed as a hindrance for intercultural operations. Ratoon trial is in progress (Fig. 68).

Fig. 68. Director, ICAR-SBI visiting frontline demonstration plot on Co 99006

A frontline demonstration on the variety Co 06027 was planted in Jothampetti village, Kaniyur Division, Tirupur district on 7 January 2015.

A frontline demonstration on the variety Co 92005 was planted in Somayampalayam, Coimbatore District on 17 February 2015.

Audio-visual aids

Two museum table display cases of 10' x 5' with illuminations were designed and custom made at ICAR-SBI's new exhibition hall. The archives of institute documents were digitized, printed and displayed.

Technology Park

A 'Technology Park' with 16 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 0232, Co 0233, Co 0237, Co 0238, Co 05011) and other technologies *viz*., wider row with soybean and greengram intercropping, integrated drought management, integrated nutrient management, bud chip planting and integrated pest management were planted in the Institute during February 2014 and maintained (Fig. 69).

Fig. 69. A view of 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) and bud chip planting were planted in the Institute on 3 February 2015.

Participation in exhibitions

- `Fourteenth Agri-Intex exhibition - 2014' at CODISSIA, Coimbatore during 18-21 July 2014 (Fig. 70).
- `Farmers Day' at NRC for Banana, Tiruchirappalli during their 21st Foundation Day on 21 August 2014 (Fig. 71).

Fig. 70. A view of ICAR-SBI stall at CODISSIA

Fig. 71. Dignitaries visiting ICAR-SBI stall at NRC for Banana, Trichy

Fig. 72. Director, ICAR-SBI interacting with dignitaries in the stall

- `Regional Agricultural Fair and State level Farmers Day' at TNAU, Coimbatore during 6-9 January 2015 (Fig. 72).

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

Institute publications

- SBI Annual Report 2013-14
- SBI Annual Report 2012-13 (Hindi)
- SBI newsletter Vol. 33 (4), 34 (1), (2) & (3)

Extension pamphlets

- Co 06030 – A midlate variety for East Coast zone (English)
- Co 06027 - A midlate variety for Peninsular zone (English)
- Abiotic stress management (English and Tamil)

Interaction with Krishi Vigyan Kendras

- Participated in the Scientific Advisory Committee meeting of MYRADA KVK and Shri Avinashilingam KVK and offered suggestions for implementation of programmes.

National Science Day

National Science Day was observed as an 'open day', on 28 February 2015. Students of schools and colleges were invited for inculcating scientific awareness for nation building. Five hundred students visited the institute (Fig. 73). The students were taken around the institute's museum and the exhibits with live specimens were explained by Scientists and Technicians. A special lecture on 'Science for nation building' was delivered by Dr. K. Arulmozhiselvan, Professor (Soil Science & Agricultural Chemistry), Tami Nadu Agricultural University, Coimbatore.

Fig. 73. Director, ICAR-SBI interacting with students

Sociological appraisal of sugarcane production system through participatory approach

(T. Rajula Shanthy, C. Karpagam, D. Puthira Prathap and P. Murali)

A study was conducted in the cane areas of M/s. Thiru Arooran Sugars (TAS) and Kallakurichi Cooperative Sugar Mill (KCSM) where mechanical and manual harvesting is predominant, respectively to analyze the technology dynamics of mechanical harvesting of sugarcane using descriptive research design and ex-post facto approach. Sixty cane growers @ six per cane division and five divisions per factory zone were selected at random. In the perception of growers, the advantages of mechanical harvesting are low cost of cultivation, timely harvest and coverage of larger areas in short period, higher yield and returns, good ratoon, skipping the stubble shaving operation, less dependency on human labour, uniform cutting charges throughout the season *etc*.

Manual harvesting: The average harvesting charge is Rs 582 /t and an additional Rs. 38 /t is spent on conveyance of labourers to the field, which amounts to 29% of the cane price. The charges are lower at the beginning and become exorbitant during peak crushing period. Involvement of private brokers, high cutting charges, labour migration and diversion for other work, lack of incentives to labourers, delayed cutting orders, laborious nature of cane harvesting and irritation due to spines in cane, labourer scarcity and poor support by sugar mills are said to be the constraints faced by the growers.

Mechanical harvesting: The average harvesting charges is Rs. 450/t and an additional Rs.26/t is spent on food allowance and wages to the machine operators and scrap cane collectors, which amounts to 21% of the cane price resulting in a cost saving of 7% over manual harvest. The charges are uniform throughout the crushing season. A monetary gain of Rs.1475 /acre apart from the Rs.12/t saved towards additional cost results in higher profit and BC ratio. Scarcity of harvesting machines, huge initial investment, requirement of skilled people, higher deduction for extraneous materials in cane, lack of sufficient area under cluster planting and wider row crops, cane damage during harvest and infield losses and transportation difficulties are said to be the constraints faced by the growers.

A survey conducted in ten villages of Tuhili and Thiruvudaimaruthur divisions of Shree Ambika Sugars revealed that,

- Paddy, sugarcane, banana followed by coconut and vegetable crops are grown
- Sugarcane plant - ratoon - paddy crop rotation is followed
- Cane development personnel are the source of information
- Sugarcane varieties CoV 94101, Co 86032, 87 A 298, CoV 94102, CoSi 2000/2 and 91 V 83 are grown. CoV 94101 is the best suited variety which gives thick canes but the variety does not withstand waterlogging. Co 86032 is not preferred as it is not suited for waterlogged soils
- Irrigation water is available and hence the importance of water saving measures like drip irrigation is not realized by the farmers
- Labour scarcity is the major problem. Sugarcane is grown in wider spacing and mechanized cultivation is being followed.
- The factory is having eight harvesters - two big machines suitable for five feet row spacing and six machines suitable for four feet spacing
- Harvesters are not used in wetlands with deep and heavy soils
- Most of the farmers raise separate nursery crop
- Gap filling is followed in ratoon crop by quartering of clumps with good sprouting or using single bud settlings obtained from raised bed nurseries
- Medium and large farmers prefer sugarcane over paddy as the crop needs less care; whereas small and marginal farmers prefer paddy for a continuous income, three crops a year and employment throughout the year
- Sett treatment with bavistin, use of atrazine herbicide within five days of planting,

application of FYM and SSP as basal, top dressing with urea and potash, de-trashing once during 5th month are followed by few farmers

- Farmers seek information on bud chip seedling production, SSI method of cultivation, identification and management of pests and diseases etc.

Extent of adoption of recommended technologies of sugarcane in Tamil Nadu and constraint analysis

(C. Karpagam, K. Sivaraman, T. Ramasubramanian, T. Rajula Shanthy, D. Puthira Prathap, P. Murali and V. Venkatasubramanian)

The project was initiated during November 2013 to assess the extent of adoption of recommended technologies, identify the constraints influencing adoption, to determine yield gap and conduct technological demonstrations for better adoption. A survey was conducted in Dharmapuri, Vellore, and Ambur Co-operative sugars cane area for technology mapping.

Dharmapuri coop sugar mill area: Survey was conducted in Kamalpuram, Karimangalam, Mallikuttai, Palakode, Kupur, Ramiyampatti, Kariyampatti and Alangari villages of Dharmapuri district. Co 86032 is cultivated in 96% cane area. Use of two budded setts for planting, 90 cm spacing, bio-fertilizers, preparatory cultivation implements, inter-cultivation, earthing up, power weeder, split application of N and K fertilizers, *Trichogramma* for controlling internode borer, atrazine, 2,4-D and mertibuzin as weedicides are the technologies predominantly followed. Basal dose of P fertilizer, wider row spacing, drip irrigation, trash mulching, gap filling, bud chip settling, intercropping and propping were also adopted by few farmers.

Vellore coop sugar mill area: Co 86032 (70%), CoG 94077 (10%) followed by CoV 94101, CoC 90063, Co 99004, Co 99006 and CoSi 6 are the varieties grown. In the study area, 90% of the farmers are using two budded setts in 90 cm spacing (Fig. 74) and the rest of them are using bud chip settlings. Technologies highly adopted are mechanized land preparation, earthing-up, split application of N and K fertilizers. Few farmers are also adopting basal P application, intercropping, off barring, gap filling, drip irrigation and wider row spacing. Traditional method of cultivation and continuous drought are the major limiting factors identified.

Fig. 74. Conventional planting method with two budded setts at Thiruvalam village, Vellore district

Ambur cooperative sugar mill area: Co 86032 (35%), CoV 94101, CoG 94077, CoC 85061 and CoC 771 are the varieties grown. Four divisions among six are severely affected by tannery effluent. Scientific cane cultivation is not practiced.

Technology demonstration: Farmers' participatory technological demonstrations were held in Irugur, Coimbatore district with the support of Amaravathi Cooperative Sugar Mill. The sugarcane varieties Co 0212 and Co 06022 were planted and direct planting of single bud setts, drip irrigation, wider row spacing and bio-fertilizer application were demonstrated (Fig. 75). Planting materials of Co 0212 and Co 06022 and bio fertilizers were supplied by the institute.

Fig. 75. Single bud setts planting in progress in farmer's field

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

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

This project was formulated to assess the diffusion and use of ICT initiatives in the disadvantageous regions. A standardized interview schedule was prepared in consultation with the stakeholders and review of existing literature. A pilot survey was conducted in M/s.EID Parry (I) Ltd., Pugalur cane area among 30 cane growers and cane development personnel of Muthur, Karur, Kodumudi Molapalayam, Velayudhampalayam (W) and Vaangal divisions. The observations revealed that,

- Internet access is predominantly through mobile phone, followed by desktop computers, laptops and tablets
- Internet is accessed mainly for email, information on price/market, rainfall, educational and ticket booking
- Majority had ~1 to 2 years of experience in internet use.
- Mobile phones are used for Internet, SMS and sharing photographs besides making voice calls
- Helpline SMS facility offered by agencies like KVK, Karur and Kisan call centre are used
- Web attitude measurement showed that many are confident of using the internet and its usage is worthwhile
- None of the respondents had any training on ICT use
- Many are on Facebook followed by using YouTube, Skype, WhatsApp and Telegram
- On the content priorities of CaneInfo website, the cane growers needed information on varieties, seed material availability and machinery and the preferred format of technology delivery through CaneInfo was 'short videos'.
- Major barriers on ICT use were rural in-accessibility, language skills, lack of time, poor perception of benefits and lack of training.

The interview schedule was refined based on the findings of the pilot survey and the main survey was conducted in Nagapattinam district, a disadvantageous region in Tamil Nadu. Sixty farmers and 15 cane development personnel belonging to Kuthalam & Manganallur cane divisions of Thiru Arooran Sugars Ltd., Thirumandangudi and Pandanallur and Kuthalam cane divisions of NPKRR Co-op Sugar mills Ltd., Mayiladuthurai formed the sample for the survey. 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. The site hosted in www.caneinfo.nic.in has received over 23.5 lakh hits up to January 8, 2015, as per the National Informatics Centre, Govt. of India -WebTrends data.

Innovative training module for development of sugarcane farm leaders for up-scaling sugarcane production and protection technologies in Tamil Nadu

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

A novel training module of development of Sugarcane Farm Leaders (SFL) is envisaged in this project. The trained SFL would act as technology providers for other farmers in their respective area.

Selection of study area: The productivity score analysis based on sugarcane area, production and productivity for the last 10 years revealed that Vellore, Dharmapuri, Nagapatinam, Karur and Tirunelveli are the lower productivity districts. Focused Group discussions were carried out in the selected districts with cane development personnel and farmers and their training needs were assessed.

- *Dharmapuri cooperative sugar mill:* Information on new and high yielding varieties, cane cultivation techniques under limited water availability, drip irrigation, mechanization and ratoon management
- *Vellore and Ambur cooperative sugar mills:* Information on varieties suitable for tannery effluent polluted area, high yielding varieties, tissue culture seedlings, SSI technology, fertilizer

management, intercropping, and management of internode borer and white grub

- *Thiru Arooran sugar mill, Nagapattinam:* Success stories on wide row cultivation, varieties for heavy soil and saline water, raised bed nursery and transplanting techniques, weed management and mechanization.
- *E.I.D Parry, Karur:* Effective utilization of available water, soil health management, improving soil organic carbon, green manuring, intercropping, mechanization and management of woolly aphid, internode borer and top borer
- *Dharani sugar mill, Tirunelveli:* Information on new and high yielding varieties, wind and wild boar tolerant varieties, soil health management, wider row planting, lodging, deep ploughing, SSI technology, irrigation scheduling, mechanical weeder, drought management, bio-fertilizers, organic farming, small machineries for harvesting and intercultural operation, crop insurance, trash management, bio-control, subsidies, success stories of progressive farmers, pocket manuring, low cost technologies, sett treatment and pest and disease management

5.6 ICAR-SBI REGIONAL CENTRE, KARNAL

Development of sugarcane varieties as well as crop production and protection technologies for the North Western zone

Breeding elite clones suitable for North Western Zone

Clones accepted for inclusion in AICRP trials: Two clones viz., Co 14034 (early) and Co 14035 (mid-late) were accepted for inclusion in AICRP trials in the 30th Biennial Workshop of AICRP held at Lucknow.

Hybridization, progeny evaluation and selection

(M.R. Meena, Ravinder Kumar, M. L. Chhabra and N. Kulshreshtha)

Hybridization: A total of 65 different type of crosses including 36 experimental, 13 zonal and eight poly-crosses were done in NHG and SBI RC-Agali.

Fluff sowing and ground nursery: During May 2014, the fluff from 76 crosses of 2013-14 crossing season were sown in plastic trays. The seedlings from 53 crosses were hardened in cavity protrays. A total of 6344 seedlings representing 37 bi-parental crosses, five poly-crosses and 11 general crosses were field

Table 19. **List of better selection intensity cross combinations**

Cross combinations	Number of selections	Number of seedlings	Selection intensity (%)
Co 98008 x Co 775	20	188	10.6
CoH 99 GC	42	400	10.5
CoH 133 GC	15	150	10.0
CoPb 10183 x Co 8353	20	288	6.9
CoS 8436 x CoPant 97222	13	192	6.8
Co 7201 PCGC	27	410	6.6
Co 86002 x Co 62198	16	244	6.6
CoLk 94184 x CoH 15	12	184	6.5
CoS 8436 GC	15	263	5.7
Co 89003 GC	53	1110	4.8
Total	**512**	**11702**	**4.38**

transplanted during September 2014. The seedlings were winter ratooned during first week of January 2015.

The fluff from 145 different cross combinations including experimental, zonal and different level of diversity crosses of 2014-15 crossing season were sown in mist chamber during March 2015. Nearly 64% of crosses produced viable seedlings.

Selection in seedling ground nursery: Nearly 11,702 field survived (79.1%) seedlings were evaluated for cane yield and juice quality characters during October 2014. Based on better phenotype, H.R. Brix, stalk thickness and importance of the cross, 512 clones from ground nursery were selected and advanced to first clonal nursery after assigning K 12-001 to K12-512 clonal numbers. In general, the progeny of 68 crosses with selection intensity 4.38% were selected. The important cross combinations where more than 150 progenies were evaluated and selected are given in Table 19.

Selection from 1st clonal nursery: A total of 130 clones of K 11 series were selected from a 644 clones of C1 stage based on phenotype, cane yield and juice quality traits. One hundred and twenty six among them were advanced to Preliminary trial for further evaluation during crop season 2015-16.

Preliminary trial: From this trial consisting of 59 test clones (K10 series) and four standards evaluated for stalk yield and juice quality parameters, eight clones with better yield and quality were advanced to PZVT trial.

Red rot testing: Of the 59 preliminary clones evaluated, 13 were resistant, 18 moderately resistant, eight moderately susceptible, 11 susceptible and nine highly susceptible to red rot.

Pre-Zonal Varietal Trial

(Ravinder Kumar, M.R. Meena, M. L. Chhabra and N. Kulshreshtha)

Thirty six clones (12 of K07 series and 24 of K08 series) were evaluated in replicated (2) RBD four row trial along with two early (Co 0238, CoJ 64) and two mid-late (CoS 767, CoS 8436) standards. Based on desirable phenotype, cane yield, juice quality, red rot reaction and field stand, two early entries (K 07-540, K07-639) and three mid-late entries (K07-531, K07-880, K08-134) were selected for assigning 'Co' status (Tables 6 & 7). One entry namely K08-264 was selected as genetic stock of high sucrose. Six entries *viz*., K07-291, K07-471, K07-635, K08-376, K08-405 and K08-429 were included in 2015-16 PZVT trial for reevaluation.

Red rot testing : Among the 33 PZVT clones evaluated, nine were resistant, 20 moderately resistant, three moderately susceptible and one susceptible to red rot.

Zonal Varietal Trial

(Ravinder Kumar, M.R. Meena and N. Kulshreshtha)

IVT (Mid-late): Thirteen test clones along with standards CoS 8436, CoPant 97222 and CoS 767 were evaluated in RBD with three replications. For stalk yield, CoPant 97222 (131.85 t/ha) was the best standard and five entries *viz*., Co 11026 (133.93 t/ha), CoH 11263 (126.54 t/ha), Co 11027 (122.5 t/ha), CoLk 11205 (118.17 t/ha) and CoS 11232 (114.36 t//ha) were on par with it. At harvest, CoS 767 (18.0) was the best standard for pol% and entries Co 11027 (18.2), CoH 11263 (18.2) and CoPb 11213 (18.2) were numerically superior over it.

AVT (Early) I Plant: Three clones *viz*., Co 10035, CoH 10261 and CoS 10231 were evaluated in RBD with four replications along with the standards Co 0238 and CoJ 64. Co 0238 was the best standard for cane yield (133.33 t/ha) and sugar yield (16.81 t/ha). None of the test entry was found superior over it. Co 0238 was the best standard for pol% at 8 (16.85%) and 10 (18.0%) months. The entry Co 10035 was superior at 8th (18.44%) month and on par at 10th (18.14%) month of crop stage over Co 0238 but its cane yield (77.0 t/ha) was low.

AVT Midlate two crops + one ratoon: Five test clones along with three standards were evaluated for two crop and one ratoon crops during 2013-14 and 2014-15 crop seasons. CoS 8436 was the best standard for average cane yield (83.2 t/ha) and sugar yield (10.4 t/ha) in two crops and one ratoon trial. Co 09022 was the best entry in the experiments (Fig. 76) and it recorded 19.59% higher cane yield and 25% higher sugar yield over CoS 8436.

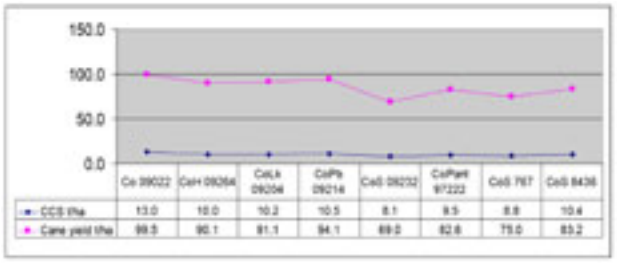


Fig. 76. Mean performance of AVT Midlate entries in two crop and one ratoon crops

AVT (Midlate) II Plant: CoPant 97222 (100.53 t/ha) was the best standard for cane yield and two test entries viz., Co 09022 (104.01 t/ha) and CoH 09264 (104.27 t/ha) were numerically superior over it. Co 09022 was also numerical superior for sugar yield (13.09 t/ha) and pol% (18.1) at harvest over CoPant 97222 (12.5 t/ha and 17.9% pol).

AVT (Midlate) Ratoon: CoPant 97222 (99.57 t/ha) was the best standard for cane yield t/ha. Entries Co 09022 (126.3 t/ha) and CoPb 09214 (116.21 t/ha) produced significantly higher cane yield over CoPant 97222. Co 09022 also produced significantly higher sugar yield (16.32 t/ha) over the best standard CoPant 97222 (12.2 t/ha). CoS 8436 was the best standard for CCS% (12.7) and pol% (18.19) at harvest. The entry Co 09022 was numerically superior (12.92% CCS and 18.45% pol) over CoS 8436.

AICRP seed multiplication and supply: The seed of nine early and 12 mid-late clones of 13 series AICRP entries was multiplied and supplied to Faridkot, Kapurthala, Sriganganagar, Kota, Pantnagar, Lucknow, Shahjahanpur, Muzaffarnagar and Uchani centres. The 13 series clones were multiplied for next year trials, whereas 14 series clones received from participating centers were multiplied for the next year seed supply.

Evaluation of sugarcane germplasm under sub-tropical conditions

Evaluation of exotic clones

(Ravinder Kumar, M.R. Meena, S.K. Pandey, M.L. Chabbra and N .Kulshreshtha)

A total of 58 exotic clones were evaluated along with four standards. For cane yield, Co 0238 (128.75 t/ha) was the best standard and 23 clones were on par and among them, clones SP83-5073 (161.52 t/ha), M 76-39 (155.50 t/ha), PR1070 (146.60 t/ha), LF 69-767 (136.33 t/ha), CP57-614 (134.25 t/ha) and CP 80-1743 (133.04 t/ha) were promising. Co 0238 (16.27%) was the best standard for pol% in juice at 8th month and three entries *viz*., CP 80-1816 (18.31%), PR 975 (18.47%) and CP 80-1743 (18.31%) were numerically superior over it. The best standard was Co 0238 for pol % at 10 (17.09) and 12 months (19.22). Test entries *viz*., CP 92-1641 (19.20%) and CP 80-1816 (18.63%) were superior over Co 0238 at 10 months whereas 25 clones were at par with it. The top ranking clones for pol % at 12 months were CP 98-1029 (19.39%), CP 80-1816 (19.26%), Q-73 (19.28%), CP 80-1743 (19.16%), LF 63-1617 (19.12%), CP 92-1641(19.12%) and CP 53-99 (19.1%).

Screening of exotic clones for winter sprouting: The experiment was ratooned during peak winter month i.e. December last week and winter sprouting was taken in the February month. CoJ 64 (27.5 sprouts /2 rows) was the best standard for winter sprouting and four exotic clones; H 59-3775 (50.5/2R), CP 36-105 (47/2R), B 40-175 (41/2R) and CP 44-92 (39/2R) were superior over it.

Insect - pests: Sixty five exotic clones along with two standard varieties were evaluated for their reaction against major insect pests of sugarcane *viz*., early shoot borer (ESB), top borer (TB), stalk borer (SB) and root borer (RB). In respect of ESB, thirty two clones *viz*., PR 1070, PTV 4811, Q62, M76-39, CP 57-614, Q50, PoJ 2727, MOL 251, HJ9-3775, LF 63-1617, SP81-1763, CP98-1029, LF 05-119, LF 65-554, Q73, B35-197, CP56-519, BN-111, Cp 44-92, Cp80-1842, GU07-3785, K08-373, CYMA-09-1268, B37-193, K08-443, B44-105, H32-8560, CP80-1743, B42-231, PR 1097, B40-175, 09-900 were Least Susceptible (<15.0%). Twenty clones were Moderately Susceptible (15.1 to 30.0%) and thirteen clones were (Highly Susceptible >30.0%) to ESB. In case of top borer, sixty two clones were LS (<10.0%). Three clones *viz*., M76-39, CAC-87, CYMA-09-47 were MS (10.1 to 20.0 %). The infestation index of stalk borer varied from 0.0 to 18.8 %. Fifty eight

clones showed least susceptible reaction to SB (< 2.0). Five clones *viz*., PR 1079B, SP 81-1763, CAC-87, GU 07-3785, B37-193 were found to be moderately susceptible (infestation index 2.1-5.0). Two clones, 09-817 and GU 01-1363 were highly susceptible (infestation index >5.1). In case of root borer, twenty clones viz., PR 1070, M76-39, PoJ 2727, PR 1016, PR 1083, CP31-394, CP79-318, CP70-1133, CP98-1029, LF 05-119, LF 65-554, Q73, PoJ 29-46, B43-104, CYMA-09-1268, K08-443, H32-8560, CP96-1602, GU07-3849 and BC-51 showed LS reaction (<15.0 %). Twenty five clones were MS (15.1 to 30.0%) and twenty five clones were HS (>30.0%) .

Red rot: Among the 58 exotic clones evaluated for red rot resistance, eight it were resistant, 14 moderately resistant, 12 moderately susceptible, 10 susceptible and 14 highly susceptible to red rot.

Evaluation of ISH / IGH clones

(M.R. Meena, Ravinder Kumar, S.K. Pandey, M.L. Chabbra and N. Kulshreshtha)

A total of 47 ISH/IGH clones were evaluated along with four standards. Three test entries, Gu 07-3774 (1,52,469 NMC/ha), Gu 07-3785 (1,58,642 NMC/ha) and KGS 99-1109 (1,36,420 NMC/ha) produced significantly higher NMC over the best standard Co 0238 (1,06,173 NMC/ha). Nineteen entries were on par with Co 0238 (16.51) for pol% at 8 months and none of the test entry performed better over it. At 10 months, 16 test entries were on par with the best standard Co 0238 (17.38%) and only one entry 20-182 (17.6%) was found promising. At 12 months, five clones, WL 00-331 (19.80%), CYMA 09-165 (19.46%), CYMA 10-1038 (19.35%), CYMA10-1673 (19.32%) and 20-182 (19.29%) had numerical higher value for pol% than Co 0238 (19.14%). Fifteen test clones were on par with Co 0238 (118.89 t/ha for cane yield and three clones *viz*., CYMA 09-1405 (141.77 t/ha), CYMA 10-948 (124.42 t/ha) and CYMA 10-1528 (120.74 t/ha) were promising.

Screening for winter ratoonability: Sprouting of ISH/IGH clones during winter was studied by harvesting the plant crop (half of the row / replication x 3 m row length). The number of sprouted clumps per row, average shoots / sprouted clump were recorded during February and sprouting index was worked out. ISH / IGH clones *viz*., Gu 07-3774 (6.27), CYM 07- 284 (5.10), KGS 2004-72 (4.65), 2004-20 (4.00), CYMA 09-379 (3.85), 20-182 (3.21) and 97-92 (2.88) were significantly superior to the best standard CoS 767 (2.05) for winter sprouting.

Insect - pests: Thirty four ISH & IGH clones of sugarcane were evaluated for their insect pests reaction against early shoot borer (ESB), top borer (TB), stalk borer (SB) and root borer (RB). Sixteen clones *viz*., 20-182, KGS 99-104, G007-3803, 99-1109, CYMA 09-379, 1148-S4-242-12, CYMA 10-1460, WL00-274, 92WL-1233, 93WL -1889, CYMA 10-1528, 2004-020, 20-75, CYMA 10-1038, WL00-427 and 99-133 were LS (<15.0 %) to ESB. Twelve clones showed MS reaction (15.1 - 30.0%) and six clones were HS to ESB (>30.0%). The incidence of top borer was below ETL (<10%). Infestation index of SB varied from 0.18 to 2.87 %. Clones Gu 07-3803, CYMA 10-1673, 93WL-1889, 2004-020 and WL 00-427 had least incidence of stalk borer. Twenty nine clones showed highly susceptible reaction and none of the clones showed MS reaction against stalk borer. The root borer incidence varied from 0 to 90.0 %. Eight clones *viz*., CYM 07-284, CYMA 09-165, 93 WL-1889, 2004-020, 20-75, CYMA 10-1038, 99-133 and 93 WL-1889 were found least susceptible (<15%) and four clones *viz*., CYMA 10-1020, 97-92, CYMA 10-1566 and WL00-427 were moderately susceptible (15.1-30%) whereas 20 clones were highly susceptible (>30.0%).

Red rot: Among the 32 ISH/IGH clones evaluated, seven were found to be resistant, 11 moderately resistant, four moderately susceptible, five susceptible and five highly susceptible against red rot.

Winter ratoonability trial: Seventeen test entries were evaluated along with four standards. The best standard was CoS 767 (sprouting index = 1.43) and seven test entries *viz*., BM61/1, BM-555, LF 65 - 3661, 20-200, BM - 368, TUC 472 and POJ - 290 (2.18) were significantly superior for winter sprouting index to CoS 767 (Table 20).

Table 20. **Clones showing good sprouting during winter months**

Name of clone	% of sprouted clumps	Average shoots per clump	Winter Sprouting Index
BM61/1	86.70	3.6	3.12
BM -555	94.92	3.0	2.92
LF 65-3661	97.30	2.7	2.89
20-200	93.93	2.9	2.72
BM -368	92.39	2.6	2.40
TUC 472	71.43	3.07	2.19
POJ-290	72.81	3.0	2.18
Standard CoS 767	68.21	2.1	1.43

Identification, characterization and verification of new sugarcane varieties for DUS testing

(M.R. Meena, Ravinder Kumar and N. Kulshreshtha)

Maintenance breeding of reference varieties: One hundred and twenty six subtropical sugarcane reference varieties were maintained in two row plots under DUS field. These reference varieties were further verified for all DUS descriptor and digitized.

DUS testing material for candidate and farmers varieties: The seed material of two farmers varieties i.e. Desi –I and Desi –II were received for DUS testing. Grow out test of these varieties was conducted. Two candidate varieties, Co 0237 and Co 05011 were received from PPV & FR authority for DUS testing. The settlings of candidate varieties along with eight reference varieties *viz*., CoS 767, CoS 443, Co 1158, Co 6425, CoS 91230, CoS 95255, CoS 93259 and CoSe 95436 were raised in polybags before field transplanting for DUS testing.

Observations on quality parameters: Out of 126 reference varieties, 15 had ≥ 18 HR Brix, seven ≥ 19 HR Brix and three ≥ 20 HR Brix at 8th month. In juice analysis, 70 entries recorded numerically higher sucrose % than mean sucrose (14.50). The best performer entries were Co 0237 (18.31%), CoS 8207 (18.22%), CoJ 83 (18.22%), Co 87263 (18.11%), Co 0238 (18.00%) and CoS 95255 (17.99%) at 10 months.

Table 21. **State wise details of Breeder seed sale (in quintals) of sugarcane varieties during crop season 2014-15**

Varieties	Bihar	Haryana	Madhya Pradesh	Punjab	Rajas than	Uttar Pradesh	Uttara khand	Total (q)
Co 98014	0.0	0.0	0.0	0.0	0.0	48.1	72.2	120.3
Co 0118	182.3	41.0	0.0	35.4	10.0	78.2	35.0	381.9
Co 0238	429.7	158.8	0.0	20.0	15.0	88.6	137.9	850.0
Co 0239	0.0	25.3	0.0	0.5	2.0	8.6	12.0	48.4
Co 0124	38.4	0.0	4.0	9.0	0.0	15.0	0.0	66.4
Co 05011	26.0	784.6	41.0	13.2	4.6	712.8	85.5	1667.7
Co 0237	17.0	6.0	0.0	37.7	0.0	25.1	0.0	85.8
Co 05009 and others	18.8	172.0	0.0	19.0	0.0	45.0	11.0	265.8
Total	712.2	1187.7	45.0	135.3	31.6	1021.3	353.6	3486.7

Mega seed project-Seed production in agricultural crops and fisheries – sugarcane (Revolving Fund Scheme)

(Ravinder Kumar, M.R. Meena and N. Kulshreshtha)

Breeder seed of nine sugarcane varieties *viz*., Co 98014, Co 0118, Co 0124, Co 0237, Co 0238, Co 0239, Co 05009, Co 05011 and Co 06034 amounting to 3850 quintals was produced in four hectares. A total of 3486.7 quintal worth Rs. 10,80,877/- was supplied to the various stake holders of the region including free of cost supply of 263.9 quintals worth Rs 81809/- for frontline demonstrations in Rasulpur Jatan village (Muzaffarnagar), UP and PAU RRS, Kapurthala, Punjab. The variety wise and state wise detail of seed supply is given in the table 21.

Characterization and mining of genetic variability in sugarcane germplasm against abiotic stresses (Salinity and low tempertature) under subtropical India

(Ravinder Kumar, M.R. Meena, A. Selvi and Ashwani Kumar)

Sugarcane germplasm were screened for their winter ratooning potential, active growth during winter months, tolerance against salinity under field conditions to identify ideal germplasm against low temperature and salinity. The molecular and physiological variation within and between stress tolerant and susceptible genotypes were also studied.

The germination % of 18 varieties was tested using three EC levels of saline water (5, 10 and 15 dS/m) on single budded setts planted in polycups. The germination was 78%, 45.5% and 40.5% under 5, 10 and 15 dS/m levels of EC, respectively. The highest germination was recorded in variety Co 6811 (90% in all the three levels of salinity). The field for planting of germplasm at CSSRI's main farm, Panipat was selected. Thirty two clones including basic species clones, ISH/IGH clones, varieties and climatic resilient clones along with four standards *viz*., Co 0238, CoJ 64, CoS 767 and CoS 8436 were selected for evaluation against salinity and winter tolerance.

Sustainable sugarcane cultivation in sub- tropical India- an initiative for maximum return

(S.K. Pandey, Ravinder Kumar, M.R. Meena, M.L. Chhabra, Rajesh Kumar (IISR, Lucknow)

Demonstration plots for three planting methods *viz*., single row planting at 75 cm and 90 cm and paired row planting at 45 cm : 95 cm : 45 cm (4 rows in 185 cm) were planted with three sugarcane varieties *viz*., Co 0118, Co 0238 and Co 05011 using two budded setts @ 6 setts/meter. The plots size for the planting methods were 348.75 m^2, 312 m^2 and 274.5 m^2 for single row planting at 75 cm, 90 cm and paired row planting (45 cm: 95 cm :45 cm), respectively. The highest cane yield was observed in 90 cm spacing (114.06 t/ha) followed by 75 cm spacing (90.86 t/ha) while the least cane yield was recorded in 45:85:45 cm paired row spacing (71.60 t/ha) irrespective of the varieties. Among the varieties the highest mean yield was observed in Co 0238 (100.12 t/ha) followed by Co 05011 (96.36 t/ha) and Co 0118 (80.06 t/ha). Among the treatment combinations, the highest cane yield was recorded in Co 0238 (127.27 t/ha) at 90 cm spacing and the least was in Co 0118 (62.06 t/ha) at 45:85:45 cm paired row planting. At 10^{th} month Co 0118 and Co 0238 had higher pol% in juice (18.2 and 17.8%, respectively) over Co 05011 (17.0%), while at 12^{th} month Co 0118 (19%) had highest pol%. Co 0238 (18%) and Co 05011 (18.0%) had similar sucrose content in cane juice.

Insect – pests: Early shoot borer and top borer incidence was recorded below ETL (>15.0 and 10.0%). Stalk borer incidence was recorded in sugarcane varieties *viz*., Co 0118 (37.0%), Co 0238 (9.0%) and Co 05011 (22.0%). There was no effect of planting methods on stalk borer incidence.

AICRP on Sugarcane Pathology

(M.L. Chhabra)

Identification of pathotypes / races of red rot pathogen

Seven established *C. falcatum* pathotypes along with 16 isolates collected from CoJ 64 (7), BO 138 (1), CoSe 95422 (1), CoBln 05221(1) and CoS 8436 (6) were inoculated independently on a set of

fourteen sugarcane differentials by plug method of inoculation. The overall disease reaction indicated that there was a clear pathogenic variation on the host differentials. None of the pathotype /isolate resembled another pathotype /isolate in pathogenic behavior. Among the seven designated pathotypes, Cf11 was the most virulent followed by Cf 08, Cf03, Cf07, Cf09, Cf 02 and Cf 01, respectively. Differential CoC 671 exhibited intermediate to susceptible reaction to all the test isolates whereas, differential CoS 8436 succumbed only to isolate CfCoS (Karnal) for the third consecutive years. Of the CoJ 64 isolates, CfCoJ I exhibited more virulence, suggests the possible emergence of new pathotype in the subtropics. A resistant differential Baragua showed intermediate reaction to Cf03 and Cf08 and SES 594 expressed complete resistance to all the isolates.

Multiplication and supply of sugarcane differentials seed: The seed of four new sugarcane differentials *viz*., Co 86002, Co 86032, CoV 92102 and CoSe 95422 was multiplied and supplied to Lucknow, Uchani, Ludhiana and Pusa (Bihar) centres.

Survey for sugarcane diseases: Red rot incidence was recorded up to 10% in variety CoS 8436 and trace in variety Co 89003 under Karnal (Haryana) fields and trace in varieties CoS 97264, CoSe 92423 and CoS 8436 in Khumbi and Gularia Chini Mills (UP) area. Trace incidence of other diseases i.e. bacterial top rot in variety CoH 88, smut in varieties Co 0238, CoS 8436, CoH 119, CoJ 85; and Pokkah boeng in varieties Co 0238, CoS 8436, CoJ 85, CoH 119 and Co 89003 was also noticed in Karnal and Shahabad Co-operative sugar mills. A severe incidence of wilt up to 25% was found in most of the areas of variety CoS 97264 under Kumbhi Chini Mills (UP). Incidence of YLD was observed in entries CoS 8436, CoH 09262, CoPant 10221, CoPb 09204, CoS 09232 and Baragua at the centre.

Evaluation of Zonal varieties for resistance: In ZVT trials, 38 entries were evaluated for red rot resistance along with five standards by plug and cotton swab methods of inoculation. IVT (E) clone CoH 11261 showed HS and S reactions with isolate Cf08 by plug and cotton swab method, while clone CoLk 11201 rated susceptible by plug method only. AVT (E)-I Plant entry CoH 10261 exhibited susceptible reaction with Cf08 by both the methods. Two AVT (E)–II plant clones *viz*. CoH 09262 and CoPb 09181 exhibited MS and S reactions, respectively. Of the mid-late entries, CoH 11264 (IVT- ML) and CoPb 10182 (AVT ML- I Plant) showed MS reaction with Cf08 by plug and susceptible by cotton swab methods. All the other entries were R or MR to red rot by both the methods.

Comparative virulence of red rot isolates: One hundred fifteen red rot isolates were inoculated in susceptible varieties CoJ 64 and CoC 671 by plug method of inoculation to study their comparative virulence under sub-tropical conditions. Twenty three isolates exhibited R, five MR, six MS, thirty seven susceptible and forty four HS reactions on variety CoC 671, whereas, on variety CoJ 64, fifty two isolates rated resistant, twenty one MR, seventeen MS, twenty five S / HS to red rot.

Factors responsible for the development of wilt and Pokkah boeng diseases of sugarcane

(M. L. Chhabra and S. K. Pandey)

Two sugarcane varieties, Co 975 and Co 89003 were planted under irrigated and non-irrigated plots and inoculated with soil culture / inoculum (at planting) and conidial suspension of *Fusarium* isolates, Karnal 1, Karnal 2, Q 62 and CP 21 (plug method) at different crop stages. Among the test isolates, CP 21 was found to be most virulent on variety Co 89003 under non- irrigated field conditions. There was no impact of root borer on wilt incidence.

AICRP on Entomology

(S.K. Pandey)

Evaluation of zonal varieties for their reaction against major insect pests

Ratoon crop: Eighteen sugarcane genotypes along with three standard varieties were evaluated against major insect pests namely; black bug (BB), early shoot borer (ESB), top borer (TB) stalk borer (SB) and root borer (RB). Black bug incidence ranged from 13.6 to 33.4 %. Two genotypes, *viz*. CoLk 09204 and CoS 08234 were least susceptible (LS) to BB (<15.0%). In case of ESB, 16 genotypes showed LS reaction (<15.0%) whereas one genotype, CoS

08233 was MS to ESB (15.1 – 30.0%). Top borer incidence was below ETL (<10.0%) hence, no conclusion could be drawn. Two genotypes, namely CoS 08233 and CoS 09246 were LS (<15.0%) and 19 genotypes showed MS reaction to root borer (15.1 – 30.0%). Fifteen genotypes were LS to stalk borer (infestation index < 2.0) and one genotype, CoH 09022 was MS to stalk borer (infestation index 2.1 to 5.0).

Plant crop: Evaluated 18 sugarcane genotypes comprising eight AVT I and 10 AVT II along with two standard varieties for their reaction against major insect pests, *viz*. early shoot borer (ESB), top borer (TB), stalk borer (SB) and root borer (RB). The incidence of ESB ranged from 4.6 to 14.2 % and 1.7 to 7.5% in AVT I and AVT II, respectively. The incidence of ESB was below ETL (<15.0%) hence, no conclusion could be drawn. In case of top borer, 15 genotypes were LS (<10.0%) and one genotype, CoLk 09204 was MS (10.1 - 20.0%). Twelve genotypes were LS (Infestation index<2.0) and three genotypes, namely CoH 10261, CoPb 09181 and CoS 09246 were MS to stalk borer (Infestation index 2.1-5.0). In case of root borer two genotypes, i.e. Co 09022 and CoPb 09214 were MS (15.1 to 30.0%).

Survey and surveillance of sugarcane insect pests

Survey was carried out to identify the major key pests of sugarcane in the area. The mean incidence of early shoot borer was from traces (T) to 20.0, T to 27.0, T to 60.0 and T to 21.0% in commercial cane varieties Co 89003, CoS 8436, CoH119 and Co 0238, respectively. The incidence of top borer in these varieties, *i.e*. Co 89003, CoS 8436, CoH 119, Co 118 and Co 0238 ranged from T to 9.0, T to 9.1, T to 16.5, T to11.3 and T to 17.4 % respectively. Stalk borer infestation index recorded in sugarcane varieties was 1.8, 2.3, 2.6, 5.6.and 1.9 in Co 0238, CoH 119, CoS 8436, Co 89003 and Co 05011, respectively. The sugarcane varieties Co 0238 and Co 05011 showed LS reaction to stalk borer (infestation index <2.0) while CoH 119 and CoS 8436 showed MS reaction (infestation index 2.1 to 5.0). The variety Co 89003 was highly susceptible to stalk borer with the infestation index >5.0. Incidence of internode borer was 3.6 % in variety Co 05011 in Jind sugar Mill, Haryana. Black bug population ranged from 7.0 to 86.0 bugs/ tiller of ratoon crops in different varieties. Root borer incidence ranged from Traces to 63.3 % in different varieties grown in the area. Incidence of pyrilla was recorded from traces to 96.0 nymphs and adults/ leaf. Mealybug, thrips and whitefliy incidence was in traces. Armyworm incidence was in traces in ratoon crop. Pink borer incidence in ratoon sprouts ranged from traces to 17.0 % in different varieties. Internode borer identified as new pests of sugarcane. Root borer and pink borer were minor pests but now gained the status of major pest. Black bug was the pest of ratoon crop but now became pest of plant crop up to harvest. Early shoot borer, top borer, stalk borer, black bug, pyrilla, and white grub were identified as key pests and mealybug, whitefly and thrips as occasionals pests of sugarcane in North Western zone.

Monitoring of insect pests and bio-agents in sugarcane agro-ecosystem

Major insect pests and their bio-agents in sugarcane variety Co 0238 were monitored. The incidence of early shoot borer (ESB), top borer (TB) and stalk borer (SB) was recorded as 11.3, 12.9 and 60.3 %, respectively. The population of pyrilla was 2.0 individual/ leaf. The parasitization of pyrilla by *Epiricania melanoleuca* was 78.0%.The pyrilla eggs were parasitized (28.3%) by *Tetrastichus pyrillae*. The parasitization of top borer larvae by *Isotima javensis* and *Stenobracon* sp. was 2.7 and 4.8 % respectively. The parasitization of stalk borer larvae by *Cotesia flavipes* was recorded as 4.3 %. The prevalence of effective parasitoides of major insect pests of sugarcane was identified *viz. Isotima javensis, Cotesia flavipes, Tetrastichus pyrillae* and *Epiricania melanoleuca* parasitizing top borer larvae, stalk borer larvae, pyrilla eggs and pyrilla nymphs and adults, respectively.

Chemical control of root borer

(S.K. Pandey)

The experiment was conducted in RBD with three replications with eight treatments namely chlorantraniliprole 18.5 SC@100g a.i./ha (at planting), chlorantraniliprole 18.5 SC@100g a.i./ ha (during first week of May), clothianidin 50%

WDG@100g a.i./ha (at planting), clothianidin 50% WDG @100g a.i./ha (in August), chlorpyriphos 20 EC@1.0 kg a.i. /ha (at planting and in August), imidacloprid 17.8 SL@75g a.i./ha (at planting) and quinalphos 25EC@1.5 kg a.i./ha (in August). The root borer incidence was 31.3% in untreated control. All the treatments were superior to control. Application of chlorantraniliprole 18.5 SC@100g a.i./ha during first week of May was found to be most effective in controlling root borer (63.0% reduction over control) followed by the application of clothianidin 50% WDG@100g a.i./ha in August gave 60.8% reduction over control. Application of clothianidin 50% WDG@100g a.i. /ha at the time of planting gave 52.8% reduction over control. Imidacloprid 17.8 SL @75g a.i./ha applied at the time of planting was least effective (20.9% reduction over control) followed by chlorpyriphos 20 EC@1.0 kg a.i. /ha at the time of planting and during August gave 28.9% reduction over control.

Evaluation of fipronil 0.6%GR insecticide against early shoot borer and termites in sugarcane

(S.K. Pandey)

The experiment was conducted in RBD with three replications. There were seven treatments namely fipronil 0.6% GR @ 7.5 kg/ha, fipronil 0.6% GR @10.0 kg/ha, fipronil 0.6% GR @12.5Kg/ha, Regent 0.3GR @25 kg/ha, chlorantraniliprole 0.4%GR @ 18.75 kg/ha, bifenthrin 10EC @ 1l/ha, chlorpyriphos 20 EC @ 6.25 l/ha and untreated control. All the treatments were applied at planting.

Efficacy on the incidence of early shoot borer (ESB): All the treatments significantly reduced percent ESB incidence over control. The mean ESB incidence in control was 20.3%. Chlorantraniliprole 0.4% GR treated plot gave highest reduction in ESB incidence (64.4%) over control. Bifenthrin 10EC @1 l/ha was found least effective in controlling ESB incidence (20.8%) over control. Fipronil 0.6% granule @ 7.5 kg, 10.0 kg, 12.5 kg and 25.0 kg gave 46.9, 52.1 and 59.2% reduction in ESB incidence over control, respectively. Regent 0.3% granule @ 25 kg/ha gave 50.0% reduction in the incidence of ESB over control.

Efficacy on the incidence of termite: The incidence of termite in untreated control was 26.0%. All the treatments had significantly reduced the incidence of termite over control. Fipronil 0.6% granule @12.5 kg/ha was found to be most effective in reducing the incidence of termite (91.2%) over control followed by Regent 0.3 GR @ 25 kg (86.0%) and fipronil 0.6% GR @10 kg/ha (85.8%) over control. The lower dose (7.5 kg/ha) of fipronil 0.6% checked termite incidence up to 74.4% over control. Fipronil (three different doses i.e. 7.5, 10.0, 12.5 kg/ha) and Regent 0.3 GR @ 25 kg/ha were more effective chemicals in controlling termites than chlorantraniliprole 0.4%GR (62.2% reduction over control), bifenthrin 10EC @ 1 l/ha and chlorpyriphos 20 EC @ 6.25 l/ha gave 26.9% and 61.8% termite reduction over control.

Effect on juice quality: There was no effect of treatments on juice quality (Brix, pol and purity).

Evaluation of imidacloprid 40% + fipronil 40% - 80WG (RM) against termites and ESB with yield and sugar recovery parameters

(S.K. Pandey)

The experiment was conducted in randomized block design and replicated thrice with seven treatments namely imidacloprid 40% + fipronil 40% - 80 WG 150+150 g a.i./ha, imidacloprid 40% + fipronil 40% - 80 WG 175+175 g a.i./ha, imidacloprid 40 % + fipronil 40% - 80 WG 200+200 g a.i./ha, chlorpyriphos 20 EC @ 1kg a.i./ha, phorate 10 G @ 2500 g a.i./ha and Fertera 0.4% GR @ 75g a.i./ha with untreated control. All the treatments were applied at planting.

Efficacy on the incidence of early shoot borer (ESB): All the treatments significantly reduced per cent ESB incidence over control. The average ESB incidence in control was 26.2%. Imidacloprid 40% + fipronil 40% - 80 WG 200+200 g a.i./ha treated plot gave highest reduction in ESB incidence (35.5% over control). Chlorpyriphos 20 EC @ 1kg a.i./ha was found least effective in controlling ESB incidence (19.1% over control). Imidacloprid 40% + fipronil 40% - 80 WG 150+150 g a.i./ha, imidacloprid 40% + fipronil 40% - 80 WG 175+175 g a.i./ha and imidacloprid 40% + fipronil 40% - 80 WG 200+200 g a.i./ha gave 27.8,

32.7 and 35.5 % reduction in ESB incidence over control, respectively.

Efficacy on the incidence of termite: The incidence of termite in untreated control was 34.9%. All the treatments had significantly reduced the incidence of termite over control. Imidacloprid 40% + fipronil 40% - 80 WG 200+200 g a.i./ha was found to be most effective in reducing the incidence of termite (50.2%) over control followed by imidacloprid 40% + fipronil 40% - 80 WG 175+175 g a.i./ha (48.9%) and phorate 10 G @ 2500 g a.i./ha (43.6%) over control. Chlorpyriphos 20 EC @1kg a.i./ha was found least effective in controlling ESB incidence (21.1% over control).

Effect on juice quality: There was no effect of treatments on juice quality (Brix, pol and purity).

Identification of pathotypes in red rot pathogen

Seven established *C. falcatum* pathotypes along with 16 isolates collected from CoJ 64 (7), BO 138 (1), CoSe 95422 (1), CoBln 05221(1) and CoS 8436 (6) were inoculated independently on a set of 14 sugarcane differentials by plug method of inoculation. The overall disease reaction indicated that there was a clear pathogenic variation on the host differentials. None of the pathotype /isolate resembled another pathotype /isolate in pathogenic behavior. Among the seven designated pathotypes, Cf11 was most virulent followed by Cf 08, Cf 03, Cf 07, Cf 09, Cf 02 and Cf 01, respectively (Table 22). Differential CoC 671 exhibited intermediate to susceptible reaction to all the test isolates whereas, differential CoS 8436 succumbed only to isolate CfCoS (Karnal) for the third consecutive years. Of the CoJ 64 isolates, CfCoJ I exhibited more virulence, suggests the possible emergence of new pathotype in the subtropics. A resistant differential Baragua showed intermediate reaction to Cf03 and Cf08; and SES 594 expressed complete resistance to all the isolates.

***Table 22.* Pathogenic behaviour of *C. falcatum* pathotypes on host differentials**

Patho-type / isolate	Source	Reaction on host differentials													
		Co 419	Co 975	Co 997	Co 1148	Co 7717	Co 62399	CoC 671	CoJ 64	CoS 767	CoS 8436	BO 91	Baragua	Khakai	SES 594
CF01	C0 1148	R	R	R	S	R	R	S	R	R	R	R	R	R	R
CF02	Co 7717	S	X	R	R	S	R	X	R	R	R	R	R	R	R
CF03	CoJ 64	X	X	R	R	X	S	S	S	R	R	R	X	X	R
CF07	CoJ 64	X	R	R	X	X	S	S	S	R	R	R	R	R	R
CF08	CoJ 64	S	X	R	R	S	S	S	X	x	R	S	X	X	R
CF09	CoS 767	R	X	R	R	R	X	S	S	S	R	R	R	R	R
CF11	CoJ 64	S	S	S	S	S	S	S	X	S	R	R	R	S	R
cfBO138	BO 138	R	R	S	R	R	R	S	R	R	R	R	R	R	R
cfSe 95422	CoSe 95422	S	R	R	R	X	S	S	R	R	R	R	R	X	R
cfBLN 05521	CoBln 05521	R	X	R	R	R	R	S	X	R	R	R	R	X	R
cf8436 (K)	CoS 8436	R	X	S	R	X	S	S	R	R	S	X	R	X	R
cf8436 (R)	CoS 8436	R	X	X	R	X	R	S	R	R	R	R	R	R	R
cf8436 (O)	CoS 8436	R	R	R	R	R	R	S	R	R	R	R	R	R	R

Patho-type / isolate	Source	Reaction on host differentials												
		Co 419	Co 975	Co 997	Co 1148	Co 7717	Co 62399	CoC 671	CoJ 64	CoS 767	CoS 8436	BO 91	Baragua	Khakai	SES 594
cf8436 (P)	CoS 8436	X	R	R	R	R	S	S	R	R	R	R	R	R	R
cfUP 1	CoJ 64	R	R	R	R	R	X	X	R	R	R	R	R	R	R
cfUP 2	CoJ 64	R	R	R	R	R	R	S	X	R	R	R	R	R	R
cfUP3	CoJ 64	R	R	X	X	R	R	X	X	R	R	R	R	R	R
cfCoJ I	CoJ 64	X	R	X	X	X	S	S	X	R	R	R	R	X	R
cfCoJ II	CoJ 64	R	R	R	R	R	R	X	S	R	R	R	R	R	R
cfCoJ III	CoJ 64	R	R	R	R	R	S	S	X	R	R	R	R	X	R
cfCoJ IV	CoJ 64	X	R	R	R	X	R	S	R	R	R	R	R	R	R
cf8436 (RI)	CoS 8436	S	S	S	X	X	X	S	R	R	R	R	R	S	R
cf8436 (UPCSR)	CoS 8436	S	X	S	R	S	R	S	X	R	R	X	R	S	R

R- Resistant; X- Intermediate; S- Susceptible

Multiplication and supply of sugarcane differentials seed: The seed of four new sugarcane differentials *viz*., Co 86002, Co 86032, CoV 92102 and CoSe 95422 was multiplied and supplied to Lucknow, Uchani, Ludhiana and Pusa (Bihar) centres.

Evaluation of Zonal varieties for red rot: In ZVT trial, 38 entries were evaluated for red rot resistance along with five standards by plug and cotton swab methods of inoculation. One IVT (E) Clone CoH 11261 had shown susceptibility to isolate Cf08 by plug and cotton swab methods, while clone CoLk 11201 rated susceptible by plug method only (Table 23). Among the AVT (E)-I Plant entries, CoH 10261 exhibited susceptible reaction with isolate Cf08 by both the methods. Two AVT (E)–II plant clones viz. CoH 09262 and CoPb 09181 were found to be moderately susceptible to susceptible with Cf08 inocula by plug and nodal methods. Of the Mid late entries, CoH 11264 (IVT- ML) and CoPb 10182 (AVT ML- I Plant) showed MS reaction with Cf08 by plug and susceptible by cotton swab methods. All the other entries were resistant or moderately resistant to red rot by both the methods.

Table 23. **Evaluation of zonal varieties for red rot resistance**

Entry	Red rot rating			
	Plug Method		Cotton Swab Method	
	CF 08	CF 09	CF 08	CF 09
IVT-Early				
CoH 11261	HS	MS	S	R
CoH 11262	MS	MR	R	R
Co LK 11201	S	R	R	R
Co LK 11202	MR	R	R	R
Co LK 11203	MR	R	R	R
CoPb 11211	MR	MR	R	R

Entry	Red rot rating			
	Plug Method		Cotton Swab Method	
	CF 08	CF 09	CF 08	CF 09
CoPB 11212	R	R	R	R
AVT-Early (I Plant)				
Co 10035	R	R	R	R
CoH 10261	S	MR	S	R
CoS 10231	R	R	R	R
CoJ 64 (Standard)	MS	S	S	R
CoPant 84211 (Standard)	HS	S	S	S
AVT –Early (II Plant)				
CoH 09262	MS	R	S	R
CoH 09263	R	R	R	R
CoLk 09202	R	MR	R	R
CoPb 09181	S	MS	S	R
CoS 09246	R	R	R	R
CoS 767 (Standard)	MS	S	S	R
CoS 8436 (Standard)	R	MR	R	R
CoPant 97222 (Standard)	R	MR	R	R
Co 11026	MR	MR	R	R
IVT-ML				
Co 11027	R	R	R	R
CoH 11263	R	R	R	R
CoH 11264	MS	R	S	R
CoLk 11204	MR	MR	R	R
CoLk 11205	R	R	R	R
CoLk 11206	R	R	R	R
CoPb 11181	R + WILT	R	R	R
CoPb 11182	MS	MS	R	R
CoPb 11213	R	R	R	R
CoPb 11214	R	R	R	R
CoS 11231	MS	MS	R	R
CoS 11232	R	R	R	R
AVT –ML (I Plant)				
Co 10036	R	R	R	R
CoH 10262	R	R	R	R
CoPant 10221	R	R	R	R
CoPb 10181	R	R	R	R
CoPb 10182	MS	MS	S	R

	AVT ML (II Plant)				
39	Co 09022	R	R	R	R
40	CoH 09264	MR	R	R	R
41	ColK09204	R	R	R	R
42	CoPb 09214	MR	R	R	R
43	CoS 09232	R	R	R	R

R- Resistant; MR-Moderately Resistant; MS- Moderately Susceptible; S- Susceptible; HS- Highly Susceptible

5.7 ICAR-SBI RESEARCH CENTRE, KANNUR

Sugarcane germplasm: Collection, maintenance, evaluation, documentation and utilisation

Utilization of germplasm resources for developing new genetic stocks

(K. Chandran, M. Nisha and P. Mahesh)

Effort on utilization of germplasm resources that are not commonly used for hybridization programme were made with an emphasis on interspecific hybridization so as to widen the genetic base of sugarcane. A final clonal evaluation trial with 13 test entries and three check varieties were conducted and two clones GUK 10-413 with high biomass yield with a background of Chinese commercial hybrid YUETANG85-177 and GUK 10-481 with red rot resistance were identified as genetic stocks and proposed for Pre-zonal varietal trial (PZVT).

In the second replicated trial with 40 clones from various interspecific crosses,16 clones which are MR / R to red rot were selected for final evaluation. 25 clones in pre-clonal trial were evaluated for HR Brix, cane thickness and tested for red rot reaction. When F1 was backcrossed with *S. officinarum*, except one clone all were either S or HS to red rot. From eight clones where Baragua was used as female parent only one found to be MR to red rot and the others were susceptible.

Out of the 533 seedlings from four crosses evaluated in the ground nursery, 80 seedlings obtained from a cross involving *Erianthus arundinaceous* as female parent were found to be selfs. From the remaining three crosses the range, mean and SD for NMC, HR Brix and cane thickness were worked out Table 24. Out of these, 65 seedlings were selected for pre-clonal evaluation. Nine new crosses were attempted and 1170 seedlings were planted in ground nursery.

Table 24. **Family mean for NMC, HR Brix and cane thickness of three crosses**

Cross	Number of clones	NMC		HR Brix		Cane thickness	
		Range	Mean	Range	mean	Range	Mean
Co 99006 x GUK 11-2003	198	1-13	4.4±2.0	11.2-20.8	17.0±1.9	1.2-2.4	1.8±.2
F 49-11x WL 05-499	82	1-6	2.6±1.0	13.2-22.4	19.1±1.6	1.6-3.1	2.3±.3
GUK 12-582 x 98 GUK 333	163	1-7	3.3±1.4	10.0-23.2	19.0±2.3	1-3.1	2.1±.3

Maintenance of world collection of sugarcane germplasm

(K. Chandran, M. Nisha, P. Mahesh and V. Jayakumar)

Maintenance of germplasm: A total of 3373 germplasm clones were maintained in field gene bank in 6 ft rows in single replication and monitored for pests and diseases. Flowering of the clones ranged from 13% in *S. officinarum* to 79.2% in IA clones.

Evaluation: A replicated trial was conducted to evaluate the yield of edible inflorescence from nine regularly flowering clones of *S. edule*. Significant variation was observed for tillering at 90 days, NMC, number of edible inflorescence, fresh weight and total yield of the edible inflorescence. The colour of edible inflorescence was golden yellow in IJ 76-375 and in others it was creamy yellow (Fig. 77). The highest total number of 'cobs' and maximum yield (486.35g/plot) was recorded in IJ 76-338 with 98% flowering stalks. The highest fresh weight /'cob' were recorded for NG 77- 10. For tillering at 30 days, cane length and for total biomass yield, the difference was not significant.

Fig. 77. The edible inflorescence of S. edule

Documentation: A digital catalogue of 612 exotic hybrid clones was developed in MS Access and submitted for e-publication.

Monitoring of diseases and quarantine: A total of 450 clones comprising 201 *S. officinarum*, 247 'Co' canes and two foreign hybrid clones were subjected to hot water and fungicide treatment (52°C for 30 min combined with 0.1% Triadimephon) and planted. Monitoring of new crop in May 2014 showed early symptom of Pokkah boeng in 10 Co canes *viz*., Co 952, Co 1032, Co 1164, Co 62149, Co 62154, Co 62157, Co 62169, Co 62211, Co 62212 and BO 24 and 3 foreign hybrids *viz*., Q69, CP1161 and PR1069. Spot application of Indofil M-45 (0.1%) in the infected clones resulted in recovery of disease. In September 2014, the clones appeared healthy and no disease incidence was noticed except for mild incidence of leaf spots in few species clones. In January 2015 also, the germplasm collection showed mild incidence of leaf spot disease. In IK 76-64, smut disease was noticed hence the whip was removed and further the clone was subjected to hot water and fungicide treatment and planted in polybag. The occurrence of disease was examined in the germplasm in which destructive samples were done for pest (root borer) incidence. Among the sampled clones, five *S. officinarum* and one 'Co' cane was affected with wilt and in water stagnated areas two *S. officinarum*, one *S. robustum* and four 'Co' canes were affected with sett rot. The wilt and sett rot were associated with some pre-disposing factors *viz*., insect damage and splitting of cane. No disease incidence was noticed in the foreign hybrid clones CP03-1912 and CPCL-4111 that were planted after quarantine.

Monitoring of insect pests: Among the pests, internode borer, pink borer, root borer, termite and woolly aphid were observed to occur at various levels and their natural incidence has been recorded on selected clones. The incidence of internode borer in *S. officinarum, S. robustum, S. sinense* and *S. barberi* 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 10-20% in this species. The pink borer activity appeared during the pre-monsoon period. The extent of pink borer deadhearts ranged from 1.47 - 29.41% in *S. officinarum*, 0.00 - 30.77% in *S. robustum*, 0.00 - 21.05% in *S. barberi* and 0.00 - 37.04% in *S. sinense*. Twenty *S. officinarum* clones were also examined for the incidence of underground insect pests by destructive sampling. Thirteen clones were noticed with root borer infestation. The NC 11, 51 NG 151, 28 NG 11, Fiji 40 and Fiji 45 genotypes were found more susceptible. In foreign hybrids, destructive

sampling was done on 40 clones. Of these, 19 clones were noticed with root borer infestation. In *S. robustum*, destructive sampling was done on 12 clones, of these only one clone was found infested with root borer. 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. In 12 clones termite attack was noticed. 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. To enhance the natural control, chemical control was avoided.

Sugarcane woolly aphid infestation was observed on Co 416, Co 629, Co 896, Co 62032, Co 62213, Co 62214, Cok 28, Maneria IMP- 1648 and to some extent in the evaluation trial. It was effectively managed using insecticidal sprays (acephate 75 SP 2g /l). Subsequently, the parasitoid *Encarsia flavoscutellum* collected from Coimbatore was also released in the aphid infested plots. In addition to these, incidence of leaf miner (*Aphanisticus aeneus*), scale insect, mealybug and rice leaf folder was noticed in a few clones at negligible levels.

In vitro conservation of germplasm: One hundred germplasm clones were multiplied and maintained *in vitro.*

Germplasm exchange: 531 accessions were supplied to seven indenters.

Breeding varieties resistant to waterlogging

(K. Chandran and M. Nisha)

A final clonal evaluation trial was conducted under waterlogged condition with 13 test clones and three checks. All the clones were tested for red rot reaction. Five promising clones under waterlogged condition of which two clones resistant to red rot and three moderately resistant to red rot were proposed for PZVT. The yield and quality traits are given in table 25.

Table 25. **Yield and quality attributes of WL clones under final clonal evaluation**

Clone	Red rot reaction	NMC	Single cane weight (kg)	Brix	Cane thick-ness (cm)	Yield (kg/plot)	Sucrose (%)	CCS yield (kg/plot)	Biomass (kg/1m)
WL-10-3	MR	53.3	1.3	19.2	2.7	66.0	19.0	9.2	16.7
WL-10-18	MR	46.3	0.9	18.9	2.4	43.1	18.8	5.9	14.4
WL-10-20	MR	53.0	1.4	20.8	2.6	71.4	19.4	9.8	23.1
WL-10-24	R	51.0	1.4	22.8	2.7	69.1	22.2	11.1	14.1
WL-10-37	R	44.0	1.1	19.5	2.5	52.4	19.2	7.1	16.8
WL-10-40	R	59.7	1.1	20.0	2.7	62.0	18.7	8.2	14.0
WL-10-49	R	46.0	1.5	20.2	2.8	69.9	19.8	10.0	17.7
WL-10-62	R	39.3	1.2	21.7	2.6	46.8	21.1	7.1	13.7
WL-10-83	MR	47.3	1.0	22.9	2.5	49.2	21.3	7.5	11.6
WL-10-85	MR	61.0	1.4	19.3	2.6	85.7	19.2	12.0	18.1
WL-10-102	MR	51.0	1.5	21.6	2.7	76.7	19.5	10.2	18.9
WL-10-105	MR	49.3	1.5	21.0	2.6	74.0	20.6	11.1	18.9
WL-10-118	R	51.0	1.0	21.9	2.6	50.6	21.2	7.8	12.4
Co 86032		42.7	1.5	18.5	2.8	61.6	18.4	8.3	21.4
Co 99006		56.3	1.2	21.5	2.3	65.1	20.5	9.5	17.7
Co 62175		58.7	1.4	17.0	2.7	84.9	16.8	10.4	22.7
SE		3.2	0.1	0.3	0.1	5.2	0.4	0.8	1.5
CD		7.5	0.2	0.7	0.2	12.1	1.0	1.8	3.5

In the pre-final trial, 30 test clones were evaluated against two checks. The clones had tillering at 90 days from 12-55, HR Brix at bottom 17.5 to 23.9, middle 17.2-24.2 and top 17.3-24.3, NMC 12.3-42.7, Brix 16.1-23, cane thickness 2.1-3.0 and yield 9.9-65.3 kg/plot. 15 clones based on NMC, cane thickness, brix and reaction red rot were selected for further evaluation.

From pre-clonal evaluation with 101 clones, 37 clones were selected for further evaluation. All the clones were tested for red rot rating and 31 were R, 41 were MR, nine were MS, eight were S and nine were HS. 1030 seedlings of 11 crosses were evaluate in ground nursery and nine seedlings were selected for further evaluation based on tillering, cane thickness and HR Brix. The maximum tillering (1-8) and HR Brix range 18.2-25.4 was observed in the population of WL 04-95 x WL 10-20 and the highest cane thickness of 1-2.9 cm in 7313 xWL 05-499. The family range, mean and SD values for each cross is given in table 26.

Table 26. **Family mean for NMC, Cane thickness and HR Brix**

Cross	Number	NMC		Cane thickness (cm)		HR Brix	
		Range	Mean	Range	Mean	Range	Mean
Co 99006 x WL 06-332	198	1-5	1.7±0.8	0.9-2.5	1.7±0.2	17.2-25.2	22.8±1.2
C 7313 x WL 05-499	97	1-7	1.5±1	1.0-2.9	1.8±0.4	13.8-24.4	20.4±1.9
Co 86032 x 96 WL 120	59	1-4	2.2±0.9	1.1-2.9	2.1±0.3	18.4-24.2	22.0±1.3
WL 04-95 x WL 10-20	80	1-8	2.0±1.2	1.1-2.8	1.7±0.3	18.2-25.4	23.3±1.4
WL 06-182 x Co 62175	5	1-1	1.0±0	1.2-1.9	1.6±0.3	21.4-22.8	22.0±0.7
Co 86032x WL 09-445	8	1-4	2.0±1.0	1.6-2.9	2.1±0.4	15.6-23.4	20.9±2.4
WL 04-81 x CP 94-1100	11	1-5	2.6±1.4	1.3-2.5	1.6±0.3	18.0-23.4	21.3±1.8
WL 06-182 x 99 WL -389	48	1-5	1.8±1.0	1.4-2.8	2.1±.39	19-25.2	21.9±1.4
98 WL 1357 x WL 10-118	4	2-5	3.3±1.5	0.7-1.6	1.2±.47	14.4-20.2	17.2±2.9
Co 99006 x WL 10-20	300	1-6	2±1.0	1-2.8	1.8±.4	15.0-25.2	22.26±2
BO 91 x Co 09008	220	1-6	1.7±1	1-2.9	1.6±.33	14.2-23.8	20.8±1.5

DNA fingerprinting of *Saccharum officinarum* using SSR markers

(M. Nisha)

Two hundred typical *S. officinarum* clones representing different agro-ecological zones and with diverse morphological characters were selected for DNA fingerprinting. These clones were described for various morphological characters using the descriptor list of sugarcane. Around 300 SSR primers available in public domain were selected which includes Genomic DNA based, EST based, cDNA based, enriched genomic sequence based and unigene derived sugarcane microsatellites. In order to identify the polymorphic primers, screening of the primers was done on selected eight clones namely Chittan, 51 NG 21, NG 77-232, IJ 76-322, Ceram Red, Hawai Original 38, Iscambine and 51NG134. The clones were selected to represent various eco-geographical origin and various distinguishing morphological traits. The annealing temperature of each primer was standardized and it ranged from 51 to 64°C. Then the samples were amplified using each primer, resolved in 7.5% Poly Acrylamide Gel Electrophoresis and stained by silver staining method. (Fig. 78).

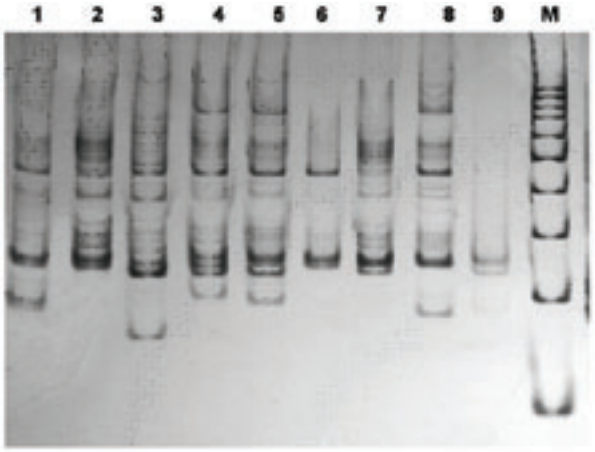


Fig. 78. SSR profile of Saccharum officinarum clones based on the marker NKS 23. Lane 1-Chittan, 2-21 NG 21, 3-NG 77-232, 4-IJ 76-322, 5-Ceram Red, 6-Hawaii Original 38, 7-Iscambine, 8-51NG 134, 9-NG 77-142, M-100bp ladder

Out of 262 primers screened to identify the polymorphic primers, 41 were Genomic DNA based, 97 EST based, 28 cDNA based, 26 enriched genomic sequence based and 62 were unigene derived sugarcane microsatellites. Of the total screened primers, 149 primers were able to produce polymorphism whereas the remaining primers were monomorphic or failed to produce amplification. The level of polymorphism was variable with 51 showing low polymorphism, 85 moderately polymorphic and 13 highly polymorphic. The percentage of polymorphic marker was 66 in case of both Genomic DNA based and EST based markers whereas the others cDNA based, enriched genomic sequence based and unigene derived sugarcane microsatellites produced 43, 54 and 44% polymorphic primers respectively. The number of alleles detected per marker ranged from 1 to 16 with an average of seven alleles among the clones screened. Most of the monomorphic primers amplified single band and the primer SMC 278 CS a cDNA based marker detected the highest number of alleles. The allelic size ranged from 100bp to 1000bp. Among the highly polymorphic primers nine primers independently able to distinguish all the eight clones. The primers are mSSCIR 68, SMC 278CS, SCB 10, SCB01, SMC 1572CL, SMC 336BS, NKS 23, NKS 27 and NKS 28. The first six are EST based microsatellite markers and the remaining three are genomic STMS markers.

5.8 ICAR-SBI RESEARCH CENTRE, AGALI

Germplasm maintenance, Distant hybridization and Off-season Nursery

(R. Karuppaiyan, K. Mohanraj and A. Annadurai)

Maintenance of germplasm

One thousand and six hundred germplasm accessions were clonally maintained and the details are given in table 27.

Table 27. **Germplasm maintained at SBI Research Centre, Agali**

Species / Category	No. of accessions
Saccharum officinarum	101
S. robustum	13
S. barberi	30
S. sinense	12
S. spontaneum	53
Erianthus arundinaceus	186
Co and Co allied clones / varieties	489
Exotic clones	45
Somaclones & mericlones	74
Population improved officinarum (PIO)	120
Population improved robustum (PIR)	80
Inter-specific hybrids (ISH)	166
Inter-generic hybrids (IGH)	231
Total	1600

Out of 1600 germplasm, 363 have shown the sign of clonal degeneracy due to yellow leaf disease and other causes. These clones were replaced with disease free planting materials obtained from SBI Coimbatore.

Another 174 clones representing the core collection of *S. officinarum* were obtained from SBI Research Centre, Kannur and planted at Agali Centre during March 2015.

Hybridization: Thirteen AICRP (Sugarcane) Centres have participated in the crossing programme at Agali Centre during 2014 flowering season. A total 106 crosses were made. Open pollinated fluffs of 28 parents were collected. Fluffs weighing 2,405 g were collected and dispatched to the fluff receiving Centre during March 2015.

Maintenance of national off-season nursery: One of the mandates of this centre is to facilitate raising off-season nursery for the mandate crops of ICAR. Off-season nursery facility was utilized by National Research Centre for Banana, Trichy. About 2.0 acre land was used for raising banana germplasm.

DUS testing of sugarcane - at Agali

(M.N. Premachandran, K. Mohanraj and R. Karuppaiyan)

One hundred and eighty nine reference varieties were maintained and were replanted in February 2015. Two Farmer's varieties received for testing were initially planted in polybags and were transplanted to field. Three candidate varieties for DUS testing along with seven reference varieties were planted in replicated trial as per DUS test guidelines for DUS testing.

6. EDUCATION AND TRAINING

6.1. EDUCATION - M.PHIL / Ph.D. PROGRAM

Bharathiyar University: The Institute has been recognized by the Bharathiyar University, Coimbatore to conduct M.Phil./ Ph.D. programme in the disciplines of Biotechnology, Botany, Zoology, Agricultural Chemistry, Agricultural Entomology and Plant Pathology. Four students , three in Biotechnology and one in Botany have been enrolled for Ph.D. The following students have obtained M.Phil./Ph. D degree from Bharathiyar University.

Name of the student	Title of the thesis	Guide
K. Devi	Molecular characterization of *Fusarium* species associated with wilt and pokkah boeng disease of sugarcane (M.Phil. degree)	Dr. A. Selvi
C. Chinnaraja	Molecular characterization of sugarcane yellow leaf virus causing yellow leaf in sugarcane and its impact on crop growth and yield (Ph.D. degree)	Dr. R. Viswanathan
V. Ganesh Kumar	Genomics and proteomics based analyses of sugarcane – *Colletotrichum falcatum* interaction (Ph.D. degree)	Dr. P. Padmanaban
Sruthy Maria Augustine	Isolation and characterization of drought responsive genes from *Erianthus arundinaceous* and development of transgenic sugarcane for drought tolerance (Ph.D. degree)	Dr. N. Subramonian
L. Nivetha	Molecular profiling and development of DNA markers associated with important traits in sugarcane (Ph.D. degree)	Dr. N.V. Nair
M. Chakravarthi	Isolation and characterization of constitutive and wound inducible promoters and validation of designed synthetic stem/root specific promoters for sugarcane transformation (Ph.D. degree)	Dr. N. Subramonian
P. Harunipriya	Targeting of recombinant proteins to sugarcane lytic vacuoles for molecular farming (Ph.D. degree)	Dr. N. Subramonian

Anna University: Anna University of Technology, Coimbatore has recognized the Institute as Research Centre for conducting Ph.D. and M.Tech (by research) programme in the faculty of Science and Humanities (Biosciences) and Science and Humanities (Chemistry). Currently, three scholars are doing Ph.D. in Science and Humanities (Biosciences).

Bharathidasan University: The Institute has also been recognized by the Bharathidasan University, Tiruchirappalli to conduct Ph.D. programme in the discipline of Biotechnology. One student has enrolled for Ph.D. programme in Biotechnology.

M.Sc. (Sugarcane Technology) course in ODL mode is being conducted in collaboration with TNAU, Coimbatore. Two batches of students, 21 in their IV semester and 19 in their II semester are undergoing the course. Fourteen students carried out their M.Sc. project work at the institute.

6.2 TRAINING PROGRAMMES ORGANIZED

Coimbatore

- Model Training course on 'Recent technologies for improving sugarcane productivity' for 14 officials of state department from seven states during 17-24 September 2014.
- Conducted a Training program on 'Sugarcane Micropropagation' to one Research Associate, Zonal Agricultural Research Station, V.C.Farm, Mandya for 19 days from 24 November - 12 December 2014.
- Five national level training programs on 'Sugarcane technologies for increased productivity' were organized with the participation of cane development personnel from Tamil Nadu, Maharashtra, Gujarat, Uttar Pradesh and Karnataka.
- A state level three days training program on 'Scientific jaggery production' was conducted for 22 farmers from Marayoor and Kanthaloor panchayats of Idukki district, Kerala during 17-19 March 2015.
- A state level six days training program was organized for 16 farmers from Lal Bahadur Shastri Ganna Sansthan, Lucknow during 21-26 March 2015.

Karnal

- Two farmers training programmes of six days duration sponsored by Lal Bahadur Shastri Ganna Kisan Sansthan, Lucknow (UP) for 40 farmers during on 9-14 and 23-28 February 2015 (Fig. 79).

Fig. 79 Valedictory function of the training programme

- One day training programme on 'Seed technologies for enhancing productivity in sub tropical India' for progressive sugarcane farmers (24) from Haryana, UP and sugar mill officials (36) of 11 sugar mills on 31 March 2015.

Agali

- One day training-cum-exposure visit was conducted for 48 students of Govt. Vocational Higher Secondary School, Pudur (Attapady) on 22 November 2014 (Fig. 80).

Fig. 80 Students visiting Agali Centre

Training programmes attended

Name of the programme	Participant (s)
Plant genome analysis at TNAU Coimbatore during 16-20 June 2014	Dr. C. Appunu
Management development programme on Biotechnology and Intellectual Property Rights at NAARM, Hyderabad during 16-21 June 2014	Dr. A. Selvi Dr. R. Manimekalai
Biosafety and detection of GM Crops at NBPGR, New Delhi during 15-19 July 2014	Dr. A. Ramesh Sundar Dr. C. Appunu
Management development programme on Consultancy projects management at NAARM, Hyderabad during 22-27 August 2014	Dr. A. Ramesh Sundar Dr. B. Singaravelu
Agricultural knowledge management techniques at NAARM, Hyderabad during 16-26 September 2014	Smt. D. Subhadra
Open access to agricultural knowledge for growth and development at NAARM, Hyderabad during 29-30 October 2014	Dr. R. Balakrishnan
Functional genomics and proteomics: Technique and tools for crop improvement from 12 November to 2 December 2014	Dr. Mintu Ram Meena
Advances in omics data analysis at Indian Agricultural Statistical Research Institute, New Delhi during 3-23 December 2014	Dr. R. Manimekalai
Managing technology value chains for Directors & Division Heads at ASCI, Hyderabad during 5-9 January 2015	Dr. C. Palaniswami
Executive development programme on Leadership development at NAARM, Hyderabad during 19-23 January 2015	Dr. Bakshi Ram
Training/ Workshop with the HRD Nodal Officers of ICAR Institutes at NAARM, Hyderabad on 26 February 2015	Dr. K. Hari

6.3 INTERNATIONAL VISITS

- Dr. B. Parameswari, Scientist (Plant Pathology), SBI RC, Karnal was deputed under Indo-US Research Fellowship in USA sponsored by IUSSTF for one year from 31 July 2014.
- Dr. G.S. Suresha, Scientist (Biochemistry) was deputed under Indo-Australian Career Boosting Gold Fellowships (IACBGF) 2013-14 at CSIRO, Australia for the research programme on Improving sucrose accumulation in sugarcane through delayed flowering sponsored by DBT for two years from 4 August 2014.
- Drs. T. Rajula Shanthy and V.P. Sobhakumari attended the 5th IAPSIT International Conference on Green technologies for sustainable growth of sugar and integrated industries in developing countries (IS 2014) at Nanning, China during 25-28 November 2014.

7. AWARDS AND RECOGNITIONS

Fig. 81 Dr N. V. Nair, Director receiving the Sardar Patel Outstanding Institution Award from Shri Narendra Modi, Hon'ble Prime Minister of India

- The Institute was awarded the Sardar Patel Outstanding ICAR Institution Award 2013 (Larger Institutes). The award was presented by the Hon'ble Prime Minister of India on the ICAR Foundation Day on 29 July 2014 (Fig. 81).
- The Institute was awarded ISO 9001:2008 Certificate by the Certification Agency w.e.f. 14 May 2014.
- The Institute has secured third place for commendable performance in the implementation of Official Language for the year 2013-14 in Government Offices Category.
- Dr. R. Viswanathan, Principal Scientist and Head, Division of Crop Protection was conferred the Fellow of National Academy of Biological Sciences, Chennai for the year 2013 during the Annual Meeting of NABS held at KSR College of Technology, Tiruchengode, Namakkal District, Tamil Nadu on 20 July 2014 (Fig. 82).
- Dr. R. Viswanathan was conferred the award of Fellow of Indian Virological Society, New Delhi during the 23rd National Conference of Indian Virological Society, New Delhi held at TNAU, Coimbatore on 18 December 2014 (Fig. 83).
- Dr. R. Viswanathan, Head, Division of Crop Protection, served as Principal Investigator (Pathology), AICPRP on Sugarcane.
- Dr. R. Viswanathan, Head, Division of Crop Protection, served as Editor of 'Indian Phytopathology' published from New Delhi and Editor of Journal of Mycology and Plant Pathology published from Udaipur.
- Dr. G. Hemaprabha, Principal Scientist was selected as a Member of the Expert Committee on Crop Molecular Breeding of Department of Biotechnology, Govt. of India for a period of three years.
- Dr. T. Rajula Shanthy, Principal Scientist and Head, Extension Section was conferred the award of Fellow of Society of Extension Education, Agra during the 7th National Extension Education Congress held at ICAR Research Complex for NEH region, Shillong during 8-11 November 2014 (Fig. 84).

Fig. 82. Dr. R. Viswanathan receiving NABS Fellow Award

Fig. 83. Dr R. Viswanathan receiving the award

Fig. 84. Dr. T. Rajula Shanthy receiving the Fellow award

Fig. 85. Dr. A. Ramesh Sundar receiving the Fellow award

- Dr. A. Ramesh Sundar, Principal Scientist was conferred Fellow of the Indian Society of Mycology and Plant Pathology, Udaipur at the 36th General Body Meeting of the Society during February 2015 (Fig. 85).

- Dr. C. Karpagam, Senior Scientist (Agrl. Extension) received Young Scientist Award from the Extension Education Society, Coimbatore for his research paper on 'Inclusive development in sugarcane' during the National seminar on Extension management strategies for sustainable agriculture: Challenges and opportunities conducted at Madurai during 12-13 December 2014.

- Dr. C. Karpagam, Senior Scientist (Agrl. Extension) received Achiever Award 2014 from the Society for Advancement of Human and Nature (SADHANA), Dr. Y.S. Parmar University of Horticulture and Forestry, Solan.

- Dr. P. Mahesh, Scientist (Agrl. Entomology) received the best poster for the paper on 'Status of pink borer *Sesamia inferens* resistance in accessions of four *Saccharum* species' during the International conference on Innovative insect management approaches for sustainable agro eco-system conducted at Madurai during 27-30 January 2015.

8. LINKAGES AND COLLABORATION IN INDIA INCLUDING EXTERNALLY FUNDED PROJECTS

The Institute has established linkages with ICAR Institutes like IARI, NBPGR, NRC-PB, NBAIR, IISR, DWR, 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, DBT/GoI, Directorate of Sugarcane Development, MoA/GoI, TNPL (a Govt. of Tamil Nadu Undertaking), MSSRF, Chennai and sugar industry in critical areas in emerging technologies for deriving maximum benefit.

Sl. No.	Project title and scientist's involved	Source of funding	Total out-lay (Rs. in lakhs)
1	Intellectual property management and transfer /commercialisation of agricultural technology scheme (upscaling of existing component i.e. IPR under ICAR head quarters scheme on management and information services (M.N. Premachandran)	ICAR/AP Cess Fund	23.52
2	Seed production in agricultural crops and fisheries (N. Rajendra Prasad and D. Neelamathi)	MoA/GoI	53.45
3	Strengthening of designated field and laboratory for DUS testing (Coimbatore, Agali and Karnal centres) (M.N. Premachandran, Bakshi Ram and C. Jayabose)	MoA/GoI	72.26
4	Characterization of intergeneric hybrids of *Saccharum* using molecular markers (N.V. Nair and A. Selvi)	DBT	27.92
5	Identification and characterization of antifungal genes for cloning and identifying sugarcane phytoalexins as marker for red rot resistance (R. Viswanathan, A. Ramesh Sundar and P. Malathi)	SDF	77.79
6	Molecular elucidation of biotic elicitor-mediated defense-responsive genes/ proteins in sugarcane x *Colletotrichum falcatum* interaction (A. Ramesh Sundar, R. Viswanathan and P. Malathi) (SBI & MSSRF)	DST	37.70
7	Delineation of sugarcane soils for micronutrients status and screening sugarcane varieties for tolerance to iron and zinc deficiency (A. Bhaskaran, C. Palaniswami and P. Rakkiyappan)	SDF	40.38
8	Structural characterization and evaluation of toxin produced by *Colletotrichum falcatum* for sugarcane red rot disease management (V.Jayakumar)	DST	21.50
9	Development of mechanized system for effective sett/bud treatment of sugarcane (R. Viswanathan, P. Malathi, Ravindra Naik and S. Jacob Annamalai)	DST	9.08
10	Development of high fibre *Erianthus arundinaceus* clones as alternate source of fibrous raw material for pulp and paper industry (C. Jayabose and P. Rakkiyappan)	TNPL	8.69

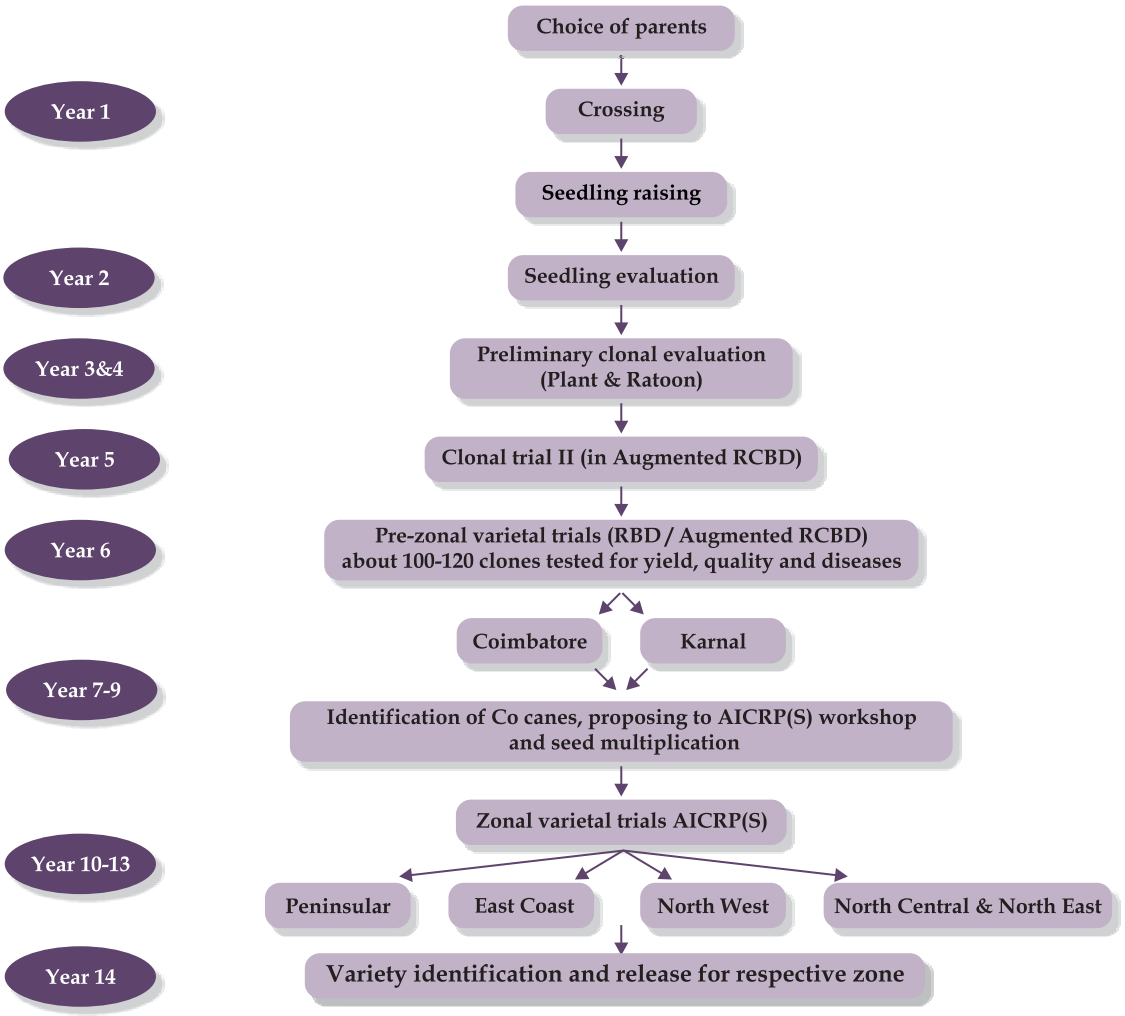
Sl. No.	Project title and scientist's involved	Source of funding	Total out-lay (Rs. in lakhs)
11	Development of hand held instrument for on - field fibre content measurement in sugarcane (P. Govindaraj)	DST	8.35
12	Evaluation of Fipronil 0.6% GR insecticide against early shoot borer and termites in sugarcane at SBI RC, Karnal (S.K. Pandey)	M/s Bayer Crop Science Ltd.,	8.47
13	Evaluation of Imidacloprid 40% + Fipronil 40% - 80 WG (RM) against termites and early shoot borer in sugarcane (S.K. Pandey)	M/s Bayer Crop Science Ltd.,	7.44
14	Genetic engineering of sugarcane for water deficit stress tolerance (N. Subramonian, Narendra Tuteja and C. Appunu) (SBI & ICGEB)	DBT	54.52
15	Identification of RNA silencing mechanism in sugarcane against RNA viruses and characterisation of virus suppressor proteins (R. Viswanathan)	DBT	64.23
16	DNA finger printing of *S. officinarum* clones using simple sequence repeat markers (M. Nisha)	DST (SERB)	12.00
17	Molecular cloning and characterization of genes involved in lignin biosynthesis pathway of sugarcane (K. Lakshmi)	DST (SERB)	12.00
18	Whole transcriptome sequencing of sugarcane for sucrose regulating genes (P.T. Prathima)	DST (SERB)	12.00
19	Developing new technologies for processing sugarcane juice (K. Hari, G.S. Suresha, K. Sivaraman and T. Arumuganathan)	MFPI	37.40
20	Isolation and functional characterization of low temperature tolerance responsive genes from high cold tolerant *Saccharum spontaneum* IND 00-1061 Arunachala Pradesh collection (C. Appunu)	DST	22.40
21	National Level training for implementation of sugarcane development programme under NFSM (Commercial crops) (T. Rajula Shanthy)	DAC, MoA	2.50
22	Model training course on Recent technologies for improving sugarcane productivity (T. Rajula Shanthy)	DAC, MoA	2.51
23	PHYTOFURA under ICAR Outreach Project on Phytophthora, Fusarium and Ralstonia Diseases of Horticultural and Field Crops (R. Viswanathan)	ICAR	19.49
24	Development of Sugarcane Farm Leaders (SFL) for outscaling sugarcane production and protection technologies in Tamil Nadu (C. Karpagam, P. Murali, D. PuthiraPrathap, T. Rajula Shanthy and V. Venkatasubramanian)	NABARD	3.67

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 following are the research areas under this project:

- 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.
- Fluff supply to various sugarcane research institutes / centres.
- 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.

VARIETAL DEVELOPMENT - SCHEMATIC DIAGRAM



10. PUBLICATIONS

Research papers

- Barnabas, L., R. Ashwin, A. Ramesh Sundar, P. Malathi and R. Viswanathan. 2015. Sugarcane proteomics: An update on current status, challenges and future prospects. *Proteomics 15:* 1658-1670.
- Bhaskaran, A and N.V. Nair. 2014. Challenges and opportunities in sugarcane cultivation under climate change scenario. *Journal of Sugarcane Research* 4 (1): 1-18.
- Chhabra, M. L. and S.K. Pandey. 2015. Impact of climate change on the incidence of insect and disease pests of sugarcane. *Journal of Agroecology and Natural Resource Management* 2 (1): 89.
- Chinnaraja, C. and R. Viswanathan. 2015. Variability in yellow leaf symptom expression caused by the Sugarcane yellow leaf virus and its seasonal influence in sugarcane. *Phytoparasitica* (DOI 10.1007/s12600-015-0468-z).
- Chinnaraja, C., R. Viswanathan, M. Sathyabhama, B. Parameswari, K. Bagyalakshmi, P. Malathi and D. Neelamathi. 2014. Quantification of sugarcane yellow leaf virus in in vitro plantlets and asymptomatic plants of sugarcane by RT-qPCR. *Current Science* 106 (5): 729-734.
- Ganesh Kumar, V., R. Viswanathan, P. Malathi, M. Nandakumar and A. Ramesh Sundar. 2014. Different induction of 3-deoxyanthocyanidin phytoalexins in relation to *Colletotrichum falcatum* resistance in sugarcane. *Sugar Tech* (DOI 10.1007/s12355-014-0334-1).
- Gomathi, R and P. Thandapani. 2014. Influence of salinity stress on growth parameters and yield of sugarcane. *Journal of Pharmacy and Biological Science 9(3):* 4-9.
- Gomathi, R., P.N. Gururaja Rao, K. Chandran and A. Selvi. 2014 Adaptive responses of sugarcane to waterlogging stress – An overview. *Sugar Tech* 15(1): 17–26.
- Hemaprabha G, P.J. Priji, and T.S. Sarath Padmanabhan. 2013. Molecular fingerprinting of recently released notified sugarcane (*Saccharum L.*) varieties using STMS markers. *Journal of Sugarcane Researc*h 3(2): 107-117.
- Karuppaiyan, R., Bakshi Ram, S Ramdiya, Masawwar Ali and M.R. Meena. 2015. The incidence of pokkahboeng in indigenous and exotic sugarcane (*Saccharum officinarum*) clones. *Indian Journal of Agricultural Sciences* 85 (4): 596–601.
- Karuppiayan, R., Bakshi Ram, Pooja, Sukhdev Kumar, Masawwar ALI, M. R. Meena and Ravinder Kumar. 2014. Sugarcane sunburn: An emerging abiotic disorder in sub topical India. *Sugar Tech* (DOI 10.1007/s12355-014-0314-5).
- Kavitha, M., A. Ramesh Sundar, P. Padmanaban, R. Viswanathan and P. Malathi. 2014. Comparative study on early detection of sugarcane smut (*Sporisorium scitamineum*) by Polymerase chain reaction (PCR) and microscopy. *African Journal of Biotechnology* 13(51): 4635-4638.
- Mahesh, P., J. Srikanth and K. Chandran. 2014. Is *Popillia clara* Arrow an occasional visitor of sugarcane crop island in a diverse habitat? Insect Environment 20(2): 50-53.
- Mahesh, P., J. Srikanth, K. Chandran and M. Nisha. 2015. Damage pattern and status of the leaf miner *Aphanisticus aeneus* Kerremans (Coleoptera: Buprestidae) in *Saccharum* spp. *International Journal of Pest Management 61(1)*: 36-46.
- Mahesh, P., J. Srikanth, K. Chandran and M. Nisha. 2015. Preliminary screening of

Saccharum spp. germplasm against pink borer *Sesamia inferens* Walker. *International Sugar Journal* (3): 212-216.

◊ Mahesh, P., J. Srikanth and K. Chandran. 2014. Pattern of pink stem borer *Sesamia inferens* (Walker) incidence in different crop seasons and *Saccharum* spp. *Journal of Sugarcane Research* 4(1): 91-95.

◊ Manimekalai, R., R.O. Mailapravan, G.K. Palliyath, S. Nair, R. Viswanathan and R. Rabindran. 2014. Molecular characterization based on spermidine/putrescine ABC transporter gene of sugarcane grassy shoot (16SrXI), coconut root wilt (16SrXI), aster yellows (16SrI) and brinjal little leaf (16SrVI) phytoplasmas. *Phytopathogenic Mollicutes* 4(1): 16-21.

◊ Mohanraj, K and N.V. Nair. 2014. Evaluation of back cross progenies of intergeneric hybrids involving *Erianthus arundinaceus* for developing sugarcane varieties with diverse genetic base. *Journal of Sugarcane Research* 4 (1): 48-54.

◊ Murali, P and N.V. Nair. 2014. Decadal prospects of global sugar trade – An empirical analysis. *Journal of Sugarcane Research* 2(3): 163-171.

◊ Nagarathinam S., R. Ashwin, A. Ramesh Sundar, P. Malathi and R. Viswanathan. 2014. Molecular profiling of systemic acquired resistance (SAR)-responsive transcripts in sugarcane challenged with *Colletotrichum falcatum*. *Applied Biochemistry and Biotechnology* 174: 2839–2850.

◊ Palaniswami, C., R. Viswanathan, A. Bhaskaran, P. Rakkiyappan and P. Gopalasundaram. 2014. Mapping sugarcane yellow leaf disease affected area using remote sensing technique. *Journal of Sugarcane Research* 4 (1): 55-61.

◊ Pandey, S.K. 2014. Comparative efficacy of some insecticides on early shoot borer (*Chilo infuscatellus*) incidence in sugarcane under subtropical India. *Vegetos* 27(1): 146-148.

◊ Pandey, S.K., R Karuppaiyan, B. Singaravelu, Ravinder Kumar, M R Meena, Bakshi Ram, M L Chhabra and N.V. Nair. 2014. Reaction of sub-tropical, foreign and wild genome introgressed sugarcane hybrids against stalk borer, *Chilo auricilious* Dudgeon. *Vegetos* 27(3): 221-226.

◊ Pandey, S.K. 2014. Effect of nitrogen levels on the incidence of stalk borer (*Chilo auricilius dudgeon*) in sugarcane varieties. *Agricultural Science Digest.* 34(2): 134-136.

◊ Pandey, S.K. 2014. Efficacy of neem products vis-à-vis synthetic insecticides against early shoot borer, *Chilo infuscatellus* Snellen (Crambidae; Lepidoptera) in sugarcane. *Annals of Agri-Bio Research* 19 (3): 444-446.

◊ Pandey, S.K. 2014. Evaluation of artificial diets for rearing of *Corcyra cephalonica* (Stainton) for *Trichogramma* mass production. *Annals of Biology* 30 (3): 526-528.

◊ Pandey, S.K. 2014. Field efficacy of insecticides against top borer, *Scirpophaga excerptalis* Walker infesting sugarcane. *Agric. Sci. Digest* 34(2): 159-160.

◊ Pandey, S.K. and R. Kumar. 2014. Impact analysis of weather factors in relation to early shoot borer (*Chilo infuscatellus* Snellen) incidence in summer planted sugarcane after wheat harvest in subtropics. *Indian Journal of Agricultural Research* 48(3): 227-31.

◊ Pandey, S.K. and M. Singh, 2014. Influence of weather parameters on the population dynamics of black bug, (*Cavelerius sweeti* slater & mugomoto) in sugarcane in Haryana. *Indian Journal of Agricultural Research* 48(3): 199-204.

◊ Pandey, S.K., R. Karuppaiyan, B. Singaravelu, Kumar Ravinder, M.R. Meena, Ram Bakshi, M. L. Chhabra and N.V. Nair. 2014. Reaction

of sub-tropical, foreign and wild genome introgressed sugarcane hybrids against stalk borer, *Chilo auricilius* Dudgeon. Vegetos 27(3): 221-226.

◊ Parameswari B., K. Bagyalakshmi, C. Chinnaraja and R. Viswanathan. 2014. Molecular characterization of Indian sugarcane streak mosaic virus isolates reveals recombination and negative selection in the P1 gene. *Gene* 552: 199–203.

◊ Parasuraman, P., M. Jayachandran, C. Appunu and A. Anna Durai. 2013. Co 99006 - An early season sugarcane variety for north western Tamil Nadu. *Journal of Sugarcane Research* 3(2): 172-175.

◊ Poongothai, M., R. Viswanathan, P. Malathi and A. Ramesh Sundar. 2014. Sugarcane wilt: Pathogen recovery from different tissues and variation in cultural characters. *Sugar* Tech 16: 50-66.

◊ Poongothai, M., R. Viswanathan, P. Malathi and A. Ramesh Sundar. 2014. *Fusarium sacchari* causing sugarcane wilt: variation in morphological characteristics of the pathogen. *International Sugar Journal* 116: 54-63.

◊ Priji, P.J. and G. Hemaprabha. 2015. Sugarcane specific drought responsive candidate genes belonging to ABA dependent pathway identified from basic species clones of *Saccharum* sp. and *Erianthus* sp. *Sugar Tech* 17(2): 130–137.

◊ Rahul, P. R., V. Ganesh Kumar, M. Sathyabhama, R. Viswanathan, A. Ramesh Sundar and P. Malathi. 2015. Characterization and 3D structure prediction of chitinase induced in sugarcane during pathogenesis of *Colletotrichum falcatum*. *Journal of Plant Biochemistry and Biotechnology* 24: 1-8.

◊ Rahul, P. R., V. Ganesh Kumar, R. Viswanathan, R., A. Ramesh Sundar, P. Malathi, C. Naveen Prasanth and P.T. Pratima. 2014. Defense transcriptome analysis of sugarcane and *Colletotrichum falcatum* interaction using host suspension cells and pathogen elicitor. *Sugar Tech* (DOI 10.1007/s12355-014-0356-8).

◊ Rajula Shanthy, T and R. Subramaniam. 2015. Farmers' perspective on integrated nutrient management in sugarcane. *Indian Research Journal of Extension Education* 15(1): 100-106.

◊ Ramalashmi, K., P.T. Prathima, K. Mohanraj and N.V. Nair. 2014. Expression profiling of sucrose metabolizing genes in *Saccharum, Sorghum* and their hybrids. *Applied Biochemistry and Biotechnology* (DOI 10.1007/s12010-014-1048-2).

◊ Ramasubramanian, T., K. Ramaraju and S.K. Pandey. 2015. DNA barcodes for sugarcane Aleyrodids. *International Sugar Journal* 117: 50-55.

◊ Ravinder Kumar, C. Appunu, A. Anna Durai, M.N. Premachandran, V. Raffee Viola, Bakshi Ram, C. Mahadevaiah, M.R.Meena and T. Manjunath. 2014. Genetic confirmation and field performance comparison for yield and quality among advanced generation of *Erianthus arundinaceous, E. bengalensis & Saccharaum sponteneum* cyto-nuclear genome introgressed sugarcane intergeneric hybrids. *Sugar Tech* (DOI 10.1007/s12355-014-0333-2).

◊ Saravanakumar, K., P. Govindaraj, C. Appunu, S. Senthilkumar and Kumar Ravinder. 2014. Analysis of genetic diversity in high biomass producing sugarcane hybrids (*Saccharum* spp. complex) using RAPD and STMS markers. *Indian Journal of Biotechnology* 13 (2): 214-220.

◊ Sathyabhama, M., R. Viswanathan, P. Malathi and A. Ramesh Sundar. 2015. Identification of differentially expressed genes in sugarcane during pathogenesis of *Colletotrichum falcatum* by suppression subtractive hybridization (SSH). *Sugar Tech* (DOI 10.1007/s12355-014-0364-8).

- Senthil Kumar, S., P. Govindaraj and C. Appunu. 2014. Morphological and molecular characterization of high biomass IGH, ISH and *Saccharum* hybrids. *Sugar Tech* (DOI 10.1007/s12355-014-0327-0).
- Singaravelu, B., J. Srikanth, K. Hari, C. Sankaranarayanan, R. Nirmala, M. Meghna, S. Radesh Krishnan and S.M. Mathew. 2013. Prospecting for scarabid specific *Bacillus thuringiensis* cry 8 crystal toxin genes in sugarcane ecosystem of Tamil Nadu, India. *Journal of Sugarcane Research* 3(2): 141-144.
- Sivaraman, K., J. Srikanth, K. Hari, P. Rakkiyappan, C. Sankaranarayanan, A. Ramesh Sundar, N. Somasekhar, B. Sundara, S. Asokan, and S.D. Chandrasekhar. 2013. Sustainability of sugarcane productivity in a long-term organic production system vis-à-vis conventional system. *Journal of Sugarcane Research* 3(2): 130-140.
- Sobhakumari, V.P. 2014. Cytogenetics and performance analysis of pre-breeding hybrids of *Saccharum officinarum* and *Saccharum spontaneum*. *Journal of Sugarcane Research* 4 (1): 33-39.
- Sobhakumari, V.P. and N.V. Nair. 2014. Cytological mechanism of male sterility in intergeneric hybrids of *Sorghum x Saccharum*. *Cytologia* 79 (1): 79-83.
- Sruthy, M.A., J. Ashwin Narayan, P.S. Divya, C. Appunu, M. Chakravarthi, V. Ravichandran, N. Tuteja and N. Subramonian. 2015. Overexpression of EaDREB2 and pyramiding of EaDREB2 with the pea DNA helicase gene (PDH45) enhance drought and salinity tolerance in sugarcane (*Saccharum* spp. hybrid). *Plant Cell Rep* 34: 247-263.
- Sruthy, M. A., J. Ashwin Narayan, P.S. Divya, C. Appunu, M. Chakravarthi, V. Ravichandran, N. Tuteja, and N. Subramonian. 2015. *Erianthus arundinaceus* HSP70 (EaHSP70) overexpression increases drought and salinity tolerance in sugarcane. *Plant Science* 232: 23-34.
- Viswanathan, R. 2013. Status of sugarcane wilt: One hundred years after its occurrence in India. *Journal of Sugarcane Research* 3(2): 86-106.
- Viswanathan, R., C. Chinnaraja, P. Malathi, R. Gomathi, P. Rakkiyappan, D. Neelamathi, and V. Ravichandran. 2014. Impact of Sugarcane yellow leaf virus (ScYLV) infection on physiological efficiency and growth parameters of sugarcane under tropical climatic conditions in India. *Acta Physiologiae Plantarum* 36: 1805–1822.
- Viswanathan, R. 2015. Varietal degeneration in sugarcane and its management in India. Sugar *Tech (DOI:* 10.1007/s12355-015-0369-y).
- Viswanathan, R., M. Poongothai P. Malathi and C. Naveen Prasanth. 2015. Sugarcane wilt: Simulation of pathogenicity through different methods and environments. *International Sugar Journal* 117: 194-201.
- Viswanathan, R., P. Malathi, A. Annadurai, C. Naveen Prasanth and M. Scindiya. 2014. Sudden occurrence of wilt and pokkah boeng in sugarcane and status of resistance in the parental clones in national hybridization garden to these diseases. *Journal of Sugarcane Research* 4(1): 62-81.

Books / Compendiums / Training Manuals

- Gopalasundaram, P., A. Bhaskaran, C. Palaniswami, N. Thiraviam and N.V. Nair. 2014. Status of Centre State Coordination in Agricultural Research, Education & Extension and Proceedings of XXIV Meeting of ICAR Regional Committee No. VIII. May 02 - 03, 2014, Thiruvananthapuram, ICAR-Sugarcane Breeding Institute, Coimbatore. pp.238.
- Gopalasundaram, P., Esther D. Shekinah, A. Bhaskaran and N.V. Nair. 2014. Seminar on

Drought management and improving sugarcane productivity. 16 August 2014, Coimbatore. pp. 70.

◊ Karpagam, C., P. Murali, A. Bhaskaran, T. Rajula Shanthy and D.P. Prathap. 2014. An Inventory of Farmer's Practices for Inclusive development in sugarcane production system. ICAR-Sugarcane Breeding Institute, Coimbatore, ISBN 978-81-926387-7-5. pp.132.

◊ Muthamil Selvan M, Sangeetha, P. Thurkaiannan, I. Muthuval, C. Karpagam and S. Umesh Kanna. 2014. Agriculture (Tamil). Agricultural Scientific Tamil Society. New Delhi, ISBN 978-93-81102-94-7.

◊ Nair N.V., V.A. Amalraj, R. Balakrishnan., A.W. Jebadhas, K.G. Somarajan, C. Jayabose, A.K. Rema Devi, M. Vigneswaran and S. Sekharan. 2014. A catalogue on *Saccharaum* germplasm collection (NATP). ICAR-Sugarcane Breeding Institute, Coimbatore, India, ISBN 978-81-926387-6-8. pp.171.

◊ Prathap, D.P., C. Karpagam and A. Bhaskaran. 2014. Compendium of research articles and status papers. In: 16th meeting of Sugarcane Research and Development Workers of Northern Karnataka. ISBN 0973-8185. pp.123.

◊ Prathap, D.P., C. Karpagam and A. Bhaskaran. 2014. 45th meeting of Sugarcane Research and Development Workers of Tamil Nadu and Pondicherry, ISBN 0973-8185. pp.328.

◊ Premachandran, M.N., C. Palaniswami, J. Srikanth, A. Ramesh Sundar and A. Bhaskaran. 2015. Report on the Potentiality and cane availability in M/s Madras Sugars Ltd., Vengur, Tirukoilur, Tamil Nadu. February 2015. pp.26.

◊ Rajula Shanthy T., N.V. Nair, J.P. Singh and M.G. Joshi. 2014. Sugarcane Agriculture. PRDAG Print, Coimbatore, ISBN 978-81-926387-5-1. pp.211.

◊ Rajula Shanthy, T., Bakshi Ram, M. Krishnan and Y. Kotaiah. 2015. Multidimensional approach to make sugarcane cultivation sustainable. SISSTA & SBI, PRDAG Print, ISBN 978-93-80800-38-7. pp.140.

◊ Rajula Shanthy, T., Bakshi Ram, V. Venkatasubramanian and D.P. Prathap. 2015. Advances in sugarcane cultivation. Extension publication No. 228, PRDAG Print, ISBN 978-93-80800-36-3. pp. 130.

◊ Rajula Shanthy, T., Bakshi Ram, V. Venkatasubramanian and D.P. Prathap. 2015. Sugarcane technologies for increased productivity. PRDAG Print, ISBN 978-93-80800-37-0. pp.136.

◊ Rajula Shanthy, T., Bakshi Ram, V. Venkatasubramanian, D.P. Prathap and C. Karpagam. 2015. Sugarcane technologies. Extension publication No. 232. pp.136.

◊ Rajula Shanthy, T., Bakshi Ram, V. Venkatasubramanian, C. Karpagam and D. P. Prathap. 2014. Scientific sugarcane cultivation. PRDAG Print. ISBN 978-93-808003-5-6. pp.136.

◊ Rajula Shanthy, T., V. Venkatasubramanian, C. Karpagam and N.V. Nair. 2014. Recent technologies for increased sugarcane productivity. PRDAG Print, ISBN 978-93-808002-5-7. pp.312.

◊ Ramasubramanian, T and J. Srikanth. 2015. Insecticides for the management of sugarcane pests in tropical India – an advisory for intelligent use (English). ISBN 978-81-926387-9-9. pp.21.

◊ Ramasubramanian, T. and J. Srikanth. 2015. Insecticides for the management of sugarcane pests in tropical India – An advisory for intelligent use (Tamil). ISBN 978-81-926387-8-2 pp.21.

◊ Singh, A.K., J. Chauhan, K. Vinod, Thampan, T. Rajula Shanthy. 2014. 7th National Extension

Education Congress on Translational research-extension for sustainable small farm development. Sarai Ghat Offset Press, Guwahati. pp.410.

◊ Viswanathan, R., A. Bhaskaran, G. Hemaprabha, T. Ramasubramanian and N.V. Nair. 2014. Proceedings of the Symposium on Bioenergy for sustainable development - The potential role of sugar crops. SSRD & SBI, Coimbatore. pp.298.

Chapters in Books / Training Manuals

◊ Arjun Tayade and P. Geetha. 2014. Conventional and micro-irrigation management in sugarcane. In: Recent technologies for increased sugarcane productivity. Extension publication No. 231, Sugarcane Breeding Institute, Coimbatore. p.136-150.

◊ Arumuganathan, T., Ravindra Naik, S.J.K. Annamalai and T. Rajula Shanthy. 2014. Mechanization in sugarcane farming. In: Recent technologies for increased sugarcane productivity. Extension publication No. 231, Sugarcane Breeding Institute, Coimbatore. p.89-196.

◊ Arumuganathan, T., S.J.K. Annamalai, Ravindra Naik, and T. Rajula Shanthy. 2015. Farm implements and machinery in sugarcane cultivation. In: Sugarcane technologies. Extension publication No. 232, Sugarcane Breeding Institute, Coimbatore. p.113-130.

◊ Bhaskaran, A., C. Palaniswami and P. Gopalasundaram. 2014. Integrated nutrient management in sugarcane. In: Sugarcane Agriculture. ISBN 978-81-926387-5-1. NFCSF & ICAR-SBI. p.89-101.

◊ Chandran, K. 2014. PPV& FRA, 2001. In: Refresher course in Environmental Science, UGC-Academic Staff College, Kannur University, Kerala.

◊ Chandran, K. 2014. Sugarcane genetic resources: Ex-situ conservation and utilization. In: Refresher course in Environmental Science, UGC-Academic Staff College, Kannur University, Kerala.

◊ Geetha, P and Arjun Tayade. 2014. Intercropping in sugarcane. In: Recent technologies for increased sugarcane productivity. Sugarcane Breeding Institute, Coimbatore, ISBN 978-93-808002-5-7. p.154-164.

◊ Hemaprabha G. 2014. Sugarcane varieties suitable to different states. In: Sugarcane Agriculture, ISBN 978-81-926387-5-1. NFCSF & ICAR-SBI. p.31-64.

◊ Jayabose C. 2014. Sugarcane genetic resources. In: Recent technologies for increased sugarcane productivity. Sugarcane Breeding Institute, Coimbatore, ISBN 978-93-808002-5-7. p.204 -212.

◊ Karpagam C, P. Murali, T. Rajula Shanthy and D.P. Prathap. 2014. Documentation of farmers' practices for sustainable sugarcane cultivation (Tamil). In: Agriculture (Tamil). Agricultural Scientific Tamil Society, New Delhi, ISBN: 978-93-81102-94-7. p.66-72.

◊ Karpagam, C., P. Murali, T. Rajula Shanthy and D.P. Pratap. 2014. Yield gap analysis in sugarcane production. In: Recent technologies for increased sugarcane productivity. ISBN 978-93-808002-5-7, PRDAG Print. p.290-294.

◊ Karpagam. C, D.P. Prathap, V. Venkatasubramanian, K. Mohanraj and P. Murali. 2015. New initiative on farmer field school module for out-scaling drip and related technologies in sugarcane production system through farmer participatory action research programme. In: National workshop on Farmers Field School organized by NIPHM and MANAGE, Hyderabad.

◊ Murali, P., C. Karpagam and T. Rajula Shanthy. 2014. Cost of cultivation, cost and return analysis of sugarcane farms. In: Recent technologies for increased sugarcane productivity. ISBN 978-93-808002-5-7, PRDAG Print. p.295-301.

- Murali. P, C. Karpagam. D.P. Prathap and N. Sivaramane. 2014. Input and output supply chain management of sugarcane production. In: Sivaramane, N and Reddy (Eds.) Supply chain management. NAARM, Hyderabad.
- Neelamathi, D. and C. Jayabose. 2014. Micropropagation in sugarcane. In: Recent technologies for increased sugarcane productivity. Sugarcane Breeding Institute, Coimbatore, ISBN 978-93-808002-5-7. p.29-34.
- Palaniswami, C. and A. Bhaskaran. 2014. Management of soil constraints in sugarcane production. In: Sugarcane Agriculture. ISBN 978-81-926387-5-1. NFCSF & ICAR-SBI. p.79 -88.
- Prathap, D.P. 2014. Dealing with drought: Strategies for popularizing drought management technologies in sugarcane. In: Compendium of lead papers presented at the Seminar on Drought management and improving sugarcane productivity, Coimbatore, 16 August 2014. p.59-60.
- Rajula Shanthy T., and C. Karpagam. 2014. Approaches for effective technology transfer in sugarcane. In: Sugarcane Agriculture. PRDAG Print, Coimbatore, ISBN 978-81-926387-5-1. p.166-187.
- Rajula Shanthy, T., 2014. ICT enabled transfer of technology in sugarcane. In: Recent technologies for increased sugarcane productivity. ISBN 978-93-808002-5-7, PRDAG Print. p.102-110.
- Rajula Shanthy, T., 2015. Strategies for transfer of technology in sugarcane agriculture. In: Advances in sugarcane cultivation. Sugarcane Breeding Institute, Coimbatore, ISBN 978-93-80800-36-3. p.100-112.
- Rajula Shanthy, T., V. Venkatasubramaniam, C. Karpagam, P. Murali and C. Jayabose. 2014. Participatory approach in sugarcane development. In: Recent technologies for increased sugarcane productivity. ISBN 978-93-808002-5-7, PRDAG Print. p.165-177.
- Rajula Shanthy, T., V. Venkatasubramanian, C. Karpagam and D.P. Pratap. 2014. Strategies for effective transfer of technology for increased sugarcane productivity. In: Scientific sugarcane cultivation. Sugarcane Breeding Institute, Coimbatore, ISBN 978-93-808003-5-6, PRDAG Print. p.95-107.
- Ramasubramanian, M, D.P. Prathap, N. Anandaraja and S. Sethuraman. 2015. Ensuring participation of trainees in training need by analysis and training evaluation: Evidences of successful methodologies. In: Sontakki, B.S, Venkattakumar, R & Anandaraja, N (Eds.) Conducting an effective and successful training programme. New Delhi, New India Publishing Co.
- Salin, K.P. and J. Srikanth. 2014. Identification of sugarcane pests. In: Recent technologies for increased sugarcane productivity. Sugarcane Breeding Institute, Coimbatore, ISBN 978-93-808002-5-7. p.235-248.
- Srikanth, J. and K.P. Salin. 2014. Biological control of sugarcane pests. In: Recent technologies for increased sugarcane productivity. Sugarcane Breeding Institute, Coimbatore, ISBN 978-93-808002-5-7. p.272-285.
- Venkatasubramanian, V and T. Rajula Shanthy. 2014. Strategies for transfer of sugarcane technologies. In: Recent technologies for increased sugarcane productivity. ISBN 978-93-808002-5-7, PRDAG Print. p.226-234.
- Viswanathan, R. 2015. Integrated management of sugarcane diseases. In: Sugarcane technologies. Extn Publication 232, Sugarcane Breeding Institute, Coimbatore, p.71-83.
- Viswanathan, R., A. Ramesh Sundar, P. Malathi, V. Ganesh Kumar, M. Sathyabhama, M. Muthumeena and P.R. Rahul. 2014.

Molecular understanding of red rot resistance in sugarcane through genomics and proteomics - Review of Plant Pathology (Eds B. Chakraborty, U. Chakraborty), Scientific Publishers (India), Jodhpur. Vol. 6, p.189-214.

Technical/Popular articles

- Anna Durai, A., R. Gomathi and Adhini S. Pazhany. 2014. Physiologically efficient sugarcane parental clone in National Hybridization Garden. SBI News 34(2):2-3.
- Chandran, K. and M. Nisha. 2014. A small story on major activities of the Kannur Centre. Mathrubhumi Channel in Krishi bhoomi. 7 July 2014.
- Gomathi R., S. Vasantha, P.N. Gururaja Rao and T. Rajula Shanthy. 2014. Abiotic stress management in sugarcane (In English). Extension publication No. 229, Sugarcane Breeding Institute (ICAR), Coimbatore.
- Gomathi R., S. Vasantha, P.N. Gururaja Rao and T. Rajula Shanthy. 2014. Abiotic stress management in sugarcane (In Tamil). Extension publication No. 230, Sugarcane Breeding Institute, Coimbatore.
- Gomathi, R. and P.N. Gururaja Rao. 2014. Physiological perspective on ratoonability of sugarcane in tropical India. http://www scribd. com/ 224661890.
- Mahesh, P., J. Srikanth and K. Chandran.2015. Invasive alien insects: causes, consequences and management. Science India 18(3): 24-29.
- Mahesh, P., K. Chandran and J. Srikanth. 2014. How are insects important to humans? Science India 17(7): 6-15.
- Malathi, P., R. Viswanathan and A. Ramesh Sundar. 2014. PCR/Probe based diagnostics of *Colletotrichum falcatum* causing red rot in sugarcane. SBI News 34(3): 4-5.
- Ramasubramanian, T. and C. Karpagam. 2014. Early shoot borer of sugarcane: Problems and prospects. Kisan World 41(9): 19-22.
- Srikanth, J., B. Singaravelu and N. Geetha. 2014. White grub as a pest of sugarcane and its management. SBI Technical Bulletin KV/2014/E/02. Sugarcane Breeding Institute, Coimbatore.-7.
- Vasantha, S., R. Gomathi, Arup Ghosh and C. Brinda. 2014. Improved yield of sugarcane with sea weed saps. SBI News 34(4): 1-3.

Presentations in Conferences/ Symposia/ Seminars/ others

- Adhini S. Pazhany and A. Anna Durai. 2014. Studies on the flowering attributes of rare flowering sugarcane hybrids. National Symposium on Bio-energy for sustainable development - The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.201-202.
- Alarmelu, S., G. Hemaprabha and R.M. Shanthi. 2014. Recurrent selection for yield improvement in sugarcane. National Seminar on Challenges and innovative approaches in crop improvement, Madurai, 16 December 2014. p.184.
- Appunu, C., A. Anna Durai, Ravinder Kumar, G. Hemaprabha, P. Parasuraman, M. Jayachandran, S. Pannerselvam, B. Rajendran and R. Paneerselvam. 2014. Co 0212: A promising high yielding and high quality mid-late maturing sugarcane variety for Tamil Nadu. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p. 204-205.
- Ashitha, M., C. Tamilselvi, B. Hariharan, G.S. Suresha, K. Sivaraman and K. Hari. 2014. Production of sugarcane juice concentrate by lab scale rotary vacuum evaporation. National Seminar on Present status and future strategies for processing and value addition of agricultural

commodities, Ludhiana, 19-20 December 2014. p.172.

- Ashwin, N.M.R., E. Leonard Barnabas, A. Ramesh Sundar, P. Malathi and R. Viswanathan. 2014. Identification of novel pathogen associated molecular patterns (PAMPs) of *Colletotrichum falcatum* using PEAKS7 – a tool for de novo sequencing assisted database search. National Symposium on Bio-energy for sustainable development - The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.239-241.

- Bagyalakshmi, K., B. Parameswari, C. Chinnaraja, S. Brindha and R.Viswanathan. 2014. Complete genome sequence of Indian Sugarcane mosaic virus and its genetic diversity with other country isolates. National Symposium on Bio-energy for sustainable development - The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.229-232.

- Bagyalakshmi, K., B. Parameswari, K. Lakshmi, V. P. Malathi and R. Viswanathan. 2015. Transcient expression study to identify RNA silencing suppressor (RSS) in Sugarcane streak mosaic virus. National Symposium on Challenges and management approaches for crop diseases of national importance –Status and prospects, Madurai, 2-4 February 2015. p.41.

- Bagyalakshmi, K., B. Parameswari, V. G. Malathi and R. Viswanathan. 2014. Identification of conserved domains in the sugarcane viruses responsible for targeting the RNA binding proteins through *in-silico* analysis. National Conference on Recent trends in virology research in the omics era, Coimbatore, 18-20 December 2014. p.106.

- Bhaskaran, A., C. Palaniswami and P. Rakkiyappan. 2014. Yield response of sugarcane variety Co 86032 for sulphur fertilization. National Symposium on National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.206.

- Brindha S., C. Chinnaraja, K. Bagyalakshmi, B. Parameswari, K. Lakshmi, P. Malathi and R. Viswanathan. 2014. Genetic variability and potential recombination events in the P0 gene of Sugarcane yellow leaf virus causing yellow leaf disease in sugarcane. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.232-236.

- Brindha, S., V.G. Malathi and R. Viswanathan. 2014. Characterization of Sugarcane yellow leaf virus-P0 for RSS activity through Agrobacterium-mediated transient expression system. National Conference on Recent trends in virology research in the omics era, Coimbatore, 18-20 December 2014. p.136.

- Elamathi E., P. Malathi, R. Viswanathan and A. Ramesh Sundar. 2014. Differential expression of antifungal proteins during interaction of *Colletotrichum falcatum x Trichoderma* spp. in sugarcane. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.227-229.

- Elamathi E., P. Malathi, R. Viswanathan and A. Ramesh Sundar. 2015. Identification of antifungal metabolites/proteins from *Trichoderma* during interaction with *Colletotrichum falcatum*. National Symposium on Challenges and management approaches for crop diseases of national importance –Status and prospects, Madurai, 2-4 February 2015. p.155.

- Geetha, N., M. Preseetha, K. Hari and K. Subadra Bai. 2014. Combined interaction of species and agrochemicals used in sugarcane on the growth of two species of *Beauveria* and *Metarhizium anisopliae*. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.43.

- Geetha, N., M. Aneesha, K. Hari, M. Preseetha and K. Subadra Bai. 2014. Variation in the germination parameters among ten species of biocontrol- and saprophytic fungi in sugarcane due to pH at different time periods. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.62.
- Gomathi, R., S. Vasantha, P. Govindaraj and T. Manjunatha. 2014. Evaluation of promising sugarcane (AVT) clones for drought tolerance. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.293-294.
- Gopalasundaram, P., C. Palaniswami and A. Bhaskaran. 2014. Soil health management for sustainable sugarcane production. 45th meeting of Sugarcane Research and Development Workers of Tamil Nadu and Pondicherry at Tiruchirappalli, 26-27August 2014. p.141-153.
- Govindaraj, P., S. Parthiban, K. Hari, R. Naik and N. Kotwaliwale. 2014. Non-destructive and simple estimation of fibre content - an aid to energy cane development programme. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.123.
- Hari, K., G.S. Suresha, K. Sivaraman, C. Tamilselvi, B. Hariharan, T. Arumuganathan and P. Govindaraj. 2014. Production and characterization of concentrated products from sugarcane juice by spray, flash and freeze drying. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.181.
- Hemaprabha, G. and N.V. Nair. 2014. Performance of new sugarcane varieties. 16th meeting of Sugarcane Research and Development Workers of Northern Karnataka, Belagavi, 18-19 July 2014. p.75-80.
- Hemaprabha, G. and N.V. Nair. 2014. Performance of new sugarcane varieties. 45th Meeting of Sugarcane Research and Development Workers of Tamil Nadu and Puducherry, Trichy, 26-27 August 2014. p.205-213.
- Hemaprabha, G. and P. Rakkiyappan 2014. Bioethanol production potential of recent elite sugarcane hybrid clones. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.174-176.
- Hemaprabha, G. 2015. Sugarcane varieties suitable for tropical states of India. Seminar on Multidimensional Approach to make sugarcane cultivation sustainable, Coimbatore, 31 January 2015. p.11-24.
- Hemaprabha, G. and S.N. Rahana. 2014. Genetic sources for breeding dual purpose sugarcane clones and special canes for ethanol production. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore. 23-25 June 2014. p.74-75.
- Hemaprabha, G., P.J. Priji and T.S. Sarath Padmanabhan. 2014. Molecular characterization and DNA fingerprinting of elite sugarcane cultivars (*Saccharum spp*). National Seminar on Challenges and innovative approaches in crop improvement, Madurai, 16 December 2014.
- Jayabose.C., T. Arumuganathan, V.A. Amalraj, P. Rakkiyappan, T. Rajula Shanthy and P. Kailappan. 2014. Compressive profile analysis of *Erianthus* clones. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.217-218.
- Jayakumar, V., R. Viswanathan and A. Ramesh Sundar. 2014. Biocontrol of sugarcane red rot disease through production of volatiles by novel endophytic bacteria. National Symposium on

Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.243-244.

◊ Karpagam, C. 2014. Out-scaling farmers' practices for inclusive development- promoting FFS. HRD Training Programme on Farmer Field School at TNAU, Coimbatore, 20-21 November 2014.

◊ Karpagam, C., P. Murali, T. Rajula Shanthy and D.P. Prathap. 2014. Documentation of farmers' practices for sustainable sugarcane cultivation (Tamil). National Symposium on Agricultural Scientific Tamil, Coimbatore.

◊ Karpagam, C., P. Murali, T. Rajula Shanthy, D.P. Prathap and V. Venkatasubramanian. 2014. An innovative taxonomy of farmers' practices for inclusive development in sugarcane production system. National Seminar on Extension management strategies for sustainable agriculture –Opportunities and challenges, Madurai, 12-13 December 2014. p.9.

◊ Karpagam, C., V. Ravichandran, Ravi Kumar Theodore, P. Murali and P. Senthil Kumar. 2014. Impact of drip irrigation in sugarcane, onion and leaf banana – an economic feasibility analysis at farmers' field level. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore. 23-25 June 2014.

◊ Karthigeyan, S., Adhini S. Pazhany, N. Rajendra prasad and M.N. Premachandran. 2014. Seed viability and germination potential in *Saccharum spontaneum* L. germplasm collection. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.216-217.

◊ Kaverinathan K., P. Malathi, R. Viswanathan, A. Ramesh Sundar, M.L. Chhabra and B. Parameswari. 2014. Pathogen variability among *Colletotrichum falcatum* isolates causing sugarcane red rot and impact of climate on disease development. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.222-224.

◊ Leonard Barnabas, E., N.M.R. Ashwin, A. Ramesh Sundar, P. Malathi and R. Viswanathan. 2014. Grass infecting smut fungi - *Ustilago cynodontis* in the vicinity of sugarcane – an intriguing observation and beyond. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.242-243.

◊ Mahesh, P. and J. Srikanth. 2015. Status of pink borer, *Sesamia inferens* resistance in accessions of four *Saccharum* spp. International Conference on Innovative insect management approaches for sustainable agro eco-system, Madurai, 27–30 January 2015. p. 291.

◊ Mahesh, P., J. Srikanth, K. Chandran, M. Nisha and S. Balan. 2014. Leaf miner *Aphanisticus aeneus* Kerremans (Coleoptera: Buprestidae) occurrence in sugarcane germplasm. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p. 249.

◊ Malathi P., R. Viswanathan and A. Ramesh Sundar. 2015. Management of sugarcane red rot by mechanized means of sett treatment. National Symposium on Challenges and management approaches for crop diseases of national importance –Status and prospects, Madurai, 2-4 February 2015. p.303.

◊ Malathi P., R. Viswanathan, A. Ramesh Sundar and C. Naveen Prasanth. 2014. Rapid treatment of sugarcane planting material for the management of major fungal diseases – A new approach. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore. 23-25 June 2014. p.184-186.

- Manjunath, T., Sreenivasa, G. Hemaprabha, R.M. Shanthi, A. Annadurai, K. Mohanraj, and S. Karthigeyan. 2014. Potential parents for breeding high yielding dual purpose sugarcane varieties. National Symposium on bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.209-210.
- Mohanraj, K. and N.V. Nair. 2014. Development and evaluation of back cross hybrids involving *Erianthus* for agronomically important trait. 3rd International Conference on Agriculture & Horticulture, Hyderabad, 27-29 October 2014. p.2-4.
- Murali, P., A. Bhaskaran, C. Karpagam, K. Hari and D.P. Prathap. 2014. Carbon sequestration and CO_2 mitigation through sugarcane production system - An empirical analysis. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014.
- Naik, R., P. Govindaraj, S. Parthiban, K. Hari and N. Kotwaliwale. 2015. Development of digital penetrometer for field estimation of fibre content in sugarcane. 49th Annual convention of ISAE and Symposium on Engineering solutions for sustainable agriculture and food processing, Ludhiana, 23 – 25 February 2015. p.16.
- Nandakumar, M., R. Viswanathan, P. Malathi and A. Ramesh Sundar. 2014. WRKY transcription factor in sugarcane defence against *Colletotrichum falcatum*. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.237-239.
- Naveen Prasanth C., R. Viswanathan, P. Malathi and A. Ramesh Sundar. 2014. Screening the pathogenome – insight on pathogen mechanism from expressed transcripts and genome of Colletotrichum falcatum. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.195-197.
- Neelamathi, D. and N. Rajendra Prasad. 2014. Sugarcane seed nursery programme. 45th Meeting of Sugarcane Research and Development Workers of Tamil Nadu and Puduchery, Trichy. 26-27 August 2014.
- Nisha, M., Surabhi Ramesh and K. Chandran. 2014. *In-vitro* multiplication and conservation studies on sugarcane germplasm with ABA as growth retardant. National Seminar on New horizons and challenges in biotechnology and bioinformatics, Kasaragod, 9-10 October 2014. p.52-53.
- Nisha, M., A. Thasneem and K. Chandran. 2014. Genetic diversity analysis of red fleshed *Saccharum robustum* clones using SSR markers. National Seminar on New horizons and challenges in biotechnology and bioinformatics, Kasaragod, 9-10 October 2014. p.94-95.
- Palaniswami, C., R. Viswanathan, A. Bhaskaran, P. Rakkiyappan and Gopalasundaram. P 2014. Optimizing fertilizer inputs to sugarcane using GIS based precision farming tools. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.183-184.
- Rahana, P., K. Chandran and M. Nisha. 2014. Genotypic variation for indirect regeneration in red fleshed *Saccharum robustum*. New horizons and challenges in biotechnology and bioinformatics, Kasaragod, 9-10 October 2014. p.56-57.
- Rajula Shanthy, T. 2014. Approaches for effectual dissemination of technologies for sustained sugarcane productivity. 7th National Extension Education Congress on Translational research-extension for sustainable small farm development, Shillong, 8-11 November 2014. p.145.
- Rajula Shanthy, T. and C. Jitendra. 2014. Translating research outcomes into action for sustained agricultural productivity. 7th National

Extension Education Congress on Translational research-extension for sustainable small farm development, Shillong. 8-11 November 2014. p. 11-14.

◊ Rajula Shanthy, T., P. William Antony and C. Karpagam. 2014. Mechanization of sugarcane harvesting: A socio-economic assessment. 73rd Annual Convention of STAI, Bengaluru. 9-11 September 2014.

◊ Rajula Shanthy, T., R. Subramanian, C. Karpagam, A. Bhaskaran and C. Jayabose. 2014. Integrated nutrient management in sugarcane – A performance analysis. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.199-200.

◊ Ramasubramanian, T., K. Ramaraju and S.K. Pandey. 2014. DNA Barcode of *Sesamia inferens*. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p. 192-194.

◊ Ramasubramanian, T., K. Ramaraju and S.K. Pandey. 2015. DNA Barcode of *Melanaphis sacchari*. International symposium on New perspectives in modern biotechnology, Puducherry, 23-25 March 2015. p.26.

◊ Ramasubramanian, T., N. Geetha, B. Ramanujam and G. Santhalakshmi. 2014. Endophytic-*Beauveria bassiana* - An ideal candidate for managing the internode borer of sugarcane. 73rd Annual Convention of Sugar Technologists' Association of India, Bengaluru. 9-11 September 2014. p.192-194.

◊ Ramasubramanian, T. 2015. An insight into molecular toxicology of insecticide resistance. International Conference on Innovative insect management approaches for sustainable agro ecosystem, Madurai, 27-30 January 2015. p.426-427.

◊ Ramesh Sundar, A., E.L. Barnabas, N.M.R. Ashwin, P. Malathi and R. Viswanathan. 2015. Secretomics-based investigations to unravel plant-pathogen interactions in sugarcane. National Symposium on Understanding host-pathogen interaction through science of omics, Kozhikode, 16-17 March 2015. p.107.

◊ Ramesh Sundar, A., E.L. Barnabas, R. Viswanathan and P. Malathi. 2015. Understanding the enigma of sugarcane – *Sporisorium scietamineum* interaction – a paradigm shift. National Symposium on Challenges and management approaches for crop diseases of national importance – status and prospects, Madurai, 2-4 February 2015. p.24.

◊ Sarath Padmanabhan, T.S. and G. Hemaprabha. 2014. Drought specific candidate gene markers for introgression breeding using *Saccharum spontaneum* and *Erianthus* spp. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.134-135.

◊ Sankaranarayanan, C., B. Singaravelu and M. Rajeshkumar. 2014. Synergistic effect of insecticide imidacloprid and entomopathogenic nematodes against white grub *Holotrichia serrata* on sugarcane. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p. 246.

◊ Sankaranarayanan, C. and B. Singaravelu. 2014. Bio-efficacy of entomopathogenic nematode *Heterorhabditis indica* against different instars of white grub *Holotrichia serrata* infecting sugarcane. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.247

◊ Scindiya, M., P. Malathi, R. Viswanathan and A. Ramesh Sundar. 2014. Characterization

of pathogenicity genes in *Colletotrichum falcatum* causing red rot in sugarcane. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops at Coimbatore. 23-25 June 2014. p.224-226.

◊ Scindiya M., P. Malathi, R. Viswanathan and A. Ramesh Sundar. 2015. Pathogencity gene homologs in red rot pathogen *Colletotrichum falcatum*. National Symposium on Challenges and management approaches for crop diseases of national importance –Status and prospects, Madurai, 2-4 February 2015. p.34.

◊ Selvi, A., K. Devi, A.S. Anu and N.V. Nair. 2014. Efficient SSR based markers for sugarcane varietal improvement programs. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014.

◊ Selvi, A., R. Gomathi, K. Devi, P.T. Prathima, and R. Manimekalai. 2014. Changes in gene expression in sugarcane under water deficit conditions. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.248.

◊ Shanthi, R.M. and G. Hemaprabha. 2014. Mining genic SSRs for sucrose metabolic pathway enzymes for sugarcane improvement. National Seminar on Challenges and innovative approaches for crop improvement, Madurai, 16 December 2014. p.210.

◊ Singaravelu, B., C. Sankaranarayanan, J. Srikanth, K. Hari and R. Nirmala. 2014. Molecular detection of indigenous strains of nematicidal *Bacillus thuringiensis* for management of plant parasitic nematodes in sugarcane. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore. 23-25 June 2014.

◊ Sobhakumari, V.P., C. Jayabose and V.A. Amalraj. 2014. Exploration of intraspecific cytomorphological diversity in *S. spontaneum* from Himachal Pradesh and Uttaranchal, India. International Conference on Green technologies for sustainable growth of sugar and integrated industries in developing countries, Nanning, China, 25-28 November 2014. p.107-108.

◊ Sobhakumari, V. P. 2015. Cytotype diversity in *S. spontaneum* population of North East region of India. Indian genetics congress, Chennai. 4-6 March 2015. p.111.

◊ Srikanth, J. 2014. Sugarcane pests and their management. 45th meeting of Sugarcane Research and Development Workers of Tamil Nadu and Puducherry, Trichy, 26-27 August 2014. p.22-32.

◊ Suresha, G.S., K. Lakshmi, S.C. Divya, S. Parthiban, P. Govindaraj and K. Hari. 2014. Profiling high biomass sugarcane clones for cellulose and lignin content. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.130.

◊ Suresha, G.S., M. Naveena Rani, K. Hari and C. Appunu. 2014. Isolation and characterization of cellulases and hemicellulases producing bacterial from insect sources. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.117.

◊ Venkataramana, S. 2014. Impact of drought on sugarcane growth and productivity. Seminar on Drought management and improving sugarcane productivity, Coimbatore, 16 August 2014. p.17-23.

◊ Venkataramana, S. and A. Vasantha. 2014. Energy production capabilities of sugarcane varieties at different growth phases. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.298.

- Viswanathan, R. 2014. Managing sugarcane diseases under drought. Seminar on Drought management and improving sugarcane productivity, Coimbatore, 16 August 2014. p.41-54.
- Viswanathan, R. 2014. Sugarcane pathology in India: Application of molecular techniques to understand pathogen variability, disease diagnosis and management. National Seminar on Integrated crop management in sugarcane for increasing cane, sugar and jaggery yields, Visakhapatnam, 5-6 December 2014. p.139-152.
- Viswanathan, R. and R. Karuppaiah. 2014. Characterization of variation in Sugarcane bacilliform virus (SCBV) associated with leaf fleck of sugarcane in India. National Conference on Recent trends in virology research in the omics era, Coimbatore, 18-20 December 2014. p.104.
- Viswanathan, R., C. Chinnaraja, R. Dheepa, V. Ganesh Kumar and P. Malathi. 2014. Management of varietal degeneration in sugarcane through tissue culture combined with virus testing. National Symposium on Bio-energy for sustainable development –The potential role of sugar crops, Coimbatore, 23-25 June 2014. p.187-189.
- Viswanathan, R., M. Poongothai, P. Malathi, A. Ramesh Sundar, M. Scindiya, M.L. Chhabra and C.G. Balaji. 2015. Characterization of intriguing pathogen *Fusarium sacchari* causing wilt in sugarcane. National Symposium on Challenges and management approaches for crop diseases of national importance –Status and prospects, Madurai, 2-4 February 2015. p.49.
- Viswanathan, R., R. Jayanthi and C. Sankaranarayanan. 2015. Need for a paradigm shift in sugarcane and pest management. Seminar on Multidimensional approach to make sugarcane cultivation sustainable, Coimbatore, 31 January 2015. p.89-108.
- Viswanathan, R., M. Nandakumar, V. Ganesh Kumar, A. Ramesh Sundar and P. Malathi. 2015. Host-pathogen interaction in sugarcane - red rot pathogen: Role of 3-deoxyanthocyanidin biosynthesis pathway enzymes. National Symposium on Understanding host-pathogen interaction through science of omics, Kozhikode, 16-17 March 2015. p.97.

11. RESEARCH PROGRAMMES

- Breeding superior sugarcane varieties of different maturity with improved cane yield, quality and resistance to biotic and abiotic stresses
- Basic and strategic researches for sugarcane varietal improvement
- Sugarcane germplasm: Collection, maintenance, characterization, evaluation, documentation and utilisation
- Improving productivity of promising sugarcane varieties by integrated, cost effective and sustainable crop management technologies
- Physiological investigations on growth productivity and flowering in sugarcane
- Studies on the effect of certain soil conditions & fertilisers on nutrient uptake, yield and quality of sugarcane
- Mechanization to improve sugarcane productivity and reduce drudgery
- Studies on host pathogen relationship and management of sugarcane diseases
- Host plant resistance and behavioural studies of sugarcane pests

- Biological control of sugarcane pests
- Chemical control of sugarcane pests
- Basic and applied studies of sugarcane phytonematodes and entomopathogenic nematodes
- Development of information systems and statistical models for sugarcane research
- Economic analysis of sugarcane production systems and sugar industry
- Transfer of technologies
- Development of sugarcane varieties as well as crop production and protection technologies for the North Western Zone

12. CONSULTANCY, PATENTS, COMMERCIALIZATION OF TECHNOLOGIES

- A Contract Service for 'Evaluation of Fipronil 0.6% GR insecticide against early shoot borer and termites' for two crop seasons during 2013-2015 sponsored by Bayer Crop Science Ltd. (Funds received: Rs. 8,46,925)
- A Contract Service for 'Evaluation of Imidacloprid 40% + Fipronil 40%-80WG (RM) against termites and early shoot borer in sugarcane' for two crop seasons during 2014-2016 sponsored by Bayer Crop Science Ltd. (Funds received: Rs.7,44,273)

13. EVENTS

Sl. No.	Particulars	Dates
Coimbatore		
1	18th AIEE for admission to UG and PG programs in Agriculture and allied subjects	12-13 April 2014
2	XXIV meeting of Regional Committee No.VIII at CTCRI, Thiruvananthapuram	2-3 May 2014
3	Symposium on Bioenergy for sustainable development-The Potential role of Sugar Crops at Coimbatore	23-25 June 2014
4	16th meeting of sugarcane R&D workers of Northern Karnataka at Belagavi	15-16 July 2014
5	Agri - Intex 2014 at CODISSIA Hall, Coimbatore	18-21 July 2014
6	Research Advisory Committee meeting	26 July 2014
7	Team visit of scientists for assessing drought situation in Tamil Nadu and Karnataka	July – August 2014
8	Seminar on Drought management and improving sugarcane productivity at Coimbatore	16 August 2014
9	45th meeting of Sugarcane R&D Workers of Tami Nadu and Puducherry at Trichy	26-27 August 2014
10	Hindi Day	9 September 2014
11	Institute Research Council meeting	15-17 & 25 September 2014
12	ICAR South Zone Sports Tournament at ICAR-IIHR, Bengaluru	13-17 October 2014
13	Institute Bio-Safety Committee meeting	10 December 2014

14	Institute Industry Interface meeting	10 December 2014
15	Seminar on Multidimensional approach to make sugarcane cultivation sustainable	31 January 2015
16	National Science Day	28 February 2015
17	Foundation Day of the Institute	23 March 2015
Karnal		
18	*Ganna Vichar Gosthi* at Karnal Cooperative Sugar Mills, Karnal	04 October 2014
19	*Krishak Krishi Gosthi* during *Kharif Kisan Mela* organized by CSSRI, Karnal at Village Siwanmal, Jind District, Haryana	22 October 2014
20	District level *Kisan Mela* organized by Haryana Agricultural Department at NDRI, Karnal	27 November 2014
21	*Kisan Gosthi*–cum-exhibition organized by IIFSR, Modipuram in village Rasulpur Jattan and Barwala, Distt. Muzaffaranagar (UP)	13 & 14 December 2014
22	Kisan Vigyan Samagam organized by IISR, Lucknow at PDFSR, Modipuram (UP)	23 January 2015
23	ASC India Expo- 2015 in the XII Agricultural Science Congress at NDRI, Karnal	3-6 February 2015
24	National Dairy *Mela*-2015 at NDRI, Karnal	25-27 February 2015
25	Field day on 'Wheat cultivation in salt affected areas' at village Mundri, Kaithal organized at CSSRI, Karnal	28 February 2015
26	*Rabi Kisan Mela* at CSSRI, Karnal	9 March 2015
27	Pusa *Krishi Vigyan Mela* at IARI, New Delhi	10-12 March 2015

National Symposium on Bio-energy for sustainable development-the potential role of sugar crops

A three days 'National Symposium on Bio-energy for sustainable development – The potential role of sugar crops' was organized by Sugarcane Breeding Institute in association with the Society for Sugarcane Research and Development (SSRD) during 23-25 June 2014 at Coimbatore. About 150 delegates representing ICAR, CSIR, State Universities, private research organizations, industry and government departments participated in the symposium and shared their experiences.

Dr. N.V. Nair, Director, SBI and President SSRD chaired the inaugural function. Dr. K. Ramasamy, Vice Chancellor, TNAU was the Chief Guest. Dr. M. Manickam, Vice Chairman of Sakthi sugars Ltd., Dr. S.V. Balasubramaniam, Chairman and Managing Director, Bannari Amman Sugars Ltd., and Dr. G.S.C. Rao, President, Sugar Technologists Association of India (STAI) were the Guests of Honour (Fig. 86 & 87).

Fig. 86 Inauguration of the National Symposium

Fig. 87 Release of Symposium Proceedings

The two days deliberations were conducted in six sessions in which 41 oral presentations were made. Two poster sessions were held in which 87 posters were displayed. The sessions included policy issues in bio-energy sector, bio-fuels - present status and future prospects, advances in biomass research, process optimization and bioengineering of sugar crops, carbon footprints and green energy initiatives and sugar crops - looking beyond.

On the third day, the delegates were taken to Tamil Nadu Newsprints & Paper Limited (TNPL), Pugalur to see the recent development in paper making process using sugarcane bagasse.

National Seminar by NFCSF

A National Seminar on 'Advances in sugarcane agriculture' was organized for the National Federation of Cooperative Sugar Factories (NFCSF), New Delhi during 15-17 July 2014 (Fig. 88 & 89). The Seminar was inaugurated by Shri Ishwarlal G Patel, Chairman, Shree Chalthan Sugars, Gujarat. Forty five delegates from Maharashtra, Gujarat, Uttar Pradesh, Tamil Nadu, Haryana and New Delhi participated. A book on 'Sugarcane Agriculture' was released during the Inaugural Session. Shri M.G. Joshi, Managing Director, NFCSF, New Delhi welcomed the gathering and spoke on the initiatives taken by the Federation for increasing cane productivity. Dr. J.P. Singh, Chief Cane Adviser, National Federation of Cooperative Sugar Factories, New Delhi proposed Vote of Thanks.

Fig. 88. Release of Seminar Proceedings

Fig. 89. View of audience

Joint Seminar by SISSTA

A one-day seminar on 'Multidimensional approach to make sugarcane cultivation sustainable' was collaboratively organized by the South Indian Sugarcane & Sugar Technologists Association' (SISSTA) and ICAR-SBI on 31 January 2015 (Fig. 90 & 91). Dr. Bakshi Ram, Director, ICAR-SBI inaugurated the Seminar and Shri N Prabhakar, President, SISSTA welcomed the gathering. Shri K. Nagendran, Special Director (Cane),

Fig. 90. Seminar in progress

Fig. 91. Inauguration of exhibition

M/s. Thiru Arooran Sugars Ltd., delivered the Keynote Address followed by Special Address by Shri M Krishnan, Senior Vice President, M/s. Rajshree Sugars. Ninety five delegates from Andhra Pradesh, Telangana, Karnataka and Tamil Nadu participated. Nine invited papers were deliberated. Smt. R Indumathi, Managing Director of Amaravathi Coop Sugar Mills Ltd. inaugurated the exhibition, where in eight firms exhibited their products and services.

Karnal

A brain storming session on 'Role of newly released sugarcane varieties in the improvement of sugar recovery in Haryana' was organized for the cane development officials of sugar mills on 17 December 2014 with the participation of representatives of nine cooperative sugar mills and three private/ HAFED sugar mills.

Tribal Sub Plan

Tribal Sub Plan was implemented in the institute to ensure direct benefits to families belonging to Scheduled Tribes in two tribal villages *viz*., Vellamari village, Agali panchayat, Mannarkad taluk, Palakkad district and Attukkal village, Thondamuthur, Coimbatore district with emphasis on mechanization and horticultural interventions respectively. Fascinated by the response of the villagers in Attukkal, it was aimed to create a 'Sustainable Horticultural Village'. With 61 families settled in 54 houses in an area of around two acres in the foothills, this village was found best suited for interventions in terms of horticultural crops and

Fig. 92. Dr Bakshi Ram, Director, SBI planting coconut saplings

bring nutritional security. The responsive attitude of the tribal people "Irulas" in this village was the key motivating factor.

The tiny village was made into a horticulture hub by planting 350 seedlings of coconut, nerium, sapota, mosambi, curry leaf, acid lime, custard apple, jasmine, guava, betel nut, gooseberry and pomegranate and well protected with bamboo

Fig. 93. A view of tribal people

Fig. 94. Project Village Attukkal

cages. Double potted fuel efficient chulahs were also provided to interested families as a drudgery reduction measure for women. This project is being implemented through participatory approach mode with the active participation of the tribal villagers. The programme was formally inaugurated by the Director, SBI on 20 March 2015 (Fig. 92-94).

Swachh Bharat Abhiyan

To launch *Swachh Bharat Abhiyan* (National Sanitation Campaign), program at the institute, a Parthenium Eradication Campaign was conducted in the institute main campus on 29 December 2014 (Fig. 95 & 96). Ten teams were formed for this purpose comprising all categories of staff with all Heads of Divisions and Sections as team leaders. A Human Chain was formed in the institute on 1 January 2015 to reiterate unity in this cause. This was followed by Cleanliness Drive at the institute on 30 January 2015 (Fig. 97), Awareness programme at the institute on 28 February 2015 and an Awareness campaign at Attukkal village on 20 March 2015 (Fig. 98).

Fig. 95. Dr Bakshi Ram, Director, SBI addressing the staff

Fig. 96. Parthenium eradication in the main campus

Fig. 97. Cleanliness Drive at the campus

Fig. 98. Swachch Bharat campaign at Attukkal tribal village in Coimbatore

At SBI RC, Agali *Swacch Bharat Abhiyaan* was implemented on 27 December 2014 by Dr. Bakshi Ram, Director, wherein he briefed the staff on the activities to be undertaken at Agali Centre.

Fig. 99. Dr. Bakshi Ram, Director briefing Swacch Bharat Abhiyaan at Agali Centre

Fig. 100. Parthenium & Lantana eradication programme at Agali

This was followed by a Parthenium and Lantana weeds eradication programme with the voluntary participation of tribal villagers (Fig 99 & 100).

Hindi Activities

Hindi Day

Hindi Day was organized in the institute on 9 September 2014. Shri Jatin Kishore, 2nd Commandant, 105 Battalion Rapid Action Force, Coimbatore was the Chief Guest for the occasion (Fig. 101). Various competitions were conducted and the winners were awarded.

Fig. 101. Hindi Day celebration

Hindi Workshop

Four Hindi workshops were organized during the year. The first Hindi workshop was conducted on 26 June 2014. Shri Kannadasa, Assistant Director (Hindi), Town Official Language Implementation Committee was the Chief Guest and he spoke on the importance of Hindi as an official language.

The second Hindi Workshop was conducted on 1 October 2014. Dr. Ganesan, Head of Department, Nehru Arts and Science College, Coimbatore, Senior Hindi Translator, BSNL, Coimbatore was the Chief Guest and he spoke on Noting and drafting in Hindi and the importance of Hindi.

The third Hindi Workshop of the year was conducted on 11 December 2014. Smt Indira Aravindan, Senior Hindi Translator, BSNL, Coimbatore was the Chief Guest and she spoke on Noting and drafting in Hindi (Fig. 102).

Fig. 102. Hindi Workshop in progress

The fourth Hindi Workshop of the year was conducted on 27 March 2015. Smt Purnima, Senior Hindi Translator, ESI Corporation, Coimbatore was the Chief Guest and she spoke on Noting and drafting in Hindi.

Hindi Fortnight

Hindi fortnight was organized at SBI-RC, Karnal during 14-29 September 2014. Competitions were held for different categories of staff of SBI, RC

Fig. 103. Hindi Phakwara Valedictory Function and Urdu Kavi Sammelan in progress

Karnal and other ICAR sister institutes in karnal and winners were awarded.

On the eve of valedictory day of Hindi *Phakwara, Akhil Bhartiye Hindi – Urdu Kavi sammelan* was organized in collaboration with Haryana Hindi-Urdu Academy, Govt, of Haryana on 29 September 2014. Dr. D.K. Sharma, Director, CSSRI, Karnal was the chief guest (Fig. 103).

14. COMMITTEES

Research Advisory Committee meeting

The 20th Research Advisory Committee (RAC) meeting of the Institute was held at Coimbatore on 26 July 2014. Dr. P.L. Gautam, Former Chairman, PPV & FRA, Govt. of India and Chairman, RAC presided over the meeting (Fig. 104). The members including Dr. V.P. Singh, Dr. H.E. Shashidhar, Dr. R. Samiyappan, Dr. J. Vasanthakumar, Dr. N.V. Nair, Director, SBI, Dr. R. Viswanathan, Member Secretary and scientists of the institute participated in the meeting. The recommendations include:

- In addition to cane yield and sugar, focus should be given on superior varieties of sugarcane with multi-ratooning ability, low input requirement, and resistance to biotic and abiotic stresses. Ethanol yield from the varieties also needs to be assessed. Phenotyping of sugarcane germplasm for tolerance to cold/high temperature, salinity and drought is to be completed in time bound manner. Further, concerted efforts are to be made to isolate and validate genes for these abiotic traits.
- Currently, the institute evaluates selected populations in factory areas in coastal Andhra Pradesh. Since there is dearth of varieties for the region, a testing facility for evaluating segregating populations to identify location specific varieties for coastal region may be explored.
- In genetic transformation in sugarcane, more transgenic events have to be generated to develop transgenics for red rot and borer resistance in sugarcane. Potential candidate genes may also be identified for these traits.
- YLD has assumed serious proportion in different parts of the country. Hence, a new thrust has to be given on identifying sources of resistance to YLD in parental population. The identified resistant parents have to be effectively utilized in breeding programmes. The institute has made a headway in producing disease free seed material through tissue culture. The approach should help in reviving degenerated varieties and the technology needs to be popularized across the states to counter varietal degeneration.
- Long term experiments have revealed definite impact of climate change in sugarcane. RAC recommends initiation of an inter-disciplinary programme to assess the impact of climate change on sugarcane and its management.
- To augment sugarcane production and productivity, root studies are important. RAC recommends a detailed study on root architecture and its rate of growth in relation to shoot. Similarly RAC recommends detailed studies on soil carbon sequestration in sugarcane ecosystem to address soil health and climate change implications with more focus on the use of new tools such as remote sensing, precision farming and decision support system for effective management of natural resources. RAC also recommends developing nano-technology based smart delivery system for nutrients / other in-puts and also to develop smart sensors to detect biotic and abiotic constraints.
- Pathology team has generated huge volume of genomic and transcriptomic data on red rot pathogen and red rot resistance in sugarcane through next generation sequencing. The data may be harnessed effectively to identify candidate genes for disease resistance and manipulation of pathogenicity genes through genetic engineering.

Fig. 104. RAC meeting in progress

- RAC recommends detailed studies on the use of RNAi approach to address varietal degeneration caused by the viral pathogens in sugarcane. Developing vectors with specific hairpin constructs should enable stable transformants in sugarcane to nullify viral multiplication in sugarcane.
- Comprehensive booklets on organic sugarcane cultivation and distribution of existing and emerging diseases, nematodes and pests of sugarcane may be brought out for the benefit of farmers and other stakeholders. The RAC recommends initiation of action research project by the extension scientists based on the ongoing survey based studies.

Institute Research Council meeting

The Institute Research Council meeting was conducted during 15-17 and 25 September 2014. The progress of the ongoing research projects was reviewed and 17 new projects were approved for implementation in the ensuing year.

Co 0238 - A popular variety in sub-tropical India

Co 86032 - A popular variety in tropical India

15. SCIENTIFIC PARTICIPATION

Programme	Participant(s)	
Annual General Body Meeting of Karnal Cooperative Sugar Mills Ltd., Karnal on 9 April 2014	S. K. Pandey M. L. Chhabra	
International Conference and Expo on Renewable energy held at Chennai during 12-13 June 2014	P. Govindaraj	
Symposium on Bioenergy for sustainable development-The potential role of sugar crops at Coimbatore during 23-25 June 2014	N.V. Nair R. Viswanathan M.N.Premachandran P. Gopalasundaram G. Hemaprabha N. Rajendra Prasad R.M. Shanthi S. Alarmelu P. Govindaraj A. Selvi V.P. Sobhakumari S. Kathigeyan A. Suganya R. Karuppayyan A. Annadurai C. Jayabose C. Appunu K. Mohanraj R. Manimekalai Adhini.S.Pazhani P.T. Prathima S.N. Rahana K. Lakshmi T. Manjunatha S. Venkataramana P.N. Gururaja Rao K. Sivaraman	C. Palanisamy K. Hari S. Vasantha A. Bhaskaran R. Gomathi A.S. Tayade P. Geetha G.S. Suresha T. Arumuganathan A. Ramesh Sundar P. Malathi V. Jayakumar K.P. Salin J Srikanth N. Geetha B. Singaravelu C. Sankaranarayanan T. Ramasubramaniam P. Mahesh M. Punithavalli R. Balakrishnan P. Murali T. Rajula Shanthy D. Puthira Prathap C. Karpagam S.K. Pandey
16th meeting of sugarcane R&D workers of Northern Karnataka at Belagavi during 15-16 July 2014	N.V. Nair R. Viswanathan P.Gopalasundaram G. Hemaprabha N. Rajendra Prasad P.Govindaraj J. Srikanth D. Puthira Prathap A. Bhaskaran	

Seminar on Intellectual Property Rights & Biodiversity organized by Andhra Pradesh Technology Development and Promotion Centre and Confederation of Indian Industry at Chennai on 18 August 2014	S. Karthikeyan Adhini S Pazhany
National Seminar on Sustainability and profitability of coconut, arecanut and cocoa farming – Technological advances and way forward at CPCRI, Kasaragod during 22-23 August 2014	P. Gopalasundaram C. Palaniswami R. Dhanapal
National Seminar of Agricultural Scientific Tamil Society at Tamil Nadu Agricultural University, Coimbatore on 23 August 2014	A. Suganya K. Mohanraj T. Arumuganathan
45th Meeting of sugarcane R&D workshop of Tamil Nadu & Puthuchery at Tiruchirapalli during 26-27 August 2014	N.V. Nair P. Gopalasundaram G. Hemaprabha J. Srikanth P. Govindaraj D. Neelamathi D. PuthiraPrathap
Seminar on Sugarcane production and value addition technology at ZARS, Mandya on 30 August 2014	K. Sivaraman P. Govindaraj
Seminar on Parthenium – A scourge to ecosystem: awareness and management at CSSRI, Karnal on 6 September 2014	Ravinder Kumar M. R. Meena
73rd Annual Convention of STAI at Bengaluru at NIMHANS Convention Centre, Bengaluru during 9-11 September 2014	T. Rajula Shanthy R. Karuppaiyan T. Ramasubramanian V.P. Sobhakumari
ASRB Selection Committee meetings on 11 & 24 September 2014	N. V. Nair
International conference on Biosciences – State of art advances at Kerala during 11-12 September 2014	P. Govindaraj
Meeting for Coding of NIVT trial entries of wheat at IIWBR, Karnal on 8 October 2014	S. K. Pandey
Annual Meeting cum Workshop of the Zonal Technology Management Committee organized by CIFT, Cochin at IIHR, Bangalore during 9-10 October 2014	M.N. Premachandran K. Hari
National Seminar on New horizons and challenges in Biotechnology and Bioinformatics held at CPCRI, Kasaragod during 9-10 October 2014	R. Viswanathan

Meeting on Monitoring of cane development loans granted from Sugar Development Fund held at Krishi Bhawan, New Delhi on 10 October 2014	R. Viswanathan
ICAR Institutes -SAUs - Development & Stakeholders Interface on Farmers and Industries in Agricultural Growth at NDRI, Karnal on 18 October 2014.	S.K. Pandey M.L. Chhabra Ravinder Kumar M.R. Meena
3rd International Conference on Agricultural & Horticultural science at Hyderabad on 27-29 October 2014	K. Mohanraj
Workshop on Open Access to Agricultural knowledge for growth and development at NAARM, Hyderabad during 29-30 October 2014	R. Balakrishnan
Rabi Kisan Mela organized by Indian Institute of Wheat and Barley Research, Karnal on 30 October 2014	S.K. Pandey M.L. Chhabra M. R. Meena
30th AICRP Biennial Workshop on Sugarcane held at IISR, Lucknow during 1-2 November 2014	Bakshi Ram R. Viswanathan M.N. Premachandran G. Hemaprabha P. Govindaraj R.M. Shanthi A. Anna Durai S.K. Pandey M.L. Chhabra Ravinder Kumar
7th National Extension Education Congress at Umiam, Meghalaya during 8-11 November 2014	T. Rajula Shanthy
Meeting of Director's of Crop Science Division for discussion on Vision 2050 and prioritization of Institute's projects during 9-12 November 2014	Bakshi Ram
XXIII meeting of the ICAR Regional Committee V at PAU, Ludhiana during 14-15 November 2014	Neeraj Kulshreshtha
7th Brazilian meeting on Induction of Plant Resistance to Pathogens at the State University of Maringa-Maringa, Parana, Brazil during 19-21 November 2014	A. Ramesh Sundar
State Varietal Release Committee meeting of Tamil Nadu held at the Secretariat, Chennai on 21 November 2014	M.N. Premachandran C. Appunu
Midterm review meeting of RFD 2014-15 of CS Division Institutes at New Delhi on 21 November 2014	C. Palaniswami

5th IAPSIT International Conference on Green Technologies for sustainable growth of sugar & integrated industries in developing countries (IS 2014) at Nanning, China during 25-28 November 2014	T. Rajula Shanthy V.P. Sobhakumari
District level *Kisan Mela* organized by Haryana Agricultural Department at NDRI, Karnal on 27 November 2014	Neeraj Kulshreshtha M. R. Meena
National Seminar on Integrated crop management in sugarcane for increasing cane, sugar and jaggery yields organized by RARS, ANGRAU at Andhra University Campus, Visakhapatnam during 5-6 December 2014	R. Viswanathan
Meeting/workshop of Central research agencies and State Agriculture Department in Kerala held at Trivandrum on 9 December 2014	M. N. Premachandran
National Seminar on Extension management strategies for sustainable agriculture: Challenges and opportunities at Madurai during 12-13 December 2014	T. Rajula Shanthy C. Karpagam
Kisan Gosthi cum exhibition organized by Indian Institute of Farming System Research (IIFSR), Modipuram in village RasulpurJattan on 13 December 2014 and at village Barwala, Distt. Muzaffaranagar (UP) on 14 December 2014	Ravinder Kumar M.R. Meena
National Seminar on Challenges and innovative approaches in crop improvement at Agricultural College & Research Institute, Madurai on 16 December 2014	G. Hemaprabha R.M. Shanthi S. Alarmelu P. Govindaraj A. Suganya
Recent trend in virology research in the omics era at TNAU during 18-20 December 2014	R. Viswanathan
23rd National Conference of Indian Virological Society, New Delhi on Recent trends in virology research in the Omics era at TNAU, Coimbatore during 18-20 December 2014	R. Viswanathan
60th review meeting of Nagar Rajbhasha Karyanyavan Samittee, Karnal at Punjab National Bank, Karnal on 22 December 2014	N. Kulshreshtha
Workshop cum - Brainstorming on Optimizing talent search for the National Agricultural Research & Education System (NARES) organized by ASRB, New Delhi at NDRI, Karnal during 16-17 January 2015	N. Kulshreshtha

International conference on Innovative insect management approaches for sustainable agro eco-system (IIMASAE) at AC & RI, Madurai during 27-30 January 2015	P. Mahesh
Seminar on Multidimensional approach to make sugarcane cultivation sustainable jointly organized by SISSTA and ICAR-SBI, Coimbatore on 31 January 2015	R. Viswanathan M.N. Premachandran C.Palaniswami G. Hemaprabha T. Rajula Shanthy R. Balakrishnan P Govindaraj R.M. Shanthi S. Alarmelu A. Suganya V.P. Sobhakumari S.Venkataramana R.Jayanthi C. Sankaranarayanan D.Puthira Prathap C. Karpagam
XII Agricultural Science Congress - Sustainable livelihood security for smallholder farmers at ICAR-NDRI, Karnal during 3-6 February 2015	Bakshi Ram S.K. Pandey M.L. Chhabra M.R. Meena Ravinder Kumar Vishal Goel N. Kulshreshtha
International Conference on Social entrepreneurship and sustainable development by TISS, Mumbai during 4-7 February 2015	T. Rajula Shanthy
Meeting of Breeders and Pathologists of NW, NC & NE Zones under AICRP on Sugarcane at the Regional Research Station (PAU), Gurdaspur, Punjab on 6 February 2015	N. Kulshreshtha M. L. Chhabra Ravinder Kumar
National Symposium on Challenges and management approaches for crop diseases of national importance – Status and prospects organized by the Indian Society of Mycology and Plant Pathology, Udaipur at Madurai during 12-14 February 2015	R.Viswanathan P. Malathi A. Ramesh Sundar
Meeting for the preparation of guidelines and the proforma for executing MoU with farmers/different seed companies at CSSRI, Karnal on 18 February 2015	N. Kulshreshtha

5th International Conference on Next generation genomics and integrated breeding for crop improvement at ICRISAT, Hyderabad during 18-20 February 2015	A. Suganya
International Congress on Role of agri-science, forestry, food technology and participatory natural resource management for mitigation of climate change (AF-Nature 2015) at JNU, New Delhi during 21-22 February 2015	M.L. Chhabra
Workshop on Training needs assessment for HRD Nodal Officers of ICAR at NAARM, Hyderabad on 26 February 2015	K. Hari
9th DUS Annual Review meeting held at JAU, Junagadh during 9-10 March 2015	C. Jayabose K. Mohanraj
National Symposium on Understanding host-pathogen interaction through science of omics at IISR, Kozhikode during 16-17 March 2015	R. Viswanathan A. Ramesh Sundar
International Symposium on New perspectives in modern Biotechnology at Puducherry during 23-25 March 2015	T. Ramasubramaniam

16. DISTINGUISHED VISITORS

Sl.No.	Name	Affiliation	Date
Coimbatore			
1	Shri T. Jacob	Joint Secretary (Sugar), Ministry of Consumer Affairs, Govt. of India , New Delhi	27 June 2014
2	International delegates	Nanchil Technologies Private Ltd., (Consultants to Sugar Industry), Chennai	15 July 2014
3	Dr. P.L. Gautham	Vice Chancellor, Career Point University, Hamirpur (HP) and Former DDG (Crop Science), ICAR, New Delhi	26 July 2014
4	Delegates from United Kingdom	LANTRA, UK	16 October 2014
5	Students from Cornell University, USA	TNAU, Coimbatore	12 January 2015
6	Delegates from seven countries	Kothari Research Management Centre, Coonoor	18 January 2015
Karnal			
1	Delegation from Zimbabwe of progressive sugarcane farmers, Agro-innovators and officials	Ministry of Industry & Trade, Zimbabwe and Zimbabwe Sugarcane Development Association	2 August 2014
2	Dr. S.K. Dutta	DDG (Crop Science), ICAR, New Delhi	27 May 2014
3	Dr. Gurbachan Singh	Chairman, ASRB, New Delhi	4 February 2015

Fig. 105. Zimambwe delegates visiting Karnal farm

Fig. 106. Director, ICAR-SBI with Dr Gurbachan Singh in the SBIRC Karnal experimental farm

17. PERSONNEL

Director: **Bakshi Ram Ph.D.** **bryadav2003@yahoo.com**
N. Vijayan Nair Ph.D. **vijay52in@yahoo.com (till 30.09.2014)**

Name	Designation & Discipline	E-mail ID
Division of Crop Improvement		
M.N. Premachandran Ph.D.	Pr. Scientist (Gen. & Cyto.) & Head	premsbi@rediffmail.com
N. Subramonian Ph.D.	Pr. Scientist (Gen. & Cyto.)	monian_52@yahoo.com
G. Hemaprabha Ph.D.	Pr. Scientist (Plant Breeding)	hemaprabha@sify.com
N. Rajendra Prasad Ph.D.	Pr. Scientist (Seed Technology)	rajendra@hotmail.com
R.M. Shanthi Ph.D.	Pr. Scientist (Plant Breeding)	rmshanthi288_@rediff.com
D. Neelamathi Ph.D.	Pr. Scientist (Seed Technology)	neelamathi2005@hotmail.com
P. Govindaraj Ph.D.	Pr. Scientist (Plant Breeding)	govindsbi@rediffmail.com
S. Alarmelu Ph.D.	Pr. Scientist (Plant Breeding)	alar_kannan@rediffmail.com
A.Selvi Ph.D.	Pr. Scientist (Plant Biotechnology)	selviathiappan@yahoo.co.in
A. Suganya Ph.D.	Pr. Scientist (Economic Botany)	suganyamuns@rediff.com
V.P. Sobhakumari Ph.D.	Pr. Scientist (Gen. & Cyto.)	vpsobhakumari@rediffmail.com
S. Karthigeyan Ph.D.	Pr. Scientist (Plant Breeding)	sugaris@vsnl.com
A. Anna Durai Ph.D.	Sr. Scientist (Plant Breeding)	ayyadu@gmail.com
C. Jayabose Ph.D.	Sr. Scientist (Genetics)	jayabosec@yahoo.com
R. Manimekalai Ph.D.	Sr. Scientist (Plant Biotechnology)	rmanimekalai@rediffmail.com
R. Karuppaiyan Ph.D.	Sr. Scientist (Plant Breeding)	sugaris@vsnl.com
K. Mohanraj Ph.D.	Scientist (Plant Breeding)	mohangene@yahoo.com
C. Appunu Ph.D.	Scientist (Plant Breeding)	cappunu@gmail.com
P.T. Prathima Ph.D.	Scientist (Plant Biotechnology)	prathimasambandam@gmail.com
C. Mahadevaiah M.Sc	Scientist (Plant Breeding)	msheshadri@gmail.com
V. Sreenivasa M.Sc	Scientist (Plant Breeding)	seenugpb@gmail.com
K. Lakshmi Ph.D.	Scientist (Plant Biotechnology)	lakshmimbb@gmail.com
Adhini S Palani M.Sc	Scientist (Plant Breeding)	adhinisp@gmail.com
S.N. Rahana M.Sc.	Scientist (Plant Breeding)	rahana.sci@gmail.com
T. Manjunatha Ph.D	Scientist (Plant Breeding)	manju21april@gmail.com
Division of Crop Production		
C. Palaniswami Ph.D.	Pr. Scientist (SCFM) & Head	darsanpalaniswami@yahoo.co.uk
P. Rakkiyappan Ph.D.	Pr. Scientist (SCFM) & Head (till 31.5.2014)	sugaris@vsnl.com
P. Gopalasundaram Ph.D.	Pr. Scientist (Agronomy)	pegeyes@yahoo.com
K. Sivaraman Ph.D.	Pr. Scientist (Agronomy)	spice01@gmail.com
P.N. Gururaja Rao Ph.D.	Pr. Scientist (Plant Physiology)	pngrao@yahoo.com
S. Venkataramana Ph.D.	Pr. Scientist (Plant Physiology)	svramana54@yahoo.com
R. Dhanapal Ph.D.	Pr. Scientist (Agronomy)	sugaris@vsnl.com
S. Vasantha Ph.D.	Pr. Scientist (Plant Physiology)	vasanthavedantham@yahoo.com
K. Hari Ph.D	Pr. Scientist (Microbiology)	sbi_hari@yahoo.com

Name	Designation & Discipline	E-mail ID
D. Esther Shekinah Ph.D.	Sr. Scientist (Agronomy)	eshekinah@yahoo.co.in
R. Gomathi Ph.D.	Sr. Scientist (Plant Physiol.)	gomathi_sbi@yahoo.co.in
A. Vennila Ph.D.	Sr. Scientist (Soil Science)	avennila@gmail.com
A. Bhaskaran Ph.D.	Sr. Scientist (SCFM)	bhaskaran@sugarcane.res.in
A.S. Tayade Ph.D.	Sr. Scientist (Agronomy)	arjuntayade3@gmail.com
T. Arumuganathan Ph.D.	Sr. Scientist (Farm Machinery & Power)	arumuganathan@gmail.com
G.S. Suresha Ph.D.	Scientist (Biochemistry)	sureshgiriyapur@gmail.com
P. Geetha Ph.D.	Scientist (Agronomy)	sugaris@vsnl.com
Division of Crop Protection		
R. Viswanathan Ph.D.	Pr. Scientist (Pl. Patho.) & Head	rasaviswanathan@yahoo.co.in
N. Prakasam Ph.D.	Pr. Scientist (Pl. Patho.)	prakasamn@yahoo.co.in
R. Jayanthi Ph.D.	Pr. Scientist (Ag. Ento)	natpento@yahoo.com
K.P. Salin Ph.D.	Pr. Scientist (Ag. Ento.)	kpsalin@hotmail.com
J. Srikanth Ph.D.	Pr. Scientist (Ag. Ento.)	srikanth_jsk@yahoo.co.in
A. Ramesh Sundar Ph.D.	Pr. Scientist (Pl. Patho.)	rameshsundar_sbi@yahoo.co.in
N. Geetha Ph.D.	Pr. Scientist (Ag. Ento.)	mvsbi@yahoo.com
B. Singaravelu Ph.D.	Pr. Scientist (Ag. Ento.)	bsingaravelu@rediffmail.com
P. Malathi Ph.D.	Pr. Scientist (Pl. Patho.)	emalathi@yahoo.com
C. Sankaranarayanan Ph.D.	Pr. Scientist (Nematol.)	csankar@lycos.com
V. Jayakumar Ph.D.	Sr. Scientist (Pl. Patho.)	jkpath@rediffmail.com
T. Ramasubramanian Ph.D	Sr. Scientist (Ag. Ento.)	tramasubbu@gmail.com
M. Punithavalli Ph.D.	Scientist (Ag. Ento)	punithaentomol@yahoo.co.in
P. Mahesh Ph.D.	Scientist (Ag.Ento.)	sugaris@vsnl.com
Statistics and Economics Section		
R. Balakrishnan Ph.D.	Pr. Scientist (Agr. Stat.) and Head	raghupathy_bala53@yahoo.com
P. Murali Ph.D.	Scientist (Agrl. Econ.)	muralisundar@rediffmail.com
Extension Section		
T. Rajula Shanthy Ph.D.	Pr. Scientist (Agrl. Extn.) and Head	rajula.sbi@gmail.com
D. Puthira Prathap Ph.D.	Pr. Scientist (Agrl. Extn.)	puthira@yahoo.com
V. Venkatasubramanian Ph.D.	Sr. Scientist (Agrl. Extn.)	sugaris@vsnl.com
C. Karpagam Ph.D.	Sr. Scientist (Agrl. Extn.)	karpsicar@gmail.com
SBI- Regional Centre, Karnal		
Neeraj Kulshreshtha Ph.D.	Pr. Scientist (Pl. Breeding) & Head	headsbirc@dataone.in
S.K. Pandey Ph.D.	Pr. Scientist (Ag. Ento.)	s_kantpandey@yahoo.com
M.L. Chhabra Ph.D	Sr. Scientist (Pl. Patho.)	mlchhabrasbi@gmail.com
Minturam Meena Ph.D.	Scientist (Plant Breeding)	meena.mintu7@gmail.com
B. Parameswari Ph.D.	Scientist (Pl. Patho.)	parampathmem@gmail.com
Pooja M.Sc	Scientist (Pl. Physiol.)	sugaris@vsnl.com
Ravinder Kumar Ph.D.	Scientist (Plant Breeding)	raviagricos@gmail.com
SBI- Research Centre, Kannur		
K. Chandran Ph.D.	Pr. Scientist (Pl. Breeding) &SIC	sbirc@dataone.in

Name	Designation & Discipline	E-mail ID
M. Nisha Ph.D.	Scientist (Plant Breeding)	nishathanima@yahoo.com
R. Arun Kumar Ph.D.	Scientist (Plant Physiol.)	sugaris@vsnl.com
SBI - Research Centre, Agali		
R. Karuppaiyan Ph.D.	Sr. Scientist (Plant Breeding)	sugaris@vsnl.com
Administrative staff		
G. Asokumar	Administrative Officer	guruashok@hotmail.com
K.K. Hamza	Sr. Finance & Accounts Officer	sugaris@vsnl.com
M. Sreedevi	Jr. Acc. Officer	sreedevimangalath@gmail.com
R.Vanithamuthumaheswari	AAO (Cash & Bills)	sugaris@vsnl.com
S. Thamilarasi	AAO (Stores)	sugaris@vsnl.com
V. Asha Kumari	AAO (Farm)	sugaris@vsnl.com

ANNEXURE I

Annual Performance Evaluation Report (2013 - 2014) in respect of RFD 2013-2014 of RSCs

Name of the Division : **Crop Science**

Name of the Institution : **ICAR-Sugarcane Breeding Institute, Coimbatore**

Nodal Officer of the RSC : **Dr. P. Gopalasundaram**

S. No.	Objectives	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target / Criteria Value					Achievements	Performance		Percent achievements against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	Very Good 90%	Good80%	Fair 70%	Poor 60%		Raw Score	Weighted Score		
1	Breeding of superior sugarcane varieties / genotypes having high sugar productivity as well as sustainability and to assist state sugarcane breeding programmes	50	Evolving superior sugarcane varieties	Identification of improved clones (Co canes)	No.	15	20	15	10	5	2	33	100	15	220	This year number of clones performed better were more. Hence the more number of clones selected as Co canes.
				Evaluation of Breeding lines and germplasm	No.	10	220	200	180	160	140	250	100	10	125	-
				Clones entering national level trial for MLT	No.	10	15	13	10	5	2	13	90	9	100	-
				Making crosses under NHG for the participating centres	No.	7	550	500	450	400	300	666	100	7	133.2	More number of clones flowered during 2013 season. Hence more crosses could be made

S. No.	Objectives	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target / Criteria Value					Achievements	Performance		Percent achievements against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	Very Good 90%	Good80%	Fair 70%	Poor 60%		Raw Score	Weighted Score		
				Production of breeder seed	Tonnes	5	275	250	200	150	100	388.4	100	5	155.36	In view of higher demand for seed, the production of breeder seed was stepped-up.
				Production of tissue culture plants	No.	3	25000	20000	15000	10000	5000	24445	98.9	2.977	122.23	-
2	Development and identification of appropriate technologies for production and protection aspects of sugarcane cultivation	30	Development of technologies for productivity improvement, natural resource management and integrated pest and disease management	Technologies developed / tested / validated	No.	30	6	5	4	3	2	6	100	30	120	-
3	Technology dissemination and capacity building	9	Transfer of technology	Conducting training programmes	No.	9	9	8	7	6	5	7	80	7.2	87.5	-
	Efficient functioning of RFD System	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	15/05/13	16/05/13	17/05/13	20/05/13	21/05/13	15/05/13	100	2		
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	01/05/13	02/05/13	05/05/13	06/05/13	07/05/13	01/05/13	100	2		
	Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2	100	95	90	85	80	0	0	0		

S. No.	Objectives	Weight	Action(s)	Success Indicator(s)	Unit	Weight	Target / Criteria Value					Achievements	Performance		Percent achievements against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	Very Good 90%	Good80%	Fair 70%	Poor 60%		Raw Score	Weighted Score		
			Prepare an action plan for Innovation	On-time submission	Date	2	30/07/13	10/08/13	20/08/13	30/08/13	10/09/13	30/07/13	100	2		
	Improving internal efficiency / responsiveness / service delivery of Ministry / Department	4	Implemen tation of Sevottam	Independent Audit of Implemen tation of Citizen's Charter	%	2	100	95	90	85	80	100	100	2		
				Independent Audit of implemen tation of public grievance redressal system	%	2	100	95	90	85	80	100	100	2		

Total Composite Score : 96.17

Rating : Excellent

Procedure for computing the Weighted and Composite Score

Weighted Score of a Success Indicator = Weight of the corresponding Success Indicator x Raw Score / 100

Total Composite Score = Sum of Weighted Scores of all the Success Indicators

ANNEXURE II

RESULTS-FRAMEWORK DOCUMENT (RFD) FOR

ICAR - SUGARCANE BREEDING INSTITUTE (2013-2014)

Section 1 : Vision, Mission, Objectives and Functions

Vision

India as the World Leader in sugarcane and sugar production through appropriate sciece and technology led interventions.

Mission

The mission of Sugarcane Breeding Institute is to evolve superior sugarcane varieties and develop crop production and protection technologies suited for different agro-climatic regions of the country to make sugarcane agriculture sustainable, profitable and more efficient in the use of natural resources.

Objectives

1. Breeding of superior sugarcane varieties / genotypes having high sugar productivity as well as sustainability and to assist state sugarcane breeding programmes
2. Development and identification of appropriate technologies for production and protection aspects of sugarcane cultivation
3. Technology dissemination and capacity building

Functions

- To function as a repository for sugarcane genetic resources
- To develop improved sugarcane varieties suited for different agroclimatic conditions of the country
- To provide support to 23 Sugarcane Research Stations in developing location specific improved sugarcane varieties
- To carryout research in sugarcane production and protection technologies
- To conduct transfer of technology programmes to popularise sugarcane production technologies

Section 2: Inter se Priorities among Key Objectives, Success indicators and Targets

Sl.No.	Objectives	Weights	Actions	Success Indicators	Unit	Weights	Target / Criteria Value				
							Excellent	Very Good	Good	Fair	Poor
							100 %	90%	80 %	70 %	60 %
1	Breeding of superior sugarcane varieties / genotypes having high sugar productivity as well as sustainability and to assist state sugarcane breeding programmes	50	Evolving superior sugarcane varieties	Identification of improved clones (Co canes)	Number	15	20	15	10	5	2
				Evaluation of Breeding lines and germplasm	Number	10	220	200	180	160	140
				Clones entering national level trial for MLT	Number	10	15	13	10	5	2
				Making crosses under NHG for the participating centres	Number	7	550	500	450	400	300
				Production of breeder seed	Tonnes	5	275	250	200	150	100
				Production of tissue culture plants	Number	3	25000	20000	15000	10000	5000
2	Development and identification of appropriate technologies for production and protection aspects of sugarcane cultivation	30	Development of technologies for productivity improvement, natural resource management and integrated pest and disease management	Technologies developed / tested / validated	Number	30	6	5	4	3	2
3	Technology dissemination and capacity building	9	Transfer of technology	Conducting training programmes	Number	9	9	8	7	6	5
	Efficient functioning of RFD System	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	15/05/13	16/05/13	17/05/13	20/05/13	21/05/13
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	01/05/13	02/05/13	05/05/13	06/05/13	07/05/13
	Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2	100	95	90	85	80
			Prepare an action plan for Innovation	On-time submission	Date	2	30/07/13	10/08/13	20/08/13	30/08/13	10/09/13
	Improving internal efficiency / responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100	95	90	85	80
				Independent Audit of implementation of public grievance redressal system	%	2	100	95	90	85	80

Section 3: Trend Values of the Success Indicators

Sl. No.	Objectives	Actions	Success Indicators	Unit	Actual value for FY 11/12	Actual value for FY 12/13	Target value for FY 13/14	Projected value for FY 14/15	Projected value for FY 15/16
1	Breeding of superior sugarcane varieties / genotypes having high sugar productivity as well as sustainability and to assist state sugarcane breeding programmes	Evolving superior sugarcane varieties	Identification of improved clones (Co canes)	Number	27	36	15	20	22
			Evaluation of Breeding lines and germplasm	Number	150	150	200	200	200*
			Clones entering national level trial for MLT	Number	29	17	13	15	15*
			Making crosses under NHG for the participating centres	Number	610	598	500	520	520*
			Production of breeder seed	Tonnes	264	226.8	250	250	250*
			Production of tissue culture plants	Number	25200	19305	20000	22000	25000
2	Development and identification of appropriate technologies for production and protection aspects of sugarcane cultivation	Development of technologies for productivity improvement, natural resource management and integrated pest and disease management	Technologies developed / tested / validated	Number	8	8	5	5	5*
3	Technology dissemination and capacity building	Transfer of technology	Conducting training programmes	Number	7	8	8	8	8*
	Efficient functioning of RFD System	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	-	-	16/05/2013	-	-
		Timely submission of Results for RFD (2012-13)	On-time submission	Date	-	-	02/05/2013	-	-
	Administrative Reforms	Implement ISO 9001 as per the approved action plan	% Implementation	%			95		
		Prepare an action plan for Innovation	On-time submission	Date			10/08/2013		
	Improving internal efficiency / responsiveness / service delivery of Ministry / Department	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%			95		
			Independent Audit of implementation of public grievance redressal system	%			95		

There is no proposal to improve the infrastructure facilities and increase the staff strength. Hence the same targets will continue for FY 14/15 and FY 15/16

Section 4: Acronyms

Sl. No.	Acronym	Description
1	MLT	Multi Location Trial
2	NHG	National Hybridisation Garden
3	AICRP (S)	All India Coordinated Research Project on Sugarcane
4	SBI	Sugarcane Breeding Institute
5	SBI RC	Sugarcane Breeding Institute Regional Centre
6	SAU	State Agricultural University
7	DAC	Department of Agriculture and Cooperation

Section 5 : Description and Definition of Success Indicators and Proposed Measurement Methodology

Sl. No.	Success Indicator	Description	Definition		General Comments
1	Identification of improved clones (Co canes)	Co canes are produced by careful breeding and selection for desirable characteristics	Co canes are group of selected sugarcane plants selected for the desirable traits, from which commercial varieties are identified.	Number	The number of Co canes depends upon the availability of superior material selected with respect to yield, biotic and abiotic resistance/ tolerance over the existing varieties under early and midlate maturing groups.
2	Evaluation of Breeding lines and germplasm	Source material needed for developing improved varieties for agronomic traits to be evaluated	Material comprising of basic germplasm and improved germplasm	Number	Evaluation of germplasm depends on the collection of new germplasm from centres of origin and diversity and on the number of lines developed through breeding for specific traits.
3	Clones entering national level MLT	Co canes performing better over the standards in the Institute level trials to be advanced forward to MLT under AICRP (S)	Co canes compared with the zonal standards are selected in the AICRP for MLT in specific zones.	Number	Co canes with improved agronomic traits selected from Coimbatore find their place at AICRP centres of Peninsular zone and those from SBIRC Karnal in North Western zones. Sometimes final clonal trials are conducted at specific factory areas in Karnataka and Andhra Pradesh and the selections enter Peninsular zone and East Coast zone respectively
4	Making crosses under NHG for the participating centres	The National Hybridisation Garden, a facility under fluff supply programme at the Institute would facilitate sugarcane breeders across the country to make specific cross combinations	Under Fluff supply programme SBI would facilitate sugarcane breeders to make desired crosses in the National Hybridization Garden to breed location specific varieties	Number	SBI serves as the pivot centre for sugarcane breeding in the country through the National Hybridization Garden, with over 600 parental clones, serving as platform for the sugarcane breeders across states to choose parents and effect crosses. Fluff (true seed) is sent to the stations for seedling raising and subsequent testing.

Sl. No.	Success Indicator	Description	Definition		General Comments
5	Production of breeder seed	Production of breeder seed is the starting point in seed chain of producing quality planting material for farmers	Breeder seed is the starting point in seed chain which is multiplied/ converted in to quality planting material in the three tier nursery programme	Tonnes	Quality seeds are developed and supplied to the indenters from Sugar factories, State Departments of Agriculture and farmers.
6	Production of tissue culture plants	Produce disease free material for the primary nursery	Tissue culture plants in seed chain are raised and multiplied/ converted into quality planting material in the three tier nursery programme to multiply a new cultivar faster and to make the existing cultivars disease free	Number	Disease free seedlings are produced through meristem culture and quantity indented by Sugar factories, farmers and State Departments of Agriculture are supplied.
7	Technologies developed / tested / validated	Certain ideas and crop production/protection technologies which are usable technology and cost effective. may be directly developed from the projects. The technologies will be tested/validated for the region.		Number	
8	Conducting training programmes	Capacity building activities related to knowledge and skill improvement / development programmes conducted for farmers and developmental personnel	Training is a process of acquisition of new skills, attitude and knowledge in the context of preparing for entry into a vocation or improving productivity in an organization or enterprise	Number	Developmental Agencies(Line departments) and sugar factories will sponsor and depute officials for training to upgrade their skills.

Section 6 : Specific Performance Requirements from other Departments

Sl. No.	Location Type	State	Organisation Type	Organisation Name	Relevant Success Indicator	What is your requirement from this organisation	Justification for this requirement	Please quantify your requirement from this Organisation	What happens if your requirement is not met.
1	State Government / Sugar factories	Sugarcane growing states	State Departments / Industry	Department of Agriculture/ Directorate of Sugar / Sugar factories	[1.5] Production of breeder seed	Indent for quantity of breeder seed	Production of breeder seed is the starting point in seed chain for producing quality planting material for farmers to farmers	Quantity of breeder seed produced is as per the indent from sugar factories/ Departments	Production of breeder seed will be regulated accordingly
2	Government / Sugar factories	Sugarcane growing states	Departments/ Industry / Farmers	Sugar factories, SAUs and State Departments of Agriculture and Directorate of Sugar	[3.1] Conducting training programmes	Request to train the personnel	Capacity building activities related to knowledge and skill development programmes conducted for farmers and developmental personnel	Developmental Agencies/(Line Departments) and sugar factories will sponsor and depute officials and farmers for training to upgrade their skills.	Number of trainings/ programmes will be restricted to the requirement

Section 7 : Outcome / Impact of activities of organisation

Sl. No.	Outcome/impact	Jointly responsible for influencing this outcome / impact with the following department (s) / ministry(ies)	Success indicator	Unit	FY 11/12	FY 12/13	FY 13/14	FY 14/15	FY 15/16
1	Enhanced sugarcane productivity	DAC, Planning Commission , State Governments, SAUs, State Departments of Agriculture, Directorate of Sugar and Sugar factories	Increase in productivity	%	2	1	2	2	2
2	Enhanced farmer's income	DAC, Planning Commission , State Governments, SAUs, State Departments of Agriculture, Directorate of Sugar and Sugar factories	Improvement in farmers' income	%	3	1	2	2	2