वार्षिक प्रतिवेदन 2017 - 18

ANNUAL REPORT

भा.कृ.अनु.प. - गन्ना प्रजनन संस्थान

कोयम्बत्तूर - 641 007

ICAR - SUGARCANE BREEDING INSTITUTE

(ISO 2001:2008 Institution)

Coimbatore - 641 007

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PREFACE

Sugar production in India during 2017-18 season is expected to be all time record of about 32 million tonnes. Varieties play a major role (~70% contribution) in sugarcane production, productivity and sugar recovery. During the season, Co-varieties (evolved by the Institute) alone covered about 57.4% in tropical region and 59.9% in sub-tropical region of the total area under sugarcane in the country. Co 0238 and Co 86032 continued to be the predominant varieties with about 50.4% and 47.6% area coverage in sub-tropical and tropical regions, respectively. The wonder variety Co 0238 has reversed the trend of sugarcane and sugar production in the country with higher contribution of the sub-tropical region (58% and 56%) than the tropical region (42% and 44%) during 2016-17.

The main factor responsible for this trend is adoption of Co 0238, which occupied 14.75 lakh ha or 50.4% of the cane area in subtropical states. The variety was recommended in Uttar Pradesh during 2012 and since then it has increased to over 12.08 lakh hectares (52.6%) area during 2017-18. During the last five seasons, average cane yield and sugar recovery in Uttar Pradesh has increased to 79.2 t/ha and 10.85% from 61.6 t/ha and 9.18%, respectively during 2012-13. For the first time in the history of sugar industry in sub-tropical India, $\geq$ 12% average sugar recovery by six sugar mills and $\geq$ 11% average sugar recovery by 41 sugar mills in Uttar Pradesh were recorded during 2017-18 season.

Ever since its inception in 1912, the foremost objective of the Institute is to develop improved sugarcane varieties for the different agroclimatic regions of the country. 'Co' canes, developed at the Institute, have contributed tremendously not only in the country but also in 28 other countries, either as commercial varieties or as parents in their hybridization programmes. In a further step to meet the varietal requirements of the country, the Institute has released Co 09004, an early maturing, in Peninsular Zone and Co 09022 (Karan 12), a midlate maturing clone from Institute's Regional Centre at Karnal, in North West Zone for commercial cultivation. Co 09004, with on par sucrose content with CoC 671, will help in improving sugar recovery in different states of Peninsular Zone. Co 06022, another early maturing variety with a diverse genetic base, has been identified for release by the State Variety Release Committee for commercial cultivation in Tamil Nadu and Puducherry. Water stress tolerance potential of both Co 06022 and Co 09004 has been confirmed under artificial evaluation conditions.

A total of 24 elite 'Co' canes have been identified from Coimbatore (Co 18001- Co 18018 including 14 'Co' canes and four Genetic Stocks), Karnal (Co 18019 - Co 18022) and S. Nijalingappa Sugar Institute (SNSI), Belagavi (Co 18023 and Co 18024) for further evaluation under AICRP(S).

The Institute has intensified its efforts towards identification of location specific sugarcane varieties by having an institute-industry collaborative project between ICAR-SBI, Coimbatore and SISMA-Tamil Nadu and 19 other individual sugar mills in Maharashtra, Karnataka, Uttar Pradesh, Bihar and Haryana. Co 06031, Co 11015, Co 14016 and Co 15007 were identified as promising clones after one year of experimentation under SISMA's Sweet Bloom project.

Due to drought situation, flowering was delayed by about 15 days in 263 (43.33%) flowered parental clones maintained in the National Hybridisation Garden (NHG) with 607 parental clones. Fluff weighing 17.26 kg of crosses made at both NHG and NDHF, Agali was supplied to the 23 participating centers.

Breeder seed multiplication was taken up with tissue culture plants produced for nucleus seed both at the Institute and in farmer's participatory approach. A total quantity of 620.480 tons of quality seed cane was produced and supplied in September 2017. At Karnal, about 12,060 quintal breeder seed of sugarcane varieties of North West Zone were produced and supplied to the various stakeholders.

Institute is very rich as far as sugarcane germplasm is concerned, which is maintained at Coimbatore, Kannur and Agali stations of the Institute and Wellington Centre of ICAR-IARI. In order to further expand the genetic resources, germplasm exploration was conducted in Jharkhand State wherein 76 *S. spontaneum* and four *S. officinarum* were collected from 24 districts. Under National Active Germplasm (NAG) of sugarcane, 226 clones were maintained.

GISH analysis of two intergeneric hybrids involving *Sorghum*, i.e. Co 86032 x *Sorghum* and *Sorghum* x *Saccharum* were carried out using *Sorghum* as the labeled probe. Ten chromosomes of *Sorghum* were identified in the metaphase as well as in the interphase. Early condensations of the *Sorghum* chromosomes were observed.

In the Indo-Australian project on genetic control and genomic selection for important traits in sugarcane, phenotyping for drought parameters has been done in the biparental population involving CoM 0265 x Co 775 and BO 91 x Co 775. The data on Brix and Pol % were analyzed using Best Linear Unbiased Prediction method (BLUP) and the clones with high BLUPs (both at control and drought conditions) were identified.

Free living, root associated and phyllosphere bacteria, isolated from sugarcane, indicated positive results in the preliminary studies on germination and seedling vigour.

A Quadcopter Drone (DJI-Phantom 3 model with 4K resolution - FC 330X camera) was used to capture the field images of healthy sugarcane leaf and sugarcane leaf with red rot disease. Hue saturation value (HSV) and YCbCr values of the images clearly distinguished the red rot disease symptom leaves from healthy. High Optimized Soil Adjusted Vegetation Index values indicated dense, healthy vegetation whereas lower values indicate less vigour.

Six hundred and seventy soil test results were imported into the Decision Support System, Soil Health Card with package of practices for sugarcane were generated and sent to the farmers through sugar factories.

A model was developed to predict dry bulk density of soil along the depth of soil profile using Artificial Neural Network with five input layers with two hidden layers of 15 and 10 nodes, respectively and the model developed showed Training MSE of 0.126 and Validation MSE of 0.066.

Among the 11 varieties tested against grain inoculum of *C. falcatum* isolates, the cultivars Co 0403 and Co 0238 remained free from pathogen infection, exhibiting resistance to all the 11 isolates.

Genomic and proteomic approaches on identification of pathogenicity related genes of *C. falcatum* revealed that 27 proteins from mycelium, eight proteins from secretome and 12 proteins from host-pathogen interaction were found after Suppressive Subtraction Hybridization (SSH).

About 843 tissue culture raised plants from different tissue culture production units viz., M/s EID Parry, Pugalur and M/s RSCL, Theni (TN), KIAAR, Sameervadi, (Karnataka), Sree Sarvaraya Sugars, Chelluru and Nava Bharat Ventures Ltd., Samalkot (AP) and ICAR-SBI tissue culture lab were indexed for SCYLV, SCMV, SCSMV and grassy shoot phytoplasmas by following SOPs.

Bioassay studies with Bt isolate KCK 27, which contains six cry genes belonging to cry1A, cry1C, cry1D, cry1E, cry1I and cry2A families, revealed its toxicity to early shoot borer and internode borer. The full coding sequence of cry1D gene from KCK 27 isolate was deduced. Comparison of its amino acid sequence with four other cry1D holotype genes revealed that the cry1D from KCK 27 is a new holotype cry1D gene. This is the first report of cry1D holotype gene from India. The partial sequence of cry1E from KCK 27 also revealed that it could be a new holotype gene.

Technologies like Soil Moisture Indicator, Sett Treatment Device and Settling Transplanter were licensed to private entrepreneurs for manufacturing and marketing. The Decision Support System software was demonstrated to field staff, cane officials and IT personnel of sugar factories and was released for adoption for generating Soil Health Cards.

'Cane Adviser', an android mobile app on sugarcane containing information on state-wise sugarcane varieties, crop production technologies, crop protection technologies, Scheduler app and Query handler were uploaded in google play-store in three languages: Cane Adviser (English), 'Ganna Salahkar' (Hindi) and 'Karumbu Aalosakar' (Tamil) for free download.

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 2017-18. I thank all the scientists and other staff of the institute who helped in the successful conduct of research, members of the editorial board, especially Dr. T. Rajula Shanthy, for their tremendous efforts in bringing out the Annual Report. Continuous encouragement and guidance received from Dr. T. Mohapatra, Secretary, DARE and DG, ICAR, Dr. J.S. Sandhu, former DDG (CS), Dr. A.K. Singh, DDG (CS) and Dr. R.K. Singh, ADG (CC), ICAR are gratefully acknowledged.

Bakshi Ram
Director

2. THE ORGANIZATION

Background

ICAR-Sugarcane Breeding Institute (SBI), Coimbatore has been conducting research on various aspects of sugarcane agriculture and varietal improvement since its inception in 1912. The Institute has developed over 3260 'Co' selections, many of them becoming popular as commercial varieties in different parts of the country. 'Co' canes bred at SBI along with the varieties identified from the crosses made at the Institute by the State Sugarcane Research Stations occupy nearly 95% of the cane area in the country. Thus, the sugarcane varieties cultivated in the country today are directly or indirectly derived from this Institute. 'Co' canes were successful as commercial varieties in over 30 countries at one time and are being extensively used as parents in breeding programmes even today. The Institute maintains one of the largest collections of sugarcane genetic resources in the world.

Location

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

Centres

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

Mandate

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

Staff position

Table 1. Staff position as on 31.03.2018

Category	Sanctioned	Filled	Vacant
Director	1	1	-
Scientific	78	74	4
Technical	73	53	20
Administrative	40	28	12
Supporting	79	58	21
Total	271	214	57

Financial Statement

Table 2. Abstract of expenditure during 2017-18

Head	Amount in Lakhs (Rs.)
Government Grant	3701.28
Plan Schemes	22.06
Externally funded schemes	280.85
Total	4004.19

Organizational set up

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

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

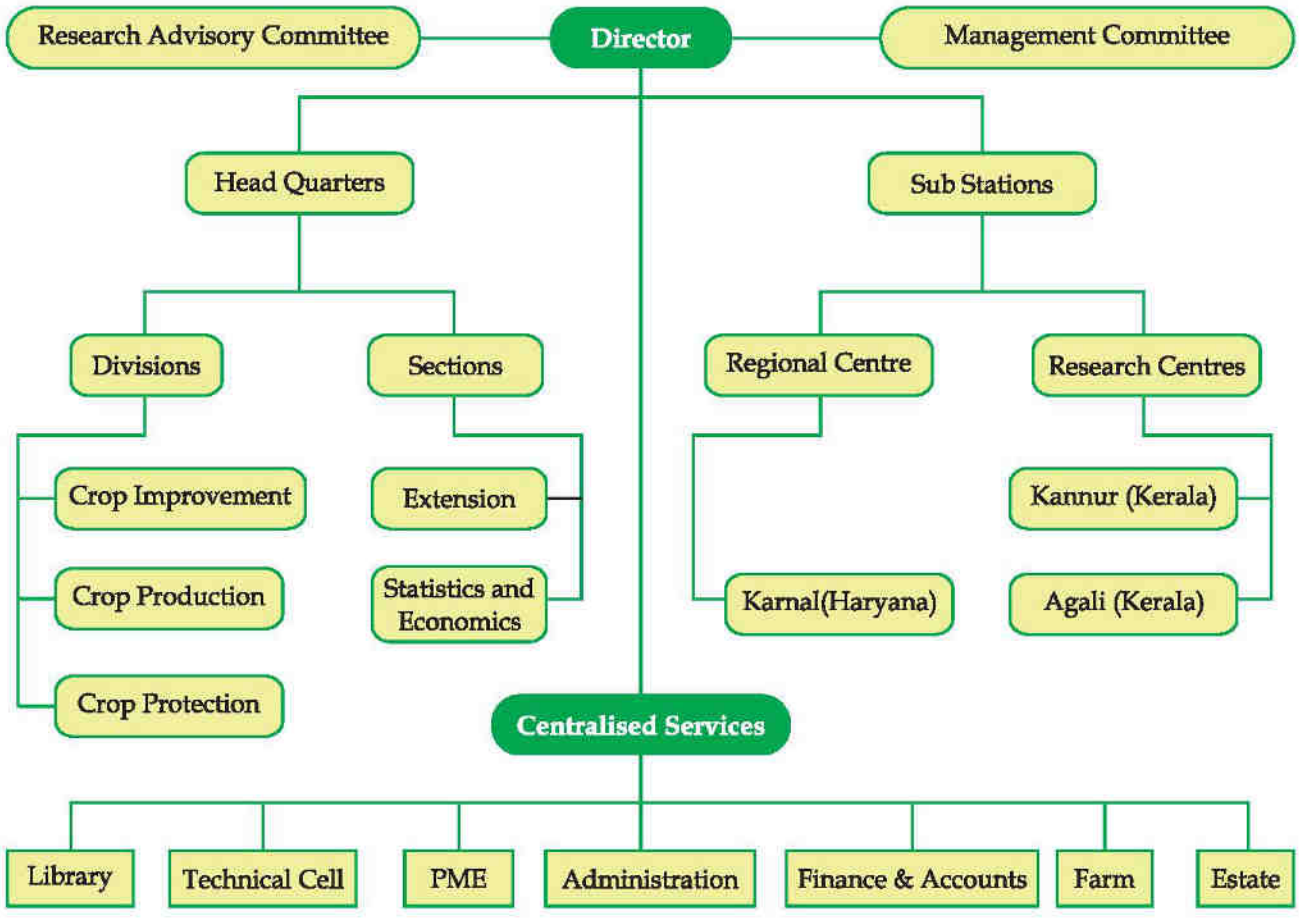


Fig.1 Organizational structure of SBI

Farm

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

Library and documentation services

The library provides information support to the Research and Development activities of the Institute. It has a collection of 12,311 books including bound volumes of journals, besides free publications such as annual reports, newsletters, scientific and technical publications etc. received from Indian and foreign organizations. During the period, library incurred an expenditure of Rs.5,72,410/- towards subscription of journals (19 journals) and books (99 Nos.).

Continued to provide IP based online access to e-Journals and e-books through CeRA. Library has facilities *viz.*, internet terminals, scanning and photocopying for the users. An online accessible bibliographic database of library holdings (OPAC) is being created using KOHA, am open-source software for integrated library system and is nearing completion. The Institute library has got ISBN and ISSN assigning facility for the publications of the Institute. The priced publications (663 Nos.) of the Institute were sold for an amount of Rs. 89,995.

Weather data

***Table 3.* Weather data for the year 2017-18**

Month	Temperature °C		RH (%)		Wind velocity (km per hour)	Open pan evaporation (mm/day)	Rainfall (mm)	No. of rainy days
	Maximum	Minimum	Forenoon	Afternoon				
April 2017	37.73	24.43	84.90	56.87	1.59	5.26	8.80	1.00
May	36.67	25.20	86.53	59.83	1.88	4.96	24.20	4.00
June	33.50	24.73	84.33	66.23	4.37	5.43	30.20	5.00
July	32.53	23.47	83.37	59.53	4.84	5.31	12.80	2.00
August	31.92	23.15	88.30	65.23	3.11	4.19	48.40	4.00
September	30.78	22.72	88.10	68.10	1.92	3.29	255.20	8.00
October	32.45	22.53	89.47	64.50	0.99	4.26	141.60	4.00
November	31.17	22.28	88.10	64.47	1.17	3.62	57.10	5.00
December	30.43	20.87	88.57	55.90	1.39	3.14	4.60	0.00
January 2018	28.15	20.90	86.70	49.20	1.25	3.90	2.20	0
February	30.35	19.65	82.85	40.05	1.85	5.10	0	0
March	33.05	22.30	82.20	39.65	1.75	5.95	27.40	3.00
Mean / Total	32.39	22.69	86.12	57.46	2.18	4.53	612.50	36.00

The total rainfall received during the year was 612.5 mm while the 60 years (1930-1990) average rainfall was 674.2 mm.

The mean maximum temperature was 32.39°C, which was 1.4°C higher than the 60 years average maximum temperature of 31.5°C.

3. कार्यकारी सारांश

फसल सुधार

केन्द्रीय किस्म विमोचन समिती द्वारा को. 09004 को एक अगेती प्रजाति के रूप में प्रायद्वीपीय क्षेत्र में व्यवसायिक खेती के लिये अधिसूचित किया गया। इसी प्रकार एक अन्य आनुवांशिक विविधतापूर्ण आधार वाली अगेती प्रजाति को. 06022 को, प्रदेश किस्म विमोचन समिती द्वारा, तमिलनाडु और पुदुचेरी में व्यवसायिक खेती हेतू लोकार्पण के लिये पहचाना गया है।

कुल मिलाकर 24 विशिष्ट को. गन्नों को कोयम्बत्तूर (को. 18001 से को. 18018 जिनमें 14 को. गन्ने और 4 आनुवांशिक स्टॉक्स शामिल हैं), करनाल (को.18019 से को.18022 तक) और श्री निजलिंगप्पा चीनी संस्थान, बेलगावी (को. 18023 व को. 18024) से पहचाना गया है।

विभिन्न स्थानों पर विशिष्टिता परीक्षण के लिये, संस्थान से विशिष्ट कृन्तकों को विकसित कर विभिन्न चीनी मिलों को भेजा गया। पूर्व तट्टीय क्षेत्र में प्रत्याशित प्रविष्टियों की पहचान के लिये 12 विशिष्ट कृन्तकों को, के.सी.पी. शूगर्स, वुय्यूरू, आन्ध्र प्रदेश, भेजा गया। अट्ठारह सूखा सहनशील विशिष्ट कृन्तकों को, महाराष्ट्र की पाँच चीनी मिलों, नामशः वसंतदादा चीनी संस्थान, पूना, समर्थ सहकारी शक्कर कारखाना, अंकुशनगर, जालना, भाऊराव चवान समर्थ सहकारी शक्कर कारखाना, नानदेद, घ्यानेश्वर सहकारी शक्कर कारखाना, नेवासा और संजीवनी टकली सहकारी शक्कर कारखाना, कोपरगाँव, ज़िला अहमदनगर, को बहुगुणन और मूल्यांकन के लिये भेजा गया। इस वर्ष 12 को. प्रविष्टियों को मैसर्स डालमिया शूगर्स, लिमिटेड में भी मूल्यांकित किया जा रहा था। श्री निजलिंगप्पा चीनी संस्थान, बेलगावी में सन 2014 से 2018 के बीच कुल 240 को. गन्नों और उन्नत आनुवांशिक स्टॉक्स को मूल्यांकित किया गया। उत्तरी कर्नाटक के लिये 22 प्रविष्टियों को सूखा सहनशीलता के लिये मूल्यांकित किया जा रहा है। तमिलनाडु कृषि विश्वविद्यालय के सहयोग से शस्य विज्ञान के समन्वित परीक्षण कार्यक्रम के अन्तरगत, तमिलनाडु के विभिन्न कृषि जलवायु क्षेत्रों के लिये उपयुक्त गन्ने की श्रेष्ठ प्रजातियों की पहचान का कार्य लगातार किया जा रहा है।

भा.कृ.अनु.प.–गन्ना प्रजनन संस्थान और तमिलनाडु की 9 गैर सरकारी चीनी मिलों के बीच सहयोगी कार्यक्रम 'मिठास की आकर्षक बहार' (स्वीट ब्लूम) के अन्तरगत 20 विशिष्ट कृन्तकों को को. 86032 और स्थानीय प्रजातियों के साथ प्रथम पौधा फसल में मूल्यांकित किया जा रहा है। गन्ना उत्पादन और रस की गुणवत्ता के आधार पर को.13014, को.11015, को.14016 और को. 06031 ने को. 86032 की तुलना में कटाई के समय (360 दिनों पर) बेहतर प्रदर्शन दिखाया। कटाई के लिए 8 महीने से ही सात फैक्टरी स्थानों पर को. 11015 में उच्च गन्ना उत्पादन व रस की गुणवत्ता के दोनों गुण समाहित पाये गये, अतः इसे एक कम अवधि की अगेती कृन्तक के रूप में प्रत्याशित पाया गया।

अखिल भारतीय समन्वित (गन्ना) अनुसंधान परियोजना परीक्षणों के शुरूआती प्रजाति परीक्षण के अन्तरगत 37 प्रविष्टियों को अल्फा डिज़ाइन में गन्ना उत्पादन व रस की गुणवत्ता के मापकों के लिये मूल्यांकित किया गया। इनमें से को. 14016 (156.14 टन/हे.) और एम.एस.14082 (150.68 टन/हे) ने गन्ना उत्पादन में सबसे बेहतर मानक से भी सार्थक रूप से बेहतर प्रदर्शन दिखाया। उन्नत प्रजाति परीक्षण के प्रथम पौधा फसल में, सी.सी..एस. उत्पादन के आधार पर, 8 परीक्षित की गई प्रजातियों में से सर्वोत्तम मानक को.सी. 671 की तुलना में को. 12009 ने बेहतर प्रदर्शन दर्शाया। अग्रिम प्रजाति परीक्षण (अगेती) में को.एम. 11082 प्रविष्टि ने सबसे अधिक 15.76 टन/हे. का सी.सी.एस. दर्ज किया। अग्रिम प्रजाति परीक्षण (मध्यम देरी) में को.एम. 11086 ने सबसे अधिक 14.38 टन/हे. का सी.सी.एस. दर्ज किया जबकि को. 11012 ने 13.48 टन/हे. की सर्वोतम सी.सी.एस. दर्शाई वहीं को. 11005 ने 113.41 टन/हे. का सर्वाधिक गन्ना उत्पादन दर्ज किया। को. और सम्बंधित कृन्तकों की 2016 श्रृंखला में से अ.भा.स.अनु.प. के परीक्षणों के लिये स्वीकृत 15 कृन्तकों को कोयम्बत्तूर में बहुगुणितकर प्रायद्वीपीय क्षेत्र के भाग लेने वाले 7 केन्द्रों को भेज दिया गया है।

मृदा लवणवता के लिये परीक्षित करने पर 8 डैसी सीमन/मीटर ई.सी. के स्तर पर को. 12008, को. 12009 और को. 12012 को सहनशील पाया गया। सूखा सहनशीलता के लिये 2010 श्रृंखला से परीक्षित किये गये 10 कृन्तकों में से को. 10015 और को. 10026 को सूखा सहनशील और को. 10004, को. 10024, को. 10027 और को. 10031 को मध्यम स्तर का सहनशील पाया गया जबकि 2010 श्रृंखला से परीक्षित किये गये कृन्तकों में से को. 11001 और को. 11005 को सूखा सहनशील और को. 11004, को. 11007 और को. 11009 को मध्यम स्तर का सहनशील पाया गया।

अ.भा.स.अनु.प. (गन्ना) में भाग लेने वाले 7 केन्द्रों को 30 नये आई.एस.एच./आई.जी.एच. कृन्तकों के दूसरे समूह को बहुगुणित और सूखे (संकेश्वर, पूने, लखनऊ और करनाल) और जलप्लावन (मोतीपुर, पूसा और पन्तनगर) के हालातों में आगे के मूल्यांकन के लिये भेजा गया।

संस्थान में संकरण एवं चयन के द्वारा नये और उन्नत कृन्तकों के विकास का प्रजनन कार्य जारी है। वर्ष 2017 के पुष्पण मौसम के दौरान कुल 258 क्रॉसेस, 78 मादा 42 नर पैतृकों का प्रयोग कर, बनाये गये। भूतल नर्सरी में 83 क्रॉसेस से प्राप्त कुल 9,800 बीज जनित पौधों को मूल्यांकित किया जा रहा है। रटून किये गये भूतल नर्सरी वाले कुल 13,180 बीज जनित पौधों, जिन्हें 88 द्विपैतृक क्रॉसेस, 14 पोलीक्रॉसेस और 11 समान्य संग्रहण से प्राप्त किया गया था, में से 1,217 को चुनकर प्रथम कृन्तक परीक्षण के लिये आगे बढ़ाया गया।

प्रथम कृन्तक परीक्षण में 3,100 कृन्तकों को मूल्यांकित कर 1,032 जीनोटाइपों को द्वितीय कृन्तक परीक्षण के लिये पदोन्नित कर दिया गया। द्वितीय कृन्तक परीक्षण में 655 कृन्तकों को गन्ना उत्पादन, रस की गुणवत्ता और लाल सड़न रोग के लिये मूल्यांकित कर 106 चयनों को अन्तिम कृन्तक परीक्षण (पूर्व क्षेत्रीय प्रजाति परीक्षण –पू.क्षे.प्र.प.) के लिये पदोन्नित कर दिया गया। कुल मिलाकर 208 विशिष्ट कृन्तकों को, विभिन्न परीक्षणों से इकठ्ठा

कर, पू.क्षे.प्र.प. के बहुलिकरण और मूल्यांकन प्लॉट में रोपित किया गया। पू. क्षे.प्र.प. 2018–19 के लिये उच्च शर्करा, गन्ना उत्पादन व लाल सड़न रोग प्रतिरोधिता के गुणों को संयुक्त करने वाले 84 श्रेष्ठ कृन्तकों को पदोन्नित किया गया।

चार कम अवधि के कृन्तकों (को. 09004, को. 11015, को. 16001 और को. 16002) को तीन मानकों (को.सी. 671, को. 8338 और को. 86032) के साथ विशेष मौसम (जुलाई रोपण) में मूल्यांकित किया गया। उत्पादन क्षमता, पेड़ी उत्पादक क्षमता और रस की गुणवत्ता के मूल्यांकन के आधार पर देखा गया कि को. 09004 ने 93.20 टन/हे. गन्ना उत्पादन दर्ज किया जो मानक को. 86032 से 10.75 टन अधिक था।

राष्ट्रीय संकरण उद्यान में भागीदार 24 केन्द्रों से प्राप्त 607 पैतृक कृन्तकों को फ्लफ आपूर्ति कार्यक्रम के अन्तरगत अनुरक्षित किया जा रहा है। वर्ष 2017 के पुष्पण मौसम के दौरान पुष्पण 15 दिन से अधिक देरी से हुआ। इस वर्ष 43.33 प्रतिशत पैतृकों ने पुष्पण दर्शाया जबकि 2016 में 52.46 प्रतिशत और 2015 के दौरान 58.26 प्रतिशत पैतृकों ने पुष्पण दर्शाया था। पैतृक विभिन्नता सूचकांक नयागढ़ के कृन्तकों में 85.71 प्रतिशत और शाहजहाँपुर वालों में 56.94 प्रतिशत था, जोकि बाकी केन्द्रों से अधिक था। राष्ट्रीय संकरण उद्यान और एन.डी.एच.एफ. से प्राप्त 17.26 किलोग्राम फ्लफ को फ्लफ आपूर्ति कार्यक्रम के अन्तरगत 23 भागीदार केन्द्रों को भेजा गया।

उष्णकटिबंधीय गन्नों की 189 डीयूएस संदर्भ प्रजातियों को डीयूएस केन्द्र, कोयम्बत्तूर में अनुरक्षित किया जा रहा है। डीयूएस परीक्षण के पहले वर्ष 2017–18 के दौरान किसानों की प्रजाति कप्तान बस्ती को संदर्भ प्रजातियों– को. 356, को. 740 और को. 8208 –के साथ परीक्षित किया गया। किसानों की चार प्रजातियों, नामशः मेइतेइ चू अंगऊबा, मेइतेइ चू अंगंगबा, देसी–2 और कुदरत का करिश्मा को संदर्भ प्रजातियों के साथ रोपित किया गया।

'कोयम्बत्तूर को. गन्नों का आकारिकी विवरण (1993–2016)' नामक एक अंग्रेजी में पुस्तक, जिसमें 528 को. गन्नों का पादप विज्ञानिक विवरण दिया गया है, को प्रकाशित किया गया। को. 0239 को को. 0118 से भिन्न होने को सुनिश्चित करने के लिये डी.एन.ए. फिंगर प्रिंटिंग के लिये 12 एस.टी.एम.एस. प्राइमरों की सहायता ली गई। डीयूएस परीक्षणों में आण्विक प्रोफाइलिंग की सहायता ली गई, ताकि किसान की सिद्धिगिरी प्रजाति को. 92005 के रूप में पहचान को हल किया जा सके।

प्रजनक बीज के बहुगुणन कार्यक्रम को, संस्थान में नामिकीय बीज से ऊतक संवर्धन द्वारा उत्पादित पौधों की सहायता से और किसानों की भागीदारी से आगे बढ़ाया गया। कुल 620.48 टन उत्तम बीज गन्ना को उत्पादित कर सितम्बर 2017 के दौरान वितरित किया गया। भा.कृ.अनु.प.–गन्ना प्रजनन संस्थान के ई.सी.सी. फार्म कोयम्बत्तूर में 2 फरवरी 2017 को बीज दिवस का आयोजन भा.कृ.अनु.प. की बीज परियोजना के अन्तरगत किया गया। इसके अतिरिक्त वेलामदाई गाँव के किसान के खेत में, जहाँ बीज उत्पादन का कार्य किया जा रहा है, एक पारस्परिक विचार विमर्श कार्यक्रम 15 फरवरी 2018 को आयोजित किया गया।

शीर्ष मेरिस्टेम टिप संवर्धन द्वारा को. 86032, को. 0212, को. 0238, को. 06022, को. 09004 और को.वी. 09356 को बहुगुणित कर 53,435 ऊतक संवर्धित पौधों को तमिलनाडु, महाराष्ट्र और ओडिशा की 14 गैर सरकारी और को–ओपरेटिव चीनी मिलों को वितरित किया गया। को. 86032, को. 0212 और को. 0238 की कुल 167 विषाणु रहित मदर कल्चर फ्लास्कों को तमिलनाडु, छत्तीसगढ़, गुजरात और उत्तर प्रदेश की गैर सरकारी ऊतक संवर्धन प्रयोगशालाओं को वितरित किया गया।

ऊतक संवर्धित पौधों का, बैक्टीरिया का एकल एवं दोहरे संयोजन द्वारा, बैक्टीरिकरण करने पर उनसे विकसित फसल में उनकी कार्यकुशलता का अध्ययन करने पर, गलुकोनोएसिटोबैक्टर + बैसिलस के संयोजन को, गन्ने के उत्पादन व रस की गुणवत्ता को बढ़ाने में सर्वोत्तम पाया गया।

दस चुने गये ऊर्जावान गन्नों को समीरवाड़ी में मूल्यांकित किया गया। एस. बी.आई.ई.सी. 14006 में 26.42 प्रतिशत रेशे पाये गये जिसके बाद एस.बी. आई.ई.सी. 13010 में 25.45 प्रतिशत और एस.बी.आई.ई.सी. 13005 में 25.32 प्रतिशत रेशे पाये गये। एस.बी.आई.ई.सी. 14006 ने सार्वधिक 187.81 टन/हे. गन्ना उत्पादन भी दर्ज किया। एस.बी.आई.ई.सी. 13009 ने 3,672 कैलोरी/ग्राम सार्वधिक ऊर्जा मूल्य और उससे कम एस.बी.आई.ई.सी. 11007 ने 3,485 कैलोरी/ग्राम ऊर्जा मूल्य दर्ज किया।

कुल 85 सायटोप्लाज्म में विभिन्नता वाले संकर, जिन्हें सैकेरम स्पॉन्टेनियम और इरिएन्थस अरूंडिनेशिअस के मिलन से प्राप्त कर कृन्तक परीक्षण में मूल्यांकित करने पर उनमें से 6 आशावान संकरों, नामशः सी.वाई.एम. 10–784, सी.वाई.एम. 12–437, सी.वाई.एम. 14–298, सी.वाई.एम. 14–688,सी.वाई.एम. 14–884 और सी.वाई.एम. 14–887 को पूर्व क्षेत्रीय प्रजाति परीक्षण के लिये पदोन्नत कर बहुगुणन के लिये डाला गया।

एक बहुपैत्रक अग्रगामी संतति संकर जनसंख्या के बीस संस्थापक पैतृकों को सूखा सहनशीलता के लिये लगातार 2 वर्षों के लिये मूल्यांकित कर संयोजित डाटा को विश्लेषित करने पर सी.वाई.एम. 08–922 ने सूखे के हालातों में सार्वधिक औसत गन्ना उत्पादन दर्शाया जिसके साथ इसमें उच्चतर जल की मात्रा और पत्तियां क्षेत्रफल सूचकांक भी देखा गया वहीं एम.डी.ए. मात्रा भी कम पाई गई। इन गुणों के कारण इस संकर को, गन्ने की सूखा सहनशील प्रजातियों को विकसित करने में, एक संभाव्य सूखा सहनशील पैतृक के रूप में प्रयोग किया जा सकता है।

सितम्बर 2017 के दौरान झारखंड राज्य में एक अन्वेषण किया गया ताकि यहाँ की अन्वेषित न की गई सैकेरम समष्टि को संग्रहित किया जा सके। चौबीस ज़िलों की 11 मुख्य नदियों के किनारों का सर्वेक्षण कर कुल 76 एस. स्पॉन्टेनियम और एस. ऑफिश्नेरम को इकठ्ठा किया गया। कोयम्बत्तूर में कुल 2,054 जंगली जर्मप्लाज्म अभिप्राप्तियों को खेत में अनुरक्षित किया जा रहा है। एस. स्पॉन्टेनियम तथा इरिएन्थस प्रोसेरस को अरूणांचल प्रदेश से और इरिएन्थस फुल्वस एवं मिस्कैंथस जातियों को मेघालय से संग्रहित कर कुल 50 कृन्तकों को भा.कृ.अनु.प.–भा.कृ.अनु.सं.. क्षेत्रीय स्टेशन, वेलिंगटन, नीलगिरी में अनुरक्षित किया जा रहा है। संस्थान में 2,006 व्यवसायिक संकरों

(को. गन्नों) और जेनेटिक स्टॉक्स को अनुरक्षित किया जा रहा है। राष्ट्रीय सक्रिय जर्मप्लाज्म के अन्तरगत 240 प्रजातियों को अनुरक्षित किया गया और 15 कृन्तकों को सूचकांक क्रमांक दिये गये हैं। पंजाब और हरियाणा से इकठ्ठे किये गये कुल 40 जर्मप्लाज्म कृन्तकों को 42 आकारकीय गुणों के आधार पर वर्णित किया गया है।

गन्ना प्रजनन संस्थान के क्षेत्रीय केन्द्र, अगली में गन्ने के जर्मप्लाज्म की 1,271 प्रविष्टियों को खेत में, रोग रहित हालातों में, अनुरक्षित किया जा रहा है। इनमें विभिन्न जातियों वाले कृन्तक, को. कृन्तक, को. सम्बंधित कृन्तक, विदेशी कृन्तक, अन्तर जातीय और अन्तर जेनेरिक संकर कृन्तक तथा इरिएन्थस जाति, स्कलेरोस्टेकिया और नारेन्गा के कृन्तक शामिल हैं। वर्ष 2017 के दौरान, 1,271 प्रविष्टियों में से, 414 में पुष्पण देखा गया। अगली केन्द्र ने अपने लिये 71 क्रॉसेस और अखिल भारतीय समन्वित अनुसंधान परियोजना (गन्ना) के केन्द्रों के लिये 15 क्रॉसेस बनाये।

शारीरिक गुणसूत्रों की संख्या एस. स्पॉन्टेनियम के 60 कृन्तकों में जाँची गई जिनमें आई.एन.डी.–01, आई.एन.डी.–02, आई.एन.डी.–03, आई.एन.डी.–04, आई.एन.डी.–05 और आई.एन.डी.–15 संग्रहणों के कृन्तक शामिल थे। विभिन्न सायटोटाइपों में 2n= 48, 56, 60, 62, 64, 70, 72, 80 और 112 वाले पहचाने गये। इ. अरूंडिनेश्यिस के 204 कृन्तकों का जब सायटोलोजिकल डाटा संकलित किया गया तो तीन सायटोटाइपों को पहचाना गया जो 2n=30, 2n=40 और 2n=60 वाले थे। अधिकांश कृन्तक 2n=60 (षट्गुणित) वाले थे जिसकी बारंबारता 60.0 प्रतिशत थी।

अजैविक तनावों के प्रति सहनशीलता के लिये कोयम्बत्तूर में गन्ने के जर्मप्लाज्म के एक समूह को मूल्यांकित किया गया है। आई.एन.डी. 08–1491, आई.एन.डी. 99–847, आई.एन.डी. 99–848, आई.एन.डी. 99–849, आई.एन.डी. 99–863, आई.एन.डी. 99–882, आई.एन.डी. 02–1186 एस.इ.एस. 121ए. को सूखे के तनाव के हालातों में बेहतर पाया गया। इ. अरूंडिनेश्यिस के 208 कृन्तकों में से 15 को सूखा सहनशील पाया गया।

गन्ना उत्पादन व रस की गुणवत्ता के लिये विभिन्न आनुवांशिक आधारों वाले अन्तर जातीय संकरों को मूल्यांकित किया गया। गन्ने के वजन के लिए विभिन्नता उन्नत पैतृकों x को. प्रजातियों की तुलना में इनके विपरीत संयोजनों को. प्रजातियों x उन्नत पैतृकों में अधिक पाई गई। इन मूल्यांकनों के आधार पर बेहतर गन्ना भार, शर्करा प्रतिशत और लाल सड़न रोग प्रतिरोधिता वाले 9 संकरों को पूर्व क्षेत्रीय प्रजाति परीक्षण के लिये चुना गया।

को. 7201 प्रजाति में से सी.ई.एन.एच.3 जीन को विलगित कर परिवर्धित किया गया। अधिकतर गुणसूत्रों में सी.ई.एन.एच.3 जीन को सेंट्रोमेरिक क्षेत्र में पाया गया। एनाफेस चरण में लैगिंग गुणसूत्रों में संकेतक का न पाया जाना सी.ई.एन.एच.3 की भूमिका को गुणसूत्र के निष्कासन में इंगित करता है।

एस. स्पॉन्टेनियम के विभिन्न सायटोटाइपों की भागीदारी से प्राप्त 45 संकरों को लाल सड़न रोग प्रतिरोधिता के लिये जाँचने पर 23 को मध्यम प्रतिरोधी व 3 को प्रतिरोधी पाया गया। पैंतीस बी.सी. 1 संकरों में, जिन्हें 2n=40 सायटोटाइपों से विकसित किया गया था, गुणसूत्रों का परिगमन एन + एन की ओर इशारा करता है।

दो अन्तर जेनेरिक संकरों, को. 86032 x ज्वार और ज्वार x सैकेरम, का जिनोमिक इन सिटू संकरण तकनीक द्वारा विश्लेषण करने पर ज्वार के 8 गुणसूत्रों को पाया गया। ज्वार के गुणसूत्रों का शीघ्र संघनन देखा गया।

छः मुख्य सुक्रोज चयापचय एन्जाइमों (एन.आई., सी.डब्लयू.आई., पी.पी.एफ. के, पी.एफ.के., एस.ए.आई. और एस.आर.इ.बी.एफ.) के लिये 44 माइक्रोसेटेलाइट मारकरों को विकसित किया गया जिन्हें जर्मप्लाज्म के एक दल पर अज़माया गया जिनमें 26 भारतीय को. गन्ने, 9 एस. ऑफिशिनेरम, 3 एस. स्पॉन्टेनियम, 2 इ. अरूंडिनेश्यिस व्युत्पाद और 1 अन्तर जातीय संकर कृन्तक शामिल थे। एस.एस.आर. विकल्पिक डाटा के आधार संरचना विश्लेषण करने पर 3 अलग अलग जनसंख्या वर्गों का पता चला। औसत अल्फा मूल्य 0.1019 इस ओर संकेत करता है कि अधिकतर उच्च शर्करा वाले जीनप्ररूप केवल कुछ ही पैतृक जातीय कृन्तकों से उत्पन्न हुए।

गन्ने में जल की कमी के तनाव के लिए क्रियात्मक जीनोमिक्स के अध्ययनों में को. 06022 और को. 8021 के आर.एन.ए. अनुक्रमिक डाटा का विश्लेषण करने पर विभिन्नता उत्पादक जीनों (DEGs) में फोल्ड बदलाव 13.00 से 1.00 तक देखा गया। सहनशील प्रजाति को. 06022 में संवेदनशील प्रजाति के मुकाबले सूखे के कारण प्रेरित हुए ट्रान्सक्रिप्टोम में ऊपर की तरफ विनियमित हुए, 6 दिन दिनों के तनाव के बाद,कुल प्रतिलिपियों की संख्या सार्वधिक 8,030 थी। यह संख्या 2 दिन के तनाव के बाद 5,581 और 10 दिन के बाद 3,499 देखी गई।

गन्ने (654) में नवीनतम एमआई आर.एन.ए., जो ऑक्सिडेटिव तनाव से जुडे थे, जिनकी मिलने की संभावना थी, और कुछ विशिष्ट एमआईआर.एन.ए. की प्रजातियाँ ऑक्सिडेटिव प्रतिक्रिया के बाद सार्थक अंतरात्मक जीन अभिव्यक्ति दर्शाते है। 17 विशिष्ट एमआई आर.एन.ए और 1,175 विशिष्ट क्षेत्रों को पहचाना गया तथा उनमें से कई पादप तनाव सहनशीलता से सम्बंधित थे।

क्लस्टर रेगुलरली इंटरस्पेस्ड सोर्ट पेलिंनड्रोमिक रिपीट्स सीएएस (सी.आर.आई.एस.पी.आर.–सी.एएस) का प्रयोग करके गन्ने के जीनोम को ठीक तरंह से सम्पादित करने की प्रयास किये गये, पुष्पण वाले और न पुष्पण वाले कृन्तकों से जीनों का विगलन एवं अभिव्यक्ति की गई। तीन प्राइमरों के समूह, नामशः ;डी.एल.एफ.1 (देर से पुष्पण वाले), टी.एल.एफ.1 (आखिरी स्थान पर पुष्पण वाले) और आई.डी.1 (जिनमें वृद्धि चलती रही) ने पुष्पण और गैर–पुष्पण वाले कृन्तकों के बीच विभिन्नता दशाते है।

लवणता तनाव के हालातों में कुल 14 एस. स्पॉन्टेनियम कृन्तकों को सहनशील को. 89029 और संवेदनशील को. 89003 को. गन्नों के साथ मूल्यांकित किया गया। अभिव्यक्ति अध्ययनों ने सिद्ध किया कि प्रतिलेखनकारक एम.वाई.बी. 2.5 प्रतिशत तनाव पर अभिव्यक्ति बढ़ी जबकि 5 प्रतिशत और 10 प्रतिशत पर धीरे धीरे गिरावट देखी गई, इन स्तरों से लगता है कि लवणता प्रतिक्रियाशील जीनों को उत्तेजित कर दिया।

गन्ने में महत्वपूर्ण गुणों के लिये आनुवांशिक नियन्त्रण और जीनोमिक चयन पर इन्डो–आस्ट्रेलियन परियोजना के अन्तरगत सूखा सहनशीलता सम्बंधित मापदण्डों के लिये लक्षण समष्टि का कार्य दो द्विपैतृक जनसंख्या के लिये किया गया है। ब्रिक्स और पोल प्रतिशत का विश्लेषण, आर. और एस.ए.एस. का प्रयोग कर सर्वोत्तम रेखीय निष्पक्ष आगामी कथन विधि से और एक बार उच्च सर्वोत्तम रेखीय निष्पक्ष आगम कथनों (समान्य एवं सूखे के हालातों में) वाले कृन्तक पहचाने गये।

वास्तविक बीज पद्धति में विभिन्न अंतरजातिय सन्ततियों की जनसंख्या की संरचना का विश्लेषण करने पर 1148–एस.4–242 के एस.5 और एस.6 संततियों के सैल्फों में उपजनसंख्या की पहचान की गई जिनका उच्च निर्धारण सूचकांक 0.88 था और जीन का धारा प्रवाह (एन.एम 0.03) निमन्न स्तर का था, जो अलग अलग होते हुए भी उनके समरूपी होने की उच्च सम्भावना की ओर इंगित करते हैं। संकरण द्वारा विकसित संकरों और चयनित अंतरजात पैतृकों को मूल्यांकित किया गया और इनमें विभिन्न स्तरों की आनुवांशिक एकरूपता देखी गई। बीस अधिक विभिन्नता वाले पैतृकों के बीच क्रॉसेस बनाकर 60 बीज जनित पौधों को उत्पादित किया गया।

बीज/पौध जनित रोगजनकों के विरूद्ध जैवनियन्त्रक ऐजेंटों की प्रतिरोधी क्षमता और प्रयोगशाला में बीज/पौध जनित रोगजनकों के व्यवसायिक कवकनाशियों की प्रभावकारिता का मूल्याकंन किया गया था। वास्तविक बीजों से जनित पौधों के लिये कृषि तकनीकों को मानकीकृत किया गया है। सत्य बीज जनित पौध के लिए नई शस्य तकनीको को पंक्ति अंतराल व रोपण की गहराई और नई पीढ़ी के तृणनाशकों द्वारा एकीकृत खरपतवार प्रबंधन मानित किया गया। प्रत्येक पुष्प से प्राप्त फलफ का औसत भार, फलफ/पुष्प का भार, 100 फलफ बीजों का औसत बीज भार, 100 रूओं रहित बीज का औसत भार और फलफ बीजों का औसत अंकुरण अनुमानित किया गया।

फसल उत्पादन

हाइड्रोपोनिक्स प्रणाली में तीन लोकप्रिय व्यवसायिक संकरों, नामशः को. 06022, को.सी. 671 और को. 86032 में जड़ों की क्षति की प्रतिक्रियाओं का अध्ययन किया गया। दी गई किस्मों में जड़ों की क्षति में अंतरात्मक परिणाम देखे गये। क्षति के 10 दिन बाद को. 06022 में द्वितीयक जडों की वृद्धि को देखा गया, जबकि को. 86032 और को.सी. 671 में इनके निकलने में केवल 3 ही दिन लगे। पोली इथिलीन ग्लाइकोल को हाइड्रोपोनिक्स के जल में डाले जाने के प्रभाव का अध्ययन दो प्रजातियों, को. 99004 और को. 85019 में किया गया। पोली इथिलीन ग्लाइकोल का 5 प्रतिशत और 10 प्रतिशत गन्ने के पौधों के लिये एक झटके की तरंह था। उपचार के 48 घंटे के भीतर ही नये पत्तों का सूखना व निर्जलीकरण देखा गया। इस उपचार के कारण प्रोलीन की मात्रा, पत्तों के ऊपर मोम और जड़ों में परऑक्सीडेस में वृद्धि देखी गई।

भा.कृ.अनु.प.– भारतीय गन्ना अनुसंधान संस्थान, लखनऊ से आई.आई.एस.आर. मॉडल की डिस्क टाइप रेटून प्रबंधन मशीन और दोहरी पंक्ति ट्रैन्च टाइप गन्ना कटर प्लांटर को मूल्यांकन के लिये खरीदा गया। खेत में गन्नों को खड़ी स्थिति में रोपित करने के लिए हास्तचलित गन्ने के बीज टुकड़ों से उगाये गये पौधों को रोपित करने के लिये यन्त्र को निर्मित किया, इस प्रक्रिया में अरूचिकर कमी का अहसास हुआ।

गन्ने से स्वतंत्र जीवन निर्वाह करने वाले, जड़ों से सम्बद्ध और आसमानी भागों पर पाये जाने वाले बैक्टीरियाओं को विलगित किया गया। शुरूआती अध्ययनों में गन्ने के अंकुरण एवं नवीन पौधों के जोश पर इन विलगनों का अच्छा प्रभाव देखने को मिला।

दूब घास को नियन्त्रित करने के लिये ग्लाइफोसेट (7.5 मिलिलिटर/लिटर जल) का लक्षित स्थान पर ही स्प्रै करने के लिये टोपीदार नोक का प्रयोग प्रभावी पाया गया।

एक क्वाड कोप्टर ड्रोन (डी.जे.आई.–फैन्टम 3 मॉडल जिसमें 4I विभेदन वाला एफ.सी. 330 x कैमरा) को गन्ने के स्वस्थ पत्तों और लाल सड़न रोग ग्रसित पौधों के पत्तों के खेतों से चित्र खींचने के लिये प्रयोग किया गया। चित्रों के विभिन्न रंगों की परिपूर्णता ह्यू सैचूरेशन मूल्यों और वाई.सी.बीसी. आर मूल्यों ने लाल सड़न रोग ग्रसित पौधों के पत्तों को स्वस्थ पत्तों से साफतौर पर अलग पहचान लिया। गन्ने की फसल के खेत से लिये गये चित्रों को मल्टीस्पैक्ट्रल कैमरे (माइका सेंस रैड ऐज), जो ड्रोन (डी.जे.आई. –इन्सपायर 1) के साथ फिट था, द्वारा लिया गया था जिनके वानस्पतिक सूचकांकों को प्रतिचित्रित, पी.आई.एक्स.4डी. और एम.आई.सी.ए. एस.ई.एन. एस.ई.–ए.टी.एल.ए.एस सॉफटवेयरों की मदद से किया गया। अनुकूलतम किये गये मृदा समायोजित वानस्पतिक सूचकांक के उच्च मूल्य घनी और स्वस्थ वनस्पती का इशारा करते हैं जबकि कम मूल्य कमज़ोर फसल का इशारा करते हैं।

प्रजातियों के बीच और सिंचाई उपचारों के बीच गन्ना उत्पादन सार्थक रूप से भिन्न भिन्न देखा गया। गन्ना उत्पादन में समान्य के मुकाबले 41 प्रतिशत की गिरावट सिंचाई जल में 50 प्रतिशत कटौती के कारण देखी गई जबकि सिंचाई की संख्या में 50 प्रतिशत कटौती से गन्ना उत्पादन में 55 प्रतिशत की गिरावट देखी गई। सिंचाई जल में कटौती मोटे तौर पर गन्ना उत्पादन में कमी के साथ मेल खाती प्रतीत होती दिखाई दी। को. 8371, को. 10026, को. 85019, को. 86010, को. 86249, को. 99004 और को.लख. 8102 में दोनों तरंह से जल में 50 प्रतिशत की कटौती से दूसरों के मुकाबले अधिक गन्ना उत्पादन देखा गया। सिंचाई जल में 50 प्रतिशत कटौती के स्तर पर 12 प्रजातियों ने गन्ना उत्पादन के औसत के मुकाबले अधिक उत्पादन दर्शाया जो प्रजातियों की वर्तमान क्षमता को उपयोग में लाने की सलाह देता है।

गन्ना उत्पादन, सिंचाई जल की प्रयोगात्मक कार्य कुशलता, जल उत्पादकता और एफवी/एफएम ने सार्थक विभिन्नता, न केवल अध्ययन किये गये सिंचाई उपचारों के मध्य बलकि प्रजातियों के मध्य भी दर्शाई। कटाई के समय रस में शर्करा: में विभिन्नता केवल प्रजातियों के मध्य देखी गई, सिंचाई उपचारों के मध्य नहीं। को. 10026, को. 13006, को. 85019, को. 86010, को. 86249, को. 99004 और को.लख. 8102 ने दोनों कम सिंचाई वाले उपचारों

में, प्रजातियों की औसत के मुकाबले, सार्थक रूप से उच्च सिंचाई जल की प्रयोगात्मक कार्यकुशलता दर्शाई। कम सिंचाई वाले उपचारों के कारण जल उत्पादक्ता में सार्थक कमी साफतौर पर दिखाई देती है कि सिंचाई जल की मात्रा का फसल उतपादन पर सीधा प्रभाव पड़ता है। प्रजातियों में से को. 8371 में उच्च 4.18 की औसत जल उत्पादकता दर्ज की गई जिसके बाद को. 85019 ने 3.92 का आंकड़ा दर्ज किया गया। सिंचाई जल में 50 प्रतिशत कटौती वाले उपचार में छः प्रजातियों, नामशः को. 0212, को. 0218, को. 10026, को. 85019, को. 86249 और को.वी. 92102, ने 4 से अधिक जल उत्पादक्ता दर्ज की। उच्च गन्ना उत्पादन, रस में शर्करा:, जैव भार, सिंचाई जल की प्रयोगात्मक कार्यकुशलता और जल उत्पादक्ता के कारण को. 8371, को. 10026, को. 13006, को. 85019, को. 86010, को. 86249, को. 95020, को. 99004 और को.लख. 8102 में सीमित सिंचाई जल की उपलब्धता के हालातों में अच्छा प्रदर्शन करने की क्षमता है।

को. 99004 में निर्माणात्मक प्रवस्था के दौरान मैरिस्टेमैटिक ऊतकों में ट्रान्सक्रिप्टोम अनुक्रमण, इल्लयूमिना एच.आईएस.ईक्यू 2500 प्लेटफार्म का प्रयोग कर, समान्य एवं उच्च तापमान तनाव के हालातों में किया। करीब 59.6 प्रतिशत संकलित प्रतिलिपियों में लम्बाई लगभग 200 से 5000 बीपी तक देखी गई। संकलित ट्रान्सक्रिप्टोम में से सबसे लम्बी प्रतिलिपी 21,435 बीपी की थी जिसकी एस. ऑफिश्नेरम से प्राप्त एक प्रोटीन मेचुरेस के. साथ 99 प्रतिशत समरूपता देखी गई। इसे एन.सी.बी.आई. को प्रस्तुत कर प्रवृष्टि क्रमांक एन.सी.बी.आई. 49659490 प्राप्त हुआ है।

तेतीस गन्ने के जीनप्ररूपों की विकिरण प्रयोगात्मक क्षमता का अध्ययन करने पर पता चला की उच्च जैव भार वाले जीनप्ररूपों ने परिपक्वता प्रवस्था के दौरान प्रकाश संश्लेषण में क्रियाशील विकिरणों का 70 प्रतिशत से अधिक प्रकाश अवरोधन दिखाया। सीमित सिंचाई के हालातों में समान्य के मुकाबले कम प्रकाश अवरोधन देखा गया। समान्य सिंचाई के मुकाबले सीमित सिंचाई के हालातों के कारण जैव भार में आई सार्थक कमी ने विकिरण प्रयोगात्मक क्षमता को घटाने में अपना योगदान दिया। जीनप्रारूपों में से को. 62175, को. 85019, को. 95020 और को. 99004 ने समान्य हालातों में 1.0 ग्राम/मेगाजूल विकिरण प्रयोगात्मक क्षमता दर्ज की। सीमित सिंचाई के हालातों में को. 0212, को. 12006, को. 13006, को. 85019, को. 86249, को. 94008 और को.एम. 0265 ने बेहतर विकिरण प्रयोगात्मक क्षमता दर्ज की।

सॉफ्टवेयर को निर्णय लेने में सहायक प्रणाली के सॉफ्टवेयर को आधुनिकृत किया गया। एक प्रमुख मॉडयूल के साथ, जिसमें भविष्य में स्थापित करने के विकल्प थे और कार्य करने वाला निर्णय लेने में सहायक प्रणाली मॉडयूल था, उसे विंडो 10 के प्लेटफार्म पर परीक्षित किया गया। इस सॉफ्टवेयर को खेत कर्मचारियों, गन्ना अधिकारियों और सूचना प्रौद्योगिकीविदों के समक्ष प्रदर्शित कर 12 दिसम्बर 2017 को अभिग्रहण के लिये लोकार्पित किया गया।

निर्णय लेने में सहायक प्रणाली सॉफ्टवेयर में 670 मृदा परीक्षण के नतीजों को आयातित किया गया। किसानों के मृदा स्वास्थ कार्ड बनाकर गन्ने की समग्र कार्यप्रणालियों के साथ इन्हें चीनी मिलों के द्वारा भेजा गया।

परीक्षण प्रमाणिकरण जाँच अप्रैल 2017 से फरवरी 2018 के बीच को. 86032 के साथ लगाई गई। इस परीक्षण में उर्वरको को परम्परागत विनियोग विधि और मुठ्ठी से खाद डालने की विधि द्वारा दो मुख्य प्लाटों में रखा गया। तीन खादों की मात्रायें 280 : 62.5 : 120, 366 : 22 : 56 और 537 : 80 : 214 किलोग्राम (नेत्रजन : फास्फोरस : पोटाश) को दो से छः हिस्सों में बांटकर दोनों प्लाटों में दिया गया। मुठ्ठी से खाद डालने की विधि से 114.6 टन/हे. गन्ना उत्पादन अनुमानित किया गया जो परम्परागत विनियोग विधि से 9.1 प्रतिशत अधिक था। उर्वरकों की सबसे अधिक मात्राओं, 537 : 80 : 214 किलोग्राम (नत्रजन : फास्फोरस : पोटाश) को रोपण के 180 दिनों बाद तक डाला जाता रहा जिससे सबसे अधिक औसत गन्ना उत्पादन 133.4 टन/हे. दर्ज किया और जिसके बराबर इसी मात्रा को 120 दिनों तक डालने पर भी करीब उतना ही उत्पादन 131.4 टन/हे. प्राप्त हुआ। आमतौर पर उर्वरकों की बढ़ती मात्रा और अधिक हिस्सों में बांटने से गन्ना उत्पादन में सार्थक बढ़ोतरी देखी गई।

विभिन्न कार्बनिक सबस्ट्रेटों (अवशेष खाद, कृषि क्षेत्र की खाद, वर्मीकम्पोस्ट और जैविक खाद) को कृषि क्षेत्र की खाद– 25 टन/हे. की दर के कार्बन समतुल्य डाला गया। कृषि क्षेत्र की खाद के इस स्तर पर समान्य के मुकाबले उच्च कार्बन डाइऑक्साइड प्रवाह (µ मोल/मीटर^2/सैकन्ड) देखा गया। सबस्ट्रेटों में से जैविक खाद के उपयोग से निमन्न स्तर का कार्बन डाइऑक्साइड प्रवाह पूरे परीक्षण अवधि के दौरान देखा गया, केवल अक्तूबर 2017 को छोड़कर जब इसमें सार्वधिक प्रवाह देखा गया।

जिप्सम वाले परीक्षण में, बिना जिप्सम वाले कन्ट्रोल में जिप्सम उपचारों के मुकाबले कार्बन डाइऑक्साइड का प्रवाह उच्च स्तर का देखा गया। कार्बन डाइऑक्साइड प्रवाह, रोपण के 45 दिन बाद, 3.24, 3.94 और 3.51 µमोल/मीटर^2/सैकन्ड फसल वाले प्लाटों में क्रमशः जिप्सम 100 प्रतिशत जी.आर., जिप्सम 50 प्रतिशत जी.आर. के उपचार और कन्ट्रोल में देखा गया।

कार्बनिक सबस्ट्रेटों (अवशेष खाद, कृषि क्षेत्र की खाद, वर्मीकमपोस्ट और जैविक खाद) का कार्बन के विभिन्न पदार्थों में प्रभाजन करने पर खाद बनने की विभिन्न प्रवस्थाओं पर फुल्विक अम्ल और ह्यूमिक अम्ल प्राप्त हुए। जैविक खाद में दूसरे कार्बनिक पदार्थों के मुकाबले सबसे ज़्यादा खाद बनना देखा गया, जो ई.4/ई.6 अनुपात पर आधारित है।

इरोड ज़िले के भवानी, अन्तियूर और गोबीचेत्तीपाल्यम तालूकों से 6 मृदा प्रोफाइलों का लक्षण वर्णन किया गया। चिन्नापालयम के प्रोफाइल में चार क्षैतिज खंड देखे गये मगर पैतृक पदार्थ 1.2 मीटर की गहराई तक भी नहीं मिला। चिन्नाकालियूर में एक गहरा मृदा प्रोफाइल मिला जहाँ चार क्षैतिज परतें पाई गई और पैतृक पदार्थ 1.6 मीटर की गहराई के नीचे मिला। बाकी चारों मृदा प्रोफाइलों की गहराई 1 मीटर से अधिक थी।

संकारागौंदन पालयम, ब्रम्मादेसम, नतिपालयम और चिन्नाकालियूर के मृदा प्रोफाइलों की सभी परतों में क्षारीय प्रतिक्रिया देखी गई। चिन्नापालयम और वयरामंगलम के मृदा प्रोफाइलों की सभी परतों में पीएच. 8.5 से नीचे रही,

केवल वयरामंगलम के 0.22 और 0.36 मीटर गहराई वाली परतों को छोड़कर। सभी मृदायें लवणीय नहीं थी।

ब्रम्मादेसम में मृदा भेदन प्रतिरोधिता के आंकड़ों से पता चला की यहाँ 10 सेंटीमीटर से नीचे की गहराई पर ही कठोरपन शुरू हो गया, जबकि कठोरपन की शुरूआत नतिपालयम में 25 सेंटीमीटर औरचिन्नाकालियूरव वयरामंगलम में 35 सेंटीमीटर के नीचे ही प्रारम्भ हुई। भेदन प्रतिरोधिता का स्तर 2 मेगापास्कल के आसपास था जो इस बात की ओर इशारा करता है की यह जड़ों की नीचे की तरफ वृद्धि को सीमित करेगा। मृदा तल के नीचे संकारागाँदन पालयम और चिन्नापालयम में कठोरपन नहीं देखा गया।

मृदा की गहराई के साथ मृदा प्रोफाइल के सूखे स्थूल घनत्व का पूर्वानुमान लगाने के लिये एक मॉडल विकसित किया गया, जिसके लिये बनावटी न्यूरल नेटवर्क, पाँच डाली गई समग्री की परतों जिनके साथ दो छिपी हुई परतें, क्रमशः 1.5 ओर 1.0 नोड वाली थी। इस विकसित मॉडल ने प्रशिक्षण एम.एस. ई. 0.126 और मान्यकरण एम.एस.ई. 0.066 दिखाया।

नत्रजन, फास्फोरस और पोटाश की पारस्परिक प्रयोगात्मक क्षमता में को. 11001 को दूसरी उन्नत प्रजाति परीक्षण की अगेती प्रविष्टी (2016–17) को. 11004 से अधिक कार्यकुशल पाया गया। मानक को. 85004 को सभी अगेती उन्नत प्रजाति परीक्षण की को. प्रविष्टियों और मानकों से फास्फोरस के लिये अधिक कार्यकुशल पाया गया। मानक को.सी. 671 को सभी अगेती उन्नत प्रजाति परीक्षण की को. प्रविष्टियों और मानकों से पोटाश के लिये अधिक कार्यकुशल पाया गया।

नत्रजन, फास्फोरस और पोटाश की पारस्परिक प्रयोगात्मक क्षमता में को. 11019 को दूसरी उन्नत प्रजाति परीक्षण की मध्यम देरी की प्रविष्टियों (2016–17), नामशः को. 11005, को. 11007 और को. 11012 तथा मानकों को. 86032 व को. 99004 से अधिक कार्यकुशल पाया गया।

जी.एफ.पी. फ्यूस्ड एस.एचआई.एन.एच. 2 का चलायमान प्रकटन विश्लेषण से पता चला की एस.एचआई.एन.एच.2 वैक्योल में स्थित प्रोटीन है जो एस. एचआई.एन.एच.2 के इनसिलिको विश्लेषण में पूर्वानुमानित की गई प्रोटीन (प्रीडिसी ओर सिगनल पी.), में एन.–टरमिनल सिगनल पैपटाइड पर स्थित, के अनुरूप है।

फसल सुरक्षा

फसल सुधार परियोजनाओं और कन्नूर से कुल 3,075 कृन्तक, जो क्लोनल परीक्षणों से, पूर्व क्षेत्रीय प्रजाति परीक्षण, पैतृक कृन्तक, जी.यू.के./डब्लयू.एल. कृन्तक, जी.यू. कृन्तक, जर्मप्लाज्म, बातावरण लचीले कृन्तक और उच्च जैव भार वाले संकरों को लाल सड़न रोग प्रतिरोधिता के लिये नियन्त्रित हालात में सी.एफ06 (सी.एफ671) रोगजनक के विरुद्ध परीक्षित किये गये। इनमें से करीब 1,598 कृन्तकों को प्रतिरोधी या मध्यम प्रतिरोधी पाया गया। जिन 11 प्रजातियों को, सी. फाल्केटम के विलगनों को दानों द्वारा इनाक्यूलम देकर परीक्षित किया गया, उनमें को. 0403 और को. 0238 को रोगजनक संक्रमण से मुक्त पाया गया जो दर्शाता है की इनमें सभी 11 विलगनों के विरुद्ध प्रतिरोधी क्षमता उपलब्ध है।

सी. फाल्केटम के करीब 35 विलगनों का गन्ने की 31 प्रजातियों पर रोगजनक व्यवहार के लिये परीक्षण करने पर उनकी उग्रता में अत्याधिक विभिन्नता देखी गई। इस वर्ष पिछले वर्षों के मुकाबले अधिक विलगनों की उग्रता में कमी देखी गई। अतिसंवेदनशील प्रजातियों, जैसे कि को. 94012, को. 95020 और को.सी. 671, को विलगनों के विरुद्ध कम संवेदनशील पाया गया, अतः इस मौसम के दौरान विलगनों की उग्रता का कम प्रकटन देखा गया। दो पुराने विलगनों, नामशः सी.एफपी.आई.1401 – कदागनूर और सी. एफवी 09356 – कीरानगुडी, ने 19 गन्ना विभेदकों पर संदर्भ रोगजनकों के मुकाबले अधिक उग्रता दर्शाई।

स्पोरिसोरिअम साइटेमिनिअम के प्रतिनिधी विलगनों के लक्षण समष्टि आधारित कंडुआ रोगजनक विलगनों, जिनकी उग्रता में भिन्नता थी, के सुस्पष्ट समागम वर्गों वाले संवर्धनों (+ और –) को सुनिश्चित किया गया। समागम वर्ग विशिष्ट जीनों को लक्षित करने वाले पी.सी.आर. प्राइमरों ने रोजनक के उल्टे समागम वर्गों (+ और –) को सुस्पष्टता से पहचाना।

माइसिलियम से प्राप्त करीब 27 प्रोटीनों में से 8 सेक्रिटोम और 12 मेज़बान–रोगजनक अन्तःक्रिया के दौरान, रोगजनकता से सम्बंधित, जीनों को एस.एस.एच. पद्यति द्वारा पहचाना गया। प्रोटिओमिक्स में बी.वाई.एस 1 परिवार प्रोटीन, दो मिथाइलट्रान्सफरेसेस और 3–आइसोप्रोपाइलमैलेट डीहाइड्रोजिनेस को आमतौर पर माइसिलियम के प्रोटिओम, सीकरेटोम और मेज़बान–रोगजनक अन्तःक्रिया के दौरान पहचाना गया।

नवीन एमआईआर.एन.ए.ओं, नामशः आर.सी.–799, आर.6–827, आर. 24–1,288, एस.सी.–960, एस.6–682 और एस.24–456, को गन्ना और सी. फाल्केटम के बीच अन्तःक्रिया के दौरान पहचाना गया। इन विभिन्न एमआईआर.एन.ए.ओं का लक्ष्य विश्लेषण करने पर कई सारी लक्षित जीनों का विभिन्न तनाव प्रतिक्रियाओं में उनकी भागीदारी का पता चला, जैसेकि हारमोन द्वारा इशारा करने के पथों, अतिसंवेदनशील प्रतिक्रियाओं, कैल्शियम इशारा करने की क्रिया, अन्य इशारा करने वाले झरने (कैसकेड), रोग प्रतिरोधिता और प्रतिलिपि बनाने वाले घटकों का।

दो प्रभावी प्रोटीनों, नामशः साइटोक्रोम पी.450 और एच.एस.पी. 20, जो सी. फाल्केटम के उग्र विलगन विशिष्ट थे, को मेज़बान–रोगजनक अन्तःक्रिया के दौरान उच्च नियन्त्रित पाया गया जबकि दूसरी तरफ इन्हें मेज़बान, रोगजनक और विरोधी ट्राइकोडर्मा हारजीएन्म के बीच त्रिघटक अन्तःक्रिया के दौरान नीचे की ओर नियन्त्रित पाया गया। साइटोक्रोम पी.450 को कवकनाशी प्रबंधन के लिये क्षमतावान लक्षित स्थान के रूप में पहचाना गया, जिस कार्य के लिये चिन्हित प्रोटीन के अवरोधक के रूप में एज़ोल कवकनाशी का प्रयोग किया गया।

पौधे में अस्थाई प्रकटन विश्लेषण के आधार पर एस. साइटेमिनियम के 5 सम्भावित प्रत्याशियों ने प्रभावोत्पादक प्रोटीनों (सी.एस.ई.पी.एस), कोडिंग

जीनों, को स्त्रावित किया जिनमें से पी.ई.पी.1का प्रकटन सार्थक रूप से अधिक देखा गया।

बीज टुकड़ों से जन्में फुज़ेरिअम सेकेराई के संक्रमण से अति तीव्र विल्ट प्रकटन को. 86010, एम.एस. 68/47, सी. 79218, 69 ऐ. 591 इत्यादि प्रजातियों में देखा गया। पोक्काह बोइंग को भी 13 अध्ययन की गई प्रजातियों में से अधिकतर में दर्ज किया गया, मगर रोग विकास कहीं कहीं था, अतः बीज टुकड़ों से जन्मे संक्रमण ओर रोग विकास में कोई सम्बंध सुनिश्चित न किया जा सका।

एफ. सेकेराई के 9 विलगनों में से एफ.एस 86010, एफ.एसएम.एस.901, एफ. एसई.बी.09004 ओर एफ.एस 419 को विभिन्न प्रजातियों पर अधिक रोगजनक पाया गया जबकि प्रजातियों में से एम.एस. 901 और को. 98010 को विभिन्न विलगनों से संवेदनशील पाया गया। कुल मिलाकर प्रजातियों में विभिन्न विलगनों से रोगजनकता ने मेज़बान प्रजातियों और परीक्षित रोजनक विलगनों के बीच स्पष्ट विभेदक अन्तःक्रिया दर्शाई।

गन्ने में पीली पत्ति रोग के साथ फाइटोप्लाज्मा के जुड़े होने को संदिग्ध माना गया है उसे एस.सी.जी.एस. फाइटोप्लाज्मा (सी.ए पी. ओरिज़ा, 16 एस.आर XI & बी) पाया गया न कि पीली पत्ति फाइटोप्लाज्मा। केवल गन्ने में पीली पत्ति विषाणु को पीली पत्ति रोग के साथ सम्बंधित पाया गया है। को.एस 88230 में इफिक्लासिफायर का प्रयोग करते हुए इन सिलिको आर.एफ.एल. पी. के आधार पर एस.सी.जी.एस. फाइटोप्लाज्मा के एक नये उपवर्ग को पहचाना गया है।

रस्ट संक्रमण के लिये जाँचे गये 275 गन्ना कृन्तकों में से 18 कृन्तक संवेदनशील वर्ग में रखे गये, 35 को मध्यम संवेदनशील वर्ग और 56 को मध्यम प्रतिरोधी वर्ग में रखा गया। फसल मौसम के दौरान 160 से अधिक प्रविष्टियों को रस्ट के संक्रमण से मुक्त पाया गया।

एस. ऑफिश्नेरम कृन्तकों एवं अन्य खेती की जा रही किस्मों के बीज टुकड़ों का केवल गर्म पानी से या पोषक तत्वों के साथ उपचार के लिये बनाये गये यन्त्र की उपयोगिता को प्रमाणित कर दिया गया है।

प्रयोगशाला में काइटोसान (सी.एस.) से ढके नैनोकणों से बी.टी.एच. और एस. ए. अणुओं के निर्गमन को 3 विभिन्न पीएच. स्तरों पर मूल्यांकित किया गया। परिणामों में पाया गया की 3.2 पीएच. पर बी.टी.एच. और एस.ए. अणुओं का निर्गमन 41 घंटों बाद शुरू हुआ और 72 घंटों तक चलता रहा जबकि पीएच. 4.2 और 5.2 पर निर्गमन केवल 74 घंटों बाद ही शुरू हुआ।

गन्ने में सी.एस. से ढके बी.टी.एच. और एस.ए. के नियमानुसार अर्जित की गई प्रतिरोधिता (नि.अ.प्र.) प्रेरित गुण को लाल सड़न रोग, कंडुआ रोग ओर विल्ट रोग के विरुद्ध परीक्षित किया गया। सी.एस. से ढके बी.टी.एच. नैनोकणों से उपचारित बीज टुकड़ों का अंकुरण स्वस्थ कन्ट्रोल के बराबर था जबकि सी. एस. से ढके एस.एच. नैनोकणों से उपचारित बीज टुकड़ों का अंकुरण स्वस्थ कन्ट्रोल से 7 से 26 प्रतिशत तक कम था वहीं रोगजनक से इनाक्यूलेट किये गये कन्ट्रोल में बीज टुकड़ों का अंकुरण 14 से 27 प्रतिशत तक कम था।

लाल सड़न रोग परीक्षण में सी.एस.–नि.अ.प्र. प्रेरित नैनोकणों से उपचारित किसी भी पौधे में रोपण से 90 दिनों बाद तक रोग के कोई लक्षण दिखाई नहीं दिये थे जबकि रोगजनक से इनाक्यूलेट किये गये कन्ट्रोल में रोग के लक्षण 33.3 प्रतिशत पौधों में देखे गये।

खेत में तीन प्रजातियों की विषाणु–युक्त और विषाणु–मुक्त रोपण समग्री से रोपित की गई फसलों के तुलनात्मक अध्ययन से पीली पत्ति रोग के प्रभाव को गन्ने की वृद्धि और गन्ना उत्पादन पर अनुमानित किया गया। विषाणु संक्रमण के कारण गन्ना उत्पादन में 18.5 से 40.7% तक की कमी आइे जबकि रस उत्पादन में 42.1 प्रतिशत से 50.0 प्रतिशत तक की कमी आई। एफिड जनसंख्या की गतिकी को गन्ने की विभिन्न प्रजातियों में 6 महीने के लिये अप्रैल से सितम्बर 2017 तक निरीक्षित किया गया। जून के महीने में सभी प्रजातियों में एफिड जनसंख्या उच्च पाई गई जबकि इसके बाद जुलाई अन्त/अगस्त में इसमें धीरे धीरे गिरावट देखी गई।

परम्परागत आर.टी.–पी.सी.आर ओर क्यूआर.टी.–पी.सी.आर. का प्रयोग कर गन्ने के पच्चीकारी विषाणु और गन्ने के धारीदार पच्चीकारी विषाणु के लिये आर.टी.–एल.ए.एम.पी. परख विकसित कर पच्चीकारी रोग निदान के लिये मानकीकृत की गई है।

विभिन्न ऊतक संवर्धन इकाईयों, नामशः तमिलनाडु से मैसर्स ई.आई.डी. पैरी, पुगालूर और आर.एस.सी.एल., थेनी, कर्नाटक से के.आई.ए.ए.आर., समीरवाड़ी, आन्ध्र प्रदेश से चेल्लूरू और नव भारत वैंचर्स, लिमिटेड, समालकोट और भा.कृ.अनु.प.–गन्ना प्रजनन संस्थान, कोयम्बत्तूर में. ऊतक संवर्धन प्रयोगशाला से उत्पादित करीब 843 ऊतक संवर्धित पौधों को एस.सी. वाई.एल.वी., एस.सी.एम.वी., एस.सी.एस.एम.वी. ओर घसैला रोग फाइटोप्लास्मा के लिये एस.ओ.पी.एस का अनुसरण करते हुए सूचकांकित किया गया।

काइलो इन्फुसकेटेलस के विरुद्ध 39 को. संकरों की प्रतिरोधिता का अध्ययन करने पर 35 जीनप्रारूपों को कम से कम संवेदनशील जबकि 4 को मध्यम संवेदनशील पाया गया। विभिन्न जैवरसायनिक पदार्थों में से पोलीफिनोल ऑक्सीडेस क्रियाशीलता जीनप्रारूपों के बीच में सार्थक रूप से भिन्न भिन्न पाई गई। आई.जे. 76 88, आई.जे. 76 364 और आई.जे. 76 370 में उच्च क्रियाशीलता जबकि को. 86032 तथा ई.आर.आई. 2798 में क्रियाशीलता निमन्न स्तर की थी। परखे गये दूसरे जीन प्रारूपों के मुकाबले आई.के. 76 84 में अति ही कम क्रियाशीलता देखी गई।

शाखा बेधक के प्रति अति कम संवेदनशील प्रजातियों को.सन्के.0361, 84ए. 146, 94.ए.37, को. 775, को. 7805, को. 94012 औरको. 98013 ने डिम्भों के जीवनकाल में कोई सार्थक भिन्नता नहीं देखी गई।

जैवपरख बी.टी विलगन के.सी.के. 27, जिसमें 6 क्राई जीन उपस्थित हैं जो क्राई 1ए., क्राई 1सी., क्राई 1डी., क्राई 1ई., क्राई 1ए और क्राई 2ए. परिवारों से सम्बंधित हैं और यह कंसूआ और पोरी बेधक के विरुद्ध विषाक्त थे। के.सी.के. 27 विलगन से क्राई 1डी. जीन के पूरे कोडिंग अनुक्रमको निकाला गया और

देखा गया की यह क्राई 1 डी. जीन का नया होलोटाइप है। यह भारत से क्राई 1डी. होलोटाइपजीन की पहली रिपोर्ट है।के.सी.के. 27 विलगन से क्राई 1ई. जीन के हिस्से के कोडिंग अनुक्रम को निकाला गया और देखा गया की यह भी नया होलोटाइप जीन हो सकती है।

बी.टी शटल वैक्टर का प्रयोग कर क्राई 8 एस.एएल. की क्लोनिंग और प्रकटन की कोशिश एक्रिस्टेलिफैरस बी.टी विलगन एच.डी.73 की गई। तथाकथित बी.टी परिवर्तित विलगन ने सफेद गिंडार में मृत्युशीलता नहीं दर्शाई और न ही एक्रिस्टेलिफैरस बी.टी विलगन में विशाक्त का उत्पादन देखा गया।

पेरासिटॉयड टेलिनोमस डिगनस को गर्मी के मार्च व अप्रैल महीनों को छोड़कर पूरे वर्ष क्रियाशील पाया गया। अंडों के समूहों के आधार पर परजीवीकरण दर 33.3 प्रतिशत से 100 प्रतिशत के बीच देखी गई जो मई 2017 में निमन्न स्तर पर थी जबकि जून और अगस्त में उच्चतम स्तर देखी गई। टेलिनोमस के ताज़े निकले प्रौढ़ों को एक दिन पुराने और ताज़े निकले पोरी बेधकों के अंडों से अनावृत किये गये। इस परीक्षण से देखा गया की परजीवीकरण और अंडों के समूहों से पौढ़ों के निकलने की दरें तुलनात्मक थी।

सफेद गिंडारों के प्रथम इनस्टार की मृत्युशीलता अकेले ब्युवेरिया बेसिआना या किसी एक कीटनाशक, नामशः क्लोरेंट्रानिलिपरोल, क्लोरोपायरिफास, फिपरोनिल, कारबोफयूरान,इमिडाकलोपरिड या फोरेट, से उपचारित करने पर सफेद गिंडार की शत प्रतिशत मृत्युशीलता देखी गई जबकि कीटनाशकों को बी. ब्रोंगनिआरटी के साथ 93.3 प्रतिशत :, एम. एनिसोपलि के साथ 80.0 प्रतिशत , एच. इंडिका के साथ 93.3 प्रतिशत या एस. गलासेरी के साथ 66. 67 प्रतिशत की मृत्युशीलता देखी गई।

बी.टी के समूहों के बहुलीकरण चार विभिन्न मीडिया पदार्थों, नामशः शीरा, गन्ने के अवशेष, मुंगफली की खली ओर नीम की खली, से करने पर सार्वधिक बीजाणु संख्या 214.34 x 1010 सी.एफ.यू./मिलिलिटर 6% शीरे के घोल में देखी गई जिससे कम 6% गन्ने के अवशेषों के साथ यह संख्या 160.60 x 1010 सी.एफ.यू./मिलिलिटर थी।

उपोष्णकटिबंधीय क्षेत्र से विलगित किये गये मुख्य कीट रोगजनक सूत्रकृमियाद (की.रो.सू.) को हैट्रोरहैब्डाइटिस इंडिका, एच. बैक्टीरिओफोरा, स्टाइनरनीमा अब्बासी, एस. कार्पोकेप्से, एस. सियामकायाइ, एस. सुरखेटेंसे, और एस. थर्मोफायलम जातियों से होना पाया गया। उपोष्णकटिबंधी क्षेत्रीय की.रो.सू. की रोगजनक्ता का गलेरिया मैलोनैला के डिम्मों और सफेद गिंडार, होलोट्राइकिया सेरराटा, के प्रथम इनस्टार के विरुद्ध अध्ययन करने पर दोनों कीटों की मृत्युशीलता की.रो.सू. की जातियों और मात्राओं के साथ देखी गई। की.रो.सू., एस. अब्बासी स्ट्रेन एस.बी.आई.पी.4 के पुंज उत्पादन का मोनोज़ीनिक तरल संवर्धन विधि द्वारा प्रयत्न किया गया। हमारा यह प्रयत्न सफल रहा ओर हमें एस. अब्बासी स्ट्रेन के 8,700 आई.जे.एस/मिलिलिटर मीडिया जो शुरूआती इनाक्यूलम का 43 गुना था।

थीआमीथोग्ज़ाम के अवशेष उपचार के 75 दिन बाद तक मिले तथा इसका आधा जीवनकाल 9.12 दिन का अनुमानित किया गया। सिफारिशी मात्रा के दुगने स्तर पर देने से अवशेषों को उपचार के 75 दिन बाद तक विश्लेषित करने पर अवशेष की मात्रा 0.376 मिलिग्राम/किलोग्राम पाई गई। क्योंकि थीआमीथोग्ज़ाम कीटनाशक मृदा में 75 दिन तक बचा रह सकता है, अतः यह गन्ने की फसल को कीड़ियों व कंसूऐ के आक्रमणों से बचा सकता है।

सेकरीकोकस सेकराई, एन्टोनिना ग्रैमेनिस, होलोट्राइकिया सेरराटा, आइसेरया पिलोसा, शाइज़ोटैटराएनीकुस एन्डरोपोगिनि, काइलो पारटेलस ओर डिस्मीकोकस केरन्स के डी.एन.ए. बारकोडों को विकसित किया गया।

विस्तार अनुभाग

किसानों तक गन्ने के बारे में जानकारी पहुँचाने के लिये किये गये कार्यक्रमों में गन्ने के अनुसंधान और विकास कर्मचारियों की एक मीटिंग, 5 राष्ट्रीय स्तर के प्रशिक्षण कार्यक्रम, एक मॉडल प्रशिक्षण पाठ्यक्रम, 5 एक दिवसीय प्रशिक्षण कार्यक्रम और एक इन्टरफेस सभा का आयोजन किया गया। छः अगली पंक्ति के प्रदर्शन किसानों के खेतों में लगाये गये।

संस्थान ने 3 प्रदर्शनीयों में भाग लिया : एग्री–इन्टैक्स 2017 सी.ओ.डी.आई. एस.एस.आई.ए. व्यापार मेला परिसर, कोयम्बत्तूर में, शक्ति संस्थान आफ इन्जीनियरिंग कोयम्बत्तूर में आयोजित किसान मेला और तमिलनाडु कृषि विश्वविद्यालय कोयम्बत्तूर में आयोजित राज्य स्तरीय किसान मेला।

गन्ने पर 'केन एडवाइज़र', एक एन्डोरॉयड माबाइल एप्प बनाई गई जिसमें राज्य अनुसार गन्ना प्रजातियों और फसल उत्पादन तकनीकों के बारे में सूचनायें होंगी, अनुसूचक एप्प और पूछताछ प्रबंधकर्ता हैं तथा जिसे गूगल प्ले स्टोर पर तीन भाषाओं में अपलोड कर दिया गया है जो इस प्रकार हैं : केन एडवाइज़र अंग्रेजी में, गन्ना सलाहकार हिन्दी में और कारुम्बु आलोस्कर तमिल में फ्री डाउनलोड के लिये हैं।

तमिलनाडु के पिछड़े ज़िलों में आई.सी.टी. प्रसार के पैटर्न को विश्लेषित करने के लिये सर्वेक्षण किये गये।

4. EXECUTIVE SUMMARY

Crop Improvement

Co 09004 an early maturing variety was notified by Central Varietal Release Committee for commercial cultivation in Peninsular zone. Co 06022, another early maturing variety with a diverse genetic base has been identified for release by the State Variety Release Committee for commercial cultivation in Tamil Nadu and Puducherry.

A total of 24 elite 'Co' canes have been identified from Coimbatore (Co 18001-Co 18018 including 14 'Co' canes and four Genetic Stocks), Karnal (Co 18019-Co 18022) and S. Nijalingappa Sugar Institute (SNSI), Belagavi (Co 18023 and Co 18024).

Elite clones developed at the Institute were supplied to various sugar factories to test their suitability to specific locations. Twelve elite 'Co' canes were supplied to KCP Sugars, Vuyyuru, Andhra Pradesh to identify promising entries for East Coastal region. Eighteen elite drought tolerant clones were supplied for multiplication and evaluation to five sugar factories in Maharashtra *viz.*, Vasantdada Sugar Institute, Pune, Samarth Sahakari Sakhar Karkhana, Ankushnagar, Jalna, Bhaurao Chavan Samarth Sahakari Sakhar Karkhana, Nanded, Dhyaneshwar Sahakari Sakhar Karkhana, Newasa and Sanjivini Takli Sahakari Sakhar Karkhana, Kopargaon, Ahmednagar District. Twelve 'Co' entries were under evaluation at M/s. Dalmia Sugars Ltd, Kolhapur. A total of 246 'Co' canes and improved genetic stocks were evaluated at Sri Nijalingappa Sugar Institute, Belagavi from 2014 to 2018. Twenty-two entries were under testing to identify drought tolerant varieties for Northern Karnataka. In order to identify superior sugarcane varieties suitable for different agro-eco climatic regions of Tamil Nadu, CAE trials are in operation in collaboration with TNAU.

Under 'Sweet Bloom', a collaborative programme with ICAR SBI and nine private sugar factories of Tamil Nadu, 20 elite clones along with Co 86032 and local checks were evaluated in first plant crop. The clones Co 13014, Co 11015, Co 14016 and Co 06031 performed better than Co 86032 for yield and quality at harvest (360 days). Co 11015 combined high yield and quality and was found suitable for harvesting, starting from eight months onwards in seven factory locations and showed promise as a short duration and early maturing clone.

Under AICRP(S) trials, in the Initial Varietal Trial with 37 entries evaluated in Alpha Design for yield and quality traits, the entries Co 14016 (156.14 t/ha) and MS 14082 (150.68 t/ha) were significantly superior to the best standard for cane yield. In the first plant crop of Advanced Varietal Trial with eight test clones, the entry Co 12009 recorded superior CCS yield over the best standard CoC 671. In the concluded AVT early trial, the entry CoM 11082 recorded the highest CCS yield of 15.95 t/ha. In AVT Midlate Trial the entry CoM 11086 recorded the highest CCS yield of 14.38 t/ha, Co 11005 recorded highest cane yield of 113.41 t/ha and Co 11012 recorded the highest CCS of 13.48%. Fifteen 2016 series 'Co' and Co-allied clones accepted for AICRP trial were multiplied at Coimbatore and supplied to seven participating centers in the peninsular zone.

The entries Co 12008, Co 12009 and Co 12012 were rated tolerant to soil salinity based on testing at an EC of 8d S m^{-1}. Among ten clones of 2010 series, Co 10026 and Co 10015 were rated as drought tolerant and Co 10027, Co 10031, Co 10004 and Co 10024 were rated as moderately drought tolerant. Among the 2011 series, Co 11001 and Co 11005 were drought tolerant while Co 11009, Co 11004 and Co 11007 were moderately drought tolerant

The second set of 30 new ISH/IGH clones were supplied to the seven AICRP(S) centres for initial multiplication and further evaluation under drought (Sankheswar, Pune, Lucknow and Karnal) and waterlogging (Motipur, Pusa and Pantnagar) conditions.

The breeding work to develop new and improved clones continued through crossing and selection.

During the 2017 flowering season, a total of 252 crosses have been effected utilizing 78 pistil parents and 42 male parents. A total of 9800 seedlings from 83 crosses were under evaluation in ground nursery. Of the 13180 seedlings from 88 bi parental crosses, 14 poly crosses and 11 general collections in the ratooned ground nursery, 1217 selections were made and advanced for the first clonal trial.

In first clonal trial, 3100 clones were evaluated and 1032 genotypes were promoted to second clonal trial. In second clonal trial, 655 clones have been evaluated for cane yield, juice quality and red rot resistance and 106 selections were promoted to the final clonal trial (PZVT). In all, 208 elite clones were pooled from different experiments and were planted in PZVT multiplication and evaluation plot. Eighty four superior clones combining high sucrose, cane yield and red rot resistance were advanced to PZVT 2018-19.

Four short duration clones (Co 11015, Co 16001, Co 16002, Co 09004) along with three standards (CoC 671, Co 8338, Co 86032) were evaluated in special season (July planting). Assessment of yield potential, ratooning ability and quality attributes showed that Co 09004 had recorded 10.75 tonnes higher cane yield/ha (93.20 t/ha) than the standard Co 86032.

National Hybridization Garden (NHG) with 607 parental clones from 24 participating centers of fluff supply programme was maintained. The flowering was delayed by more than 15 days, 43.33% parents flowered during 2017 as against 52.46% during 2016 and 58.26% during 2015 flowering season respectively. The parental diversity index (PDI) which was found to be in the higher range at Nayagarh (85.71%) and Shahjahanpur (56.94%) than the other centres. Fluff weighing 17.26 kg of crosses made at both NHG and NDHF was supplied to the 23 participating centers of fluff supply programme.

DUS reference varieties (189 numbers) of tropical sugarcane have been maintained at DUS Centre, Coimbatore. During 2017-18, first year DUS test was conducted for farmer's variety Kaptan Basti along with reference varieties Co 356, Co 740 and Co 8208. Four farmer's varieties; Meitei Chu Angougba, Meitei chu Angangba, DESI-2 and Kudrat Ka Karishma were planted along with reference varieties.

A book entitled 'Morphological description of Coimbatore (Co) Canes (1993-2016)' containing botanical description of 528 'Co' canes was published. DNA fingerprint based on 12 STMS primers was used to distinguish the variety Co 0239 from Co 0118. In DUS testing, molecular profiling was carried out to resolve the identity of a farmer's variety Siddigiri as Co 92005.

Breeder seed multiplication was taken up with tissue culture plants produced from nucleus seed both at the Institute and in farmer's participatory approach. A total quantity of 620.48 tons of quality seed cane was produced and supplied during September 2017. A Seed day was organized at ECC Farm of ICAR-SBI, Coimbatore on February 2, 2018 under the ICAR Seed Project and an interaction programme was conducted on February 15, 2018 at the farmer's field in Vellamadai village where seed production had been taken up.

Through apical meristem tip culture, the varieties Co 86032, Co 0212, Co 0238, Co 06022,Co 09004 and CoV 09356 were multiplied and a total of 53435 tissue culture plants were supplied to 14 private and Co-operative sugar factories of Tamil Nadu, Maharashtra and Odisha. A total of 167 virus free mother culture flasks of Co 86032, Co 0212, Co 0238 were supplied to private tissue culture laboratories of Tamil Nadu, Chattisgarh, Gujarat and Uttar Pradesh.

The efficacy of bacterization with single and dual combination of bacteria showed that bacterized tissue culture crop *Gluconoactobactor* + *Bacillus* was found to be the best combination to enhance yield and quality of sugarcane crop.

Ten selected energy canes were evaluated at Sameerwadi and the cane fibre % was maximum in SBIEC 14006 (26.42) followed by SBIEC 13010 (25.45) and SBIEC 13005 (25.32). SBIEC 14006 recorded the

highest cane yield (187.81t/ha). SBIEC 13009 (3672 cal/g) recorded the highest energy value followed by SBIEC11007 (3485 cal/g).

A total of 85 cytoplasmically diverse hybrids involving *Saccharum spontaneum* and *Erianthus arundinaceus* were evaluated in clonal trial and six promising hybrids *viz.*, CYM 14-887, CYM 14-884, CYM 14-688, CYM 14-298, CYM 12-437 and CYM 10-784 were advanced to PZVT multiplication.

Twenty founder parents of a MAGIC population were evaluated for drought tolerance for two consecutive years and the pooled analysis revealed that the clone CYM 08-922 had the highest mean cane yield under drought as well as higher relative water content, leaf area index and lower MDA content making it one of the potential drought tolerant parents for breeding drought tolerant varieties in sugarcane.

An exploration was conducted in the state of Jharkhand for the collection of unexplored diversity in the *Saccharum* complex during September, 2017. Eleven major rivers were surveyed and a total of 76 *S. spontaneum* and four *S. officinarum* were collected from 24 districts. At Coimbatore, a total of 2054 wild germplasm accessions have been field maintained. A total of 50 clones comprising *S. spontaneum* and *Erianthus procerus* from Arunachal Pradesh, *Erianthus fulvus* and *Miscanthus* spp. collected from Meghalaya are maintained at ICAR – IARI Regional Station, Wellington, Nilgiris. The maintenance of 2006 commercial hybrids (Co canes) and genetic stocks was carried out. In National Active Germplasm 240 varieties were maintained and index numbers have been assigned for 15 clones. A total of 40 germplasm clones collected from Punjab and Haryana have been characterized with 42 morphometric traits.

At SBIRC, Agali, 1271 accessions of sugarcane germplasm including species clones, 'Co' clones, Co allied clones, exotic clones, inter-specific and inter-generic hybrid clones, clones of *Erianthus* sp., *Sclerostachya* and *Narenga* have been field maintained in disease free condition. Out of 1271 accessions, 414 flowered in 2017 season. Seventy-one crosses for Agali Centre and 55 crosses for 15 AICRP(S) Centres were effected.

Somatic chromosome number was determined in 60 clones of *S. spontaneum* consisting of the clones from IND-01, IND-02, IND-03, IND-04, IND-05 and IND-15 collections. Different cytotypes such as 2n=48, 56, 60, 62, 64, 70, 72, 80 and 112 were identified. Compilation of cytological data of 204 clones of *E. arundinaceus* revealed the existence of three cytotypes with 2n=30, 2n=40 and 2n=60. Majority of the clones exhibited 2n=60 (hexaploid) with the frequency distribution of 60.0%.

A set of sugarcane germplasm has been evaluated for tolerance to abiotic stresses at Coimbatore. The genotypes IND 08 – 1491, IND 99 – 848, IND 99 – 847, IND 99 – 863, IND 99 – 849, IND 99 – 882, IND 02-1186 and SES 121A were found superior under drought stress condition. Drought tolerance potential of 208 clones of *E. arundinaceus* revealed 15 *Erianthus* clones to be tolerant.

Interspecific hybrids with different genetic base have been evaluated for yield and quality. The cross combinations between improved parents and 'Co' varieties showed higher variation for cane weight than Co x improved varieties. Clones with better cane weight, sucrose % and resistance to red rot were selected and nine hybrids were forwarded for PZVT.

The newly isolated CENH3 gene was amplified in the variety Co 7201. In majority of the chromosomes, CENH3 gene was found to be localized in the centromeric region. In anaphase, the signal was absent in the lagging chromosomes, revealing the role of identified CENH3 in chromosome elimination.

Forty-five hybrids involving various cytotypes of *S. spontaneum* were screened for red rot resistance in which 23 were moderately resistant and three were resistant. Chromosome transmission in 35 BC1 hybrids derived with the cytotypes 2n =40 indicated n+n transmission.

GISH analysis of two intergeneric hybrids involving *Sorghum*, i.e. Co 86032 x *Sorghum* and *Sorghum* x *Saccharum* could identify ten chromosomes of

Sorghum. Early condensations of the *Sorghum* chromosomes were observed.

Forty-four microsatellite markers developed for six major sucrose metabolizing enzymes (NI, CWI, PPFK, PFK, SAI and SREBF) were applied to a germplasm panel of 26 Indian 'Co' canes, nine *S.officinarum*, three *S.spontaneum* clones, two *E. arundinaceus* derivatives and one inter-specific hybrid clone. Structure analysis based on SSR allelic data revealed the presence of three different populations. Mean value of alpha was 0.1019 indicated that most of the high sucrose genotypes originated from few ancestral species clones.

In functional genomics studies for water deficit stress in sugarcane, RNA seq data of two varieties Co 06022 and Co 8021 was analysed and the fold change of the differentially expressed genes (DEGs) ranged from 13.00 to 1.00. Total number of transcripts that were upregulated in the drought induced transcriptome of the tolerant variety Co 06022 as compared to the susceptible variety at six days of stress was highest (8,030) when compared to two days (5,581) and at ten days (3499).

Novel miRNAs that are associated with oxidative stress were predicted in sugarcane (654) and some of the species specific miRNAs showed significant differential gene expression after oxidative response. Seventeen unique miRNAs and 1175 unique targets were identified and many of them were related to plant stress tolerance.

In an effort to precisely edit the sugarcane genome using CRISPR-Cas, isolation and expression of genes from flowering and non-flowering clones have been done. Three primer pairs DLF1 (Delayed Flowering 1), TFL 1 (Terminal Flower 1) and ID 1 (Indeterminate growth 1) were could show marked variation among the flowering and non-flowering clones.

A total of 14 *S. spontaneum* clones along with tolerant (Co 89029) and susceptible (Co 89003) 'Co' canes were evaluated for their response to salinity stress. Expression studies revealed that the transcription factor MYB that showed increased expression under 2.5% stress gradually decreased at 5% and 10%, which would have switched on the salinity stress responsive genes.

In the Indo-Australian project on genetic control and genomic selection for important traits in sugarcane, phenotyping for drought parameters has been done in two biparental populations. The data on Brix and Pol % were analysed using Best Linear Unbiased Prediction method (BLUP) using R and SAS and ones with high BLUPs (both at control and drought conditions) were identified.

In the true seed approach, population structure of various inbred generations has been analyzed and identified the subpopulation consisting of S5 and S6 generation selfs of 1148-S4-242 with high Fixation index (Fst) of 0.88, low gene flow (Nm=0.03), indicating high probability of identical individuals. Hybrids derived by crossing selected inbred parents were evaluated and different degrees of genetic uniformity were observed. Twenty wide crosses were made and sixty seedlings were raised

Antagonistic potential of biocontrol agents against seed/seedling borne pathogens and *in vitro* efficacy of commercial fungicides against seed/seedling borne pathogens were assessed. Agro-techniques for true seed seedlings with special reference to intra-row spacings and planting depths and integrated weed management with new generation herbicides have been standardized. The data on mean weight of fluff from each arrow, weight of fluff/arrow, mean 100-seed weight of seed fluff, 100-seed weight of defuzzed seed and mean germination percent of seed fluff have been determined.

Crop Production

Response to root injury was studied in three popular commercial hybrids *viz.*, Co 06022, CoC 671 and Co 86032 in hydroponic system. The root injury has resulted in differential response among varieties. In Co 06022, the secondary roots appeared after 10 days of injury while, in Co 86032 and CoC 671, it took only three days. Two varieties Co 99004 and Co 85019 were used to study the effect of Poly Ethylene Glycol (PEG) on sugarcane in the hydroponic medium.

PEG 5 and 10% seems to be a shock for the sugarcane plants. By 48 hours of treatment, the younger leaves showed drying and desiccation. PEG treatment resulted in increase in proline, leaf epicuticular wax and root peroxidase.

Machineries namely IISR model disc type ratoon management device and IISR model two row trench type sugarcane cutter planter were purchased from ICAR-Indian Institute of Sugarcane Research, Lucknow for evaluation. Fabricated a manually operated sugarcane settling planting tool to plant sugarcane settlings in the field manually in standing posture, this has effectively reduced drudgery.

Free living, root associated and phyllosphere bacteria were isolated from sugarcane. Positive results were obtained in the preliminary studies on the effect of these isolates on sugarcane for germination and seedling vigour.

For controlling *Cyanadon dactylon* directed spot application of glyphosate using hooded nozzle (7.5 ml per litre of water) was found effective.

A Quadcopter Drone (DJI-Phantom 3 model with 4K resolution – FC 330X camera) was used to capture the field images of healthy sugarcane leaf and sugarcane leaf with red rot disease the sugarcane crop leaves. Hue saturation value (HSV) and YCbCr values of the images clearly distinguish the red rot disease symptom leaves from healthy. The vegetation indices for field images of sugarcane crop was captured using multispectral camera (Mica Sense- Red Edge) equipped with Drone (DJI- Inspire 1) were mapped using the softwares PIX4D and MICA SENSE-ATLAS. High Optimized Soil Adjusted Vegetation Index values indicated denser, healthier vegetation whereas lower values indicate less vigour.

Cane yield varied significantly among varieties as well as irrigation treatments. Cane yield declined by 41.0% and 55.0% in I_2 (50.0% reduction in irrigation water quantity) and I_3 (50% irrigation by reducing number of irrigations), respectively, as compared to control (I_1). Cane yield reductions were matching with the quantum of reduced irrigation water. Varieties Co 10026, Co 86010, Co 8371, Co 86249, CoLk 8102, Co 99004, Co 85019, yielded higher in both the treatments (I_2 and I_3). Twelve varieties recorded higher cane yield over and above the varietal mean in I_2 suggesting existing varietal potential for exploitation.

Cane yield, irrigation water use efficiency (IWUE), water productivity (WP) and fv/fm showed significant variability to irrigation treatments as well as among the varieties studied. Sucrose % juice at harvest, varied significantly among varieties and not among irrigation treatments.

The varieties *viz.*, Co 85019, Co 13006, Co 99004, CoLk 8102, Co 86249, Co 10026, and Co 86010 had significantly higher IWUE than varietal mean in both the reduced irrigation treatments. Water productivity declined significantly with restricted irrigation implying water quantity applied has a direct influence on yield. Among the varieties, Co 8371 registered high mean WP of 4.18 followed by Co 85019 (3.92), while in I_2, six varieties had significantly higher WP (Co 85019, Co 0212, Co 86249, Co 10026, Co 0218 and CoV 92102) of above 4.

Varieties *viz.*, Co 8371, Co 85019, Co 86010, Co 86249, Co 95020, Co 99004, Co 10026, Co 13006 and CoLk 8102, with higher cane yield, sucrose% juice, biomass, IWUE, have potential to perform well in water limited conditions with better water productivity.

Transcriptome sequencing in meristematic tissues of Co 99004 at formative phase under control and high temperature stress condition was carried out using Illumina HiSeq 2500 platform. About 59.6% of the assembled transcripts were ~200 to >5000 bp in length. The longest sequence in the assembled transcriptome was 21435 bp, which had a similarity of 99% with a protein of Maturase K from *S.officinarum*, the same has been submitted in NCBI and acquired an accession number (NCBI Acc. No. 49659490).

Radiation use efficiency of 33 sugarcane genotypes revealed that the genotypes with higher biomass recorded better light interception of more than

70.0% of photosynthetically active radiation (PAR) at maturity phase. Sugarcane at normal irrigated condition showed better light interception compared to limited irrigation. Significant decline in biomass has contributed to the reduction in RUE as compared to the light interception under limited irrigated condition.

Among the genotypes, Co 62175, Co 85019, Co 95020 and Co 99004 were recorded with RUE more than 1.0 g MJ-1 under normal condition I_1, while Co 94008, Co 85019 , Co 12006, Co 0212 and Co 86249, Co 85019, CoM 0265 and Co 13006 were observed with better RUE under limited water condition.

The Decision Support System software was updated with a primary module with setup options and working DSS module and tested on Windows 10 platform. The software was demonstrated to field staff, cane officials and IT personnel of sugar factories and was released for adoption on 12 December 2017.

Six hundred and seventy soil test results were imported into the Decision Support System, Soil Health Card with package of practices for sugarcane were generated and sent to the farmers through the sugar factories.

A test verification trial with Co 86032 on conventional method of fertilizer application and pocket manuring as two main plots and three fertilizer doses (280:62.5:120; 366:22:56 and 537:80:214 kg $N:P_2O_5:K_2O$/ha) in two to six splits conducted from April 2017 to February 2018. Pocket manuring gave 9.1% higher mean cane yield (114.6 t/ha) than conventional fertilizer application (105.0 t/ha). The highest mean yield of 133.4 t/ha was recorded in 537:80:214 kg $N:P_2O_5:K_2O$/ha applied up to 180 DAP which was on par with the same dose applied up to 120 DAP (131.4 t/ha). Increasing dose of fertilizers and increasing number of split application increased the cane yield significantly.

Experiment with organic substrates (trash compost, FYM, vermicompost and biocompost) treatment at the rate of carbon equivalent to FYM @ 25 t/ha showed higher CO_2 flux (µmol/m^2/sec) than the control. Among the substrates, biocompost showed lower CO_2 flux than other substrates throughout except in October 2017 where this treatment showed the highest flux.

In the gypsum experiment, CO_2 flux in the control (without gypsum) was higher than that of gypsum treatment. CO_2 flux at 45 DAP was 3.24, 3.94 and 3.51 µmol/m^2/s in cropped plot with gypsum @100%GR, gypsum @50%GR and no gypsum treatment, respectively.

Fractionation of carbon in the organic substrates (FYM, vermicompost, biocompost and trash compost) yielded fulvic acid and humic acid with varying degree of humification. The biocompost showed higher humification than other organic substances based on E4/E6 ratio.

Six soil profiles were characterised in Bhavani, Anthiyur and Gobichettipalayam Taluk of Erode District. The profile in Chinnapallam showed four horizons and parent material was not found at 1.2 m depth. A deep soil profile was found in Chinnakaliyur with four layers and the parent material was observed below 1.6 m. Depth of the other four soil profiles was below 1 m.

Alkaline reaction was observed in all the layers of soil profiles in Sankaragoundanpalayam, Brammadesam, Nathiplayam and Chinnakaliyur. While, pH of all the layers of the soil profiles in Chinnapallam and Vairamangalam was below 8.5 except the layer between 0.22 and 0.36 m in Vairamangalam. All the soils were non-saline.

Penetration resistance data indicated hardening below 10 cm in Brammadesam, below 25 cm in Nathipalayam and below 35 cm in Chinnakaliyur and Vairamanagalam with the penetration resistance of around 2 Mpa implying restriction to root growth. Subsurface soil hardening was not found in Sankaragoundanpalayam and Chinnapallam.

A model was developed to predict dry bulk density of soil along the depth of the soil profile using Artificial Neural Network with five input layers with two hidden layers of 15 and 10 nodes,

respectively and the model developed showed Training MSE of 0.126 and Validation MSE of 0.066.

Co 11001 was efficient in terms of reciprocal N, P and K use efficiency when compared to the other AVT early maturing entry (2016-17), Co 11004. The standard, Co 85004 was more P efficient than all AVT early 'Co' entries and standards. The standard, CoC 671 was more K efficient than all AVT early 'Co' entries and standards.

Co 11019 was efficient in terms of reciprocal N, P and K use efficiency when compared to other AVT midlate Co entries (2016-17) *viz.*, Co 11005, Co 11007, Co 11012 and the standards, Co 86032 and Co 99004.

Transient expression analysis of GFP fused ShINH2 revealed that *ShINH2* is vacuolar located protein which is corresponded with the *insilico* analysis where *ShINH2* is having N- terminal signal peptide in the predicted protein (Predisi and Signal P).

Crop Protection

A total of 3075 clones in crop improvement projects and Kannur comprising clonal trials, PZVT, parental clones, GUK/ WL clones, GU clones, germplasm, climate resilient clones and high biomass hybrids were tested for red rot resistance under controlled conditions against CF06 (Cf671) pathotype and ~1598 clones were identified as R and MR to red rot. Among the 11 varieties tested against grain inoculum of *C. falcatum* isolates, the cvs Co 0403 and Co 0238 remained free from pathogen infection, exhibiting resistance to all the 11 isolates.

Pathogenic behavior of ~35 *C. falcatum* isolates tested on 31 sugarcane varieties revealed enormous variation for their virulence and comparatively more isolates behaved as lesser virulence compared to the previous years. None of the highly susceptible varieties such as Co 94012, Co 95020 and CoC 671 were completely susceptible to the isolates and this proved the poor expression of virulence by the isolates during the season. Two old isolates *viz.*, CfPI1401- Kadaganur and Cfv09356- Keerangudi exhibited more virulence than the reference pathotypes on 19 sugarcane differentials.

Distinct mating type cultures (+ and -) of phenotyped smut pathogen isolates varying in virulence were established for representative isolates of *Sporisorium scitaminuem*. PCR primers targeting mating type specific genes, distinctly discriminated between opposite mating types (+ and -) of the pathogen.

About 27 proteins from mycelium, eight from secretome and 12 from host-pathogen interaction were identified as pathogenicity related genes by SSH approach. In proteomics, Bys1 family protein, two methyltransferases and 3-isopropylmalate dehydrogenase were identified commonly in mycelial proteome, secretome and host-pathogen interaction profile.

Novel miRNAs *viz.* RC-799, R6-827, R24-1,288, SC-960, S6-682 and S24-456 involved in sugarcane and *C. falcatum* interaction were identified. Further target analyses of different miRNAs revealed several target genes involved in various stress responses such as hormone signaling pathways, hypersensitive responses, calcium signaling, other signaling cascades, disease resistance and transcription factors.

Two dominant proteins *viz.*, cytochrome P450 and HSP 20 specific to virulent isolate of *C. falcatum* were found to be upregulated during host pathogen interaction and in contrast down regulated during tritrophic interaction of host, pathogen and the antagonist *Trichoderma harzianum*. Cytochrome P450 was identified as potential target site for fungicidal management using azole fungicide as inhibitor of the designated protein.

In planta temporal expression analysis targeting five putative candidates secreted effector proteins (CSEPs) coding genes in *S. scitaminuem* identified significantly higher expression of PEP1.

Sett borne infection of *Fusarium sacchari* caused very severe wilt expression in the varieties Co 86010, MS 68/47, C 79218, 69 A 591 etc. Pokkah boeng was also recorded in many of the 13 varieties studied however, the disease development was random, no relation could be made on sett infection and disease development.

Pathogenicity of nine *F. sacchari* isolates Fs86010, FsMS901, FsEB09004 and Fs419 were more pathogenic on the varieties and among the varieties MS 901 and Co 98010 were found to be susceptible to different isolates. Overall, the pathogenicity of the varieties for different isolates revealed a clear differential interaction between the host varieties and the pathogenic isolates.

The phytoplasma suspected to be associated with the yellow leaf in sugarcane is found to be SCGS Phytoplasma (*Ca. P. oryzae*, 16Sr XI-B) not the yellow leaf phytoplasma. Only Sugarcane yellow leaf virus was found associated with yellow leaf disease. New SCGS phytoplasma sub group has been identified on CoS 88230 based on *in silico* RFLP using iphyclassifier.

Out of 275 sugarcane clones screened, 18 clones were categorized under S group, 35 in MS group, and 56 under MR group. More than 160 entries were observed to be free from rust infection during crop season.

Applicability of sett treatment device for hot water treatment alone or along with nutrients for treating setts of *S. officinarum* clones and other cultivars has been proved.

In vitro release of BTH and SA molecules from chitosan (CS) coated and nanoparticles was assessed at 3 different pH levels. The results showed that at pH 3.2, the BTH and SA release was initiated at 41h and continued till 72h, at pH 4.2 and 5.2 the release was initiated at 74h only.

The systemically acquired resistance (SAR) inducer property of CS coated BTH and SA in sugarcane against red rot, smut and wilt diseases were tested. Germination in CS-BTH nanoparticles treated setts were on par with healthy control, whereas germination in CS-SA nanoparticles treated setts were reduced by 7.0 to 26%, while in pathogen inoculated control the germination was reduced by 14.0-27.0%.

In red rot experiment, no disease was recorded in any of the CS-SAR inducer nanoparticles treated plants till 90 days after while drying of seedlings due to disease incidence was noticed up to 33.3% in pathogen inoculated control.

Impact of YLD on cane growth and yield was assessed by comparing the crops planted with virus-infected and virus-free planting materials of three varieties in the field revealed that due to virus infection, cane and juice yield were reduced by 18.5 to 40.7% and 42.1 to 50%, respectively. Monitoring the dynamics in aphid population in sugarcane varieties for six months from April to September, 2017 revealed that aphid population was high in all the varieties during June and the population slowly declined by July end/ August.

RT-LAMP assay has been developed for SCMV and SCSMV and its sensitivity with the conventional RT-PCR and qRT-PCR has been standardized for the mosaic disease diagnosis.

About 843 tissue culture raised plants from different tissue culture production units *viz.*, M/s EID Parry, Pugalur and RSCL, Theni (TN), KIAAR, Sameervadi, (Karnataka), Sree Sarvaraya sugars, Chelluru and Nava Bharat Ventures Ltd., Samalkot (AP) and ICAR-SBI tissue culture lab were indexed for SCYLV, SCMV, SCSMV and grassy shoot phytoplasmas by following SOPs.

Of the 39 'Co' hybrids screened for their relative degree of resistance against *Chilo infuscatellus*, 35 genotypes were graded as least susceptible and four as moderately susceptible. Among the different biochemical constituents polyphenol oxidase activity differed significantly among genotypes. It was higher in IJ 76 370, IJ 76 364 and IK 76 88 and lower in Co 86032 and ERI 2798. Among the genotypes assayed, IK 76 84 had meager activity of PPO as compared to other genotypes.

The least susceptible varieties to shoot borer CoSnk 0361, Co 98013, 84A146, Co 7805, Co 94012, 91A37 and Co 775 did not show significantly variation for larval duration.

Bioassay studies with Bt isolate SBI-KK 27, which contains six cry genes belonging to *cry1A, cry1C, cry1D, cry1E, cry1I* and *cry2A* families, revealed its toxicity to early shoot borer and internode borer. The

full coding sequence of *cry1D* gene from SBI-KK 27 isolate was deduced and found to be a new holotype *cry1D* gene. This is the first report of *cry1D* holotype gene from India. The partial sequence of *cry1E* from SBI-KK 27 also revealed that it could be another holotype gene.

Cloning and expression of *cry8Sa1* in acrystalliferous Bt isolate HD73 was attempted using Bt shuttle vector. Putative Bt transformed isolate did not show mortality against white grub and no toxin production was found in the acrystalliferous Bt isolate.

The parasitoid *Telenomus dignus* was active throughout the year, except during the summer months, i.e. March-April. Parasitism rates ranged 33.3-100.0% on egg mass basis, the lower values being in May 2017 and the highest in June and August 2017.

Freshly emerged adults of *Telenomus* exposed to one-day old and freshly laid INB eggs indicated that parasitization and adult emergence rates within egg masses were comparable in both.

Mortality of first instar white grubs in treatments involving *B. bassiana* alone or with chlorantraniliprole, chlorpyriphos, fipronil, carbofuran, imidacloprid or phorate resulted in 100% mortality of the white grub whereas the combinations with *B. brongniartii* (93.3%), *M. anisopliae* (80%), *H. indica* (93.3%) or *S. glaseri* (66.67%) resulted in varied levels of mortality.

Among four different media material used for Bt mass multiplication, *viz.* molasses, sugarcane trash, groundnut cake and neem cake, the highest spore count of 214.34 × 10^{10} CFU/ml was observed in molasses 6% followed by sugarcane trash 6% (160.60 × 10^{10} CFU/ml).

The major EPNs isolated from the subtropical area belonged to *Heterorhabditis indica, H. bacteriophora, S. abbasi, S. carpocapsae, S. siyamkayai, S. surkhetense* and *S. thermophilum*. Pathogenecity studies with subtropical EPN against larvae of *G. mellonella* and 1st instar white grub *Holotrichia serrata* revealed mortality of both insects by various EPN species and dosages. Mass production of EPN, *S. abbasi* strain SBIP4 was attempted by monoxenic liquid culture method. Successful multiplication of EPN was observed in liquid media and the yield of *S. abbasi* was 8700 IJs/ml of media which was 43 fold compared to initial inoculum.

Residues of thiamethoxam could be detected up to 75 days after treatment (DAT) with the half-life of 9.12 days. At double the recommended dose, the residue was 0.376 mg/kg and the residues were quantified up to 75 DAT. Since thiamethoxam has the soil persistence of more than 75 days, it may protect the sugarcane crop from termites and early shoot borer.

DNA barcodes were developed for *Saccharicoccus sacchari, Antonina graminis, Holotrichia serrata, Icerya pilosa, Schizotetranychus andropogoni, Chilo partellus* and *Dysmicoccus carens*.

Extension

The outreach programme included one sugarcane Research and Development Workers meeting, five National level training programs, one model training course, five one-day training programs and one Interface Meet. Six frontline demonstrations were conducted in farmers' fields.

The Institute participated in three exhibitions: Agri-Intex 2017 at CODISSIA Trade Fair Complex, Coimbatore, Farmers Fair at Sakthi Institute of Engineering, Coimbatore and State level Farmers Day at Tamil Nadu Agricultural University, Coimbatore.

'Cane Adviser', an android mobile app on sugarcane containing information on State-wise sugarcane varieties, crop production technologies, crop protection technologies, Scheduler app and Query handler was uploaded in google playstore in three languages: Cane Adviser (English), 'Ganna Salahkar' (Hindi) and 'Karumbu Aalosakar' (Tamil) for free download.

Surveys were conducted to analyze the ICT diffusion pattern in backward districts in Tamil Nadu.

5. RESEARCH ACHIEVEMENTS

5.1 CROP IMPROVEMENT

5.1.1 BREEDING

New Varieties

Co 06022 an early maturing high yielding variety released for commercial cultivation

Co 06022 (GU 92-275 x Co 86249), an early maturing variety was released for commercial cultivation in Tamil Nadu and Puducherry during 2017-18 by State Variety Release Committee. It is a promising drought tolerant high yielding variety confirmed through Co-ordinated Agronomic Experiments / Adaptive Research Trials at 18 locations in Tamil Nadu during 2014-16. It recorded higher cane yield (135.8 t/ha), sugar yield (17.68 t/ha) and CCS% (13.10) than the early checks CoC 24 and TNAUSi 7 (Fig. 2).

'Co' canes identified

A total of 24 'Co' canes including 18 from Coimbatore, four from Karnal Centre and two from S. Nijalingappa Sugar Institute (SNSI), Belagavi were identified during 2017-18. From Coimbatore, 14 elite selections from Pre-Zonal Varietal Trial conducted during 2017-18 were assigned 'Co' numbers (Co 18001 to Co 18014). In addition, four genetic stocks were given 'Co' number as Co 18015 to Co 18018 for utilization in breeding programmes. The performance of these selections is presented in Table 4. Following three years of trials conducted at SNSI to identify location specific clones, two clones 2012-91 and 2012-88 emanated to be very good performers in both plant and ratoon crop trials. These clones are assigned as Co 18023 and Co 18024 respectively (Table 5). Based on the performance of PZVT selections at Karnal, clones *viz.*, K12-352 (Co 18019) and GU07-1841 (Co 18020) were awarded 'Co' cane status under early whereas the clones *viz.*, K12-60 (Co 18021) and K08-429 (Co 18022) were awarded 'Co' cane status under midlate category. Their performance in PZVT trial in comparison with standard is presented in Table 6 and 7.

Fig. 2. Co 06022- Field View

Table 4. **Performance of 'Co' canes (2017-18) at Coimbatore**

'Co' Numbers	Parentage	CCS yield (t/ha)	Cane yield (t/ha)	Sucrose (%)		CCS (%)		Red rot rating	
				300 days	360 days	300 days	360 days	Plug	Nodal
Co 18001	Co 07015 x Co 99008	21.85	155.21	16.37	19.88	11.21	14.08	MS	R
Co 18002	Co 11015 GC	23.74	169.58*	18.95	19.78	13.28	14.00	MS	R
Co 18003	CoM 0265 x Co 99006	25.15*	181.46*	18.06	19.63	12.66	13.86	MS	R
Co 18004	Co 94003 x CoT 8201	20.73	152.33	16.56	19.32	11.48	13.61	MR	R
Co 18005	Co 0310 x Co 94005	20.58	144.82	17.74	20.18	12.36	14.21	MS	R
Co 18006	CP 81-1384 x CoC 671	21.54	141.91	19.93	21.49	13.93	15.18	MS	R
Co 18007	Co 0403 GC	22.95	171.50*	16.68	19.10	11.59	13.38	MS	R
Co 18008	Co 98010 x Co 94008	23.42	146.81	20.06	22.52	14.09	15.95	MS	-
Co 18009	Co 07027 x ISH 69	21.99	161.37	16.71	19.39	11.59	13.63	MR	R
Co 18010	Co 99004 x Co 0403	21.67	158.86	18.28	19.75	12.83	13.93	MR	R
Co 18011	Co 94012 x Co 94008	23.36	172.11*	15.79	19.39	10.95	13.57	MS	R
Co 18012	CoM 0265 x Co 99006	23.38	172.20*	17.22	19.24	12.03	13.58	MS	-
Co 18013	Co 8353 x Co 11015	23.19	162.59	18.64	20.24	13.10	14.26	MS	R
Co 18014	Co 8371 PC	20.75	154.94	17.03	19.10	11.68	13.46	MS	R
Genetic stocks									
Co 18015	Co 99006 x Co 0209	22.01	179.51*	15.55	17.46	10.83	12.26	MS	R
Co 18016	Co 99006 x Co 94008	20.74	165.39	14.83	18.12	9.97	12.54	MS	R
Co 18017	Co 05001 GC	20.31	168.10*	14.85	17.33	10.06	12.08	S	R
Co 18018	Co 8371 x Co 86011	16.89	108.87	18.75	22.02	13.02	15.51	MS	-
Standards									
Co 86032		18.98	141.74	16.95	19.10	11.79	13.39		
Co 99004		21.79	157.57	17.19	19.73	11.91	13.83		
Co 09004		23.61	151.53	19.90	21.70	14.07	15.58		
CoC 671		17.03	111.31	18.18	21.52	12.70	15.30		
CD		1.42	9.52	1.36	0.86	1.12	0.60		
CV		15.32	14.80	8.45	4.84	6.02	5.64		

Table 5. **Co selections based mean of two Plant and one ratoon crops at SNSI, Belagavi**

'Co' Numbers	Parentage	Cane yield (t/ha)	CCS yield (t/ha)	Pol (%)	CCS (%)	Red rot rating
Co 18023	Co 94008GC	143.83*	19.85*	18.39	13.79*	MR
Co 18024	Co 86032 x Co 05011	159.56*	22.66*	18.94*	14.20*	RR
Standard (Co 86032)		117.09	15.25	17.42	13.06	
CD		18.56	4.59	1.42	0.33	
CV		10.7	12.46	3.6	3.60	

Table 6. **Performance of elite PZVT (Early) clone during 2017-18 at ICAR - Sugarcane Breeding Institute, Regional Centre, Karnal**

Clone Number	Parentage	Sugar yield (t/ha)	Cane yield (t/ha)	CCS (%)		Sucrose (%)		Pol in cane	Fibre (%)	Red rot rating
				8m	10m	8m	10m			
Co 18019	Co 0240 x CoH 70	16.7	120.8	11.84	13.8	17.0	19.7	15.2	12.6	MR
Co 18020	GU04 (29) RE-473*xCo 775	16.7	120.3	12.14	13.9	17.5	19.6	15.0	13.4	MR
Standards										
Co 0238		17.0	124.0	11.68	13.7	17.0	19.4			
CoJ 64		9.40	70.85	11.59	13.2	16.8	18.8			
GM		13.8	106.3	11.20	13.8	16.3	18.5			
CD		1.84	13.73	0.88	13.9	1.0	1.14			
CV		10.0	9.37	5.14	13.7	4.3	3.89			

*GU04(29)RE-473= PIR 98-635 x IK76-91

Table 7. **Performance of elite PZVT (Midlate) clone during 2017-18 at ICAR-Sugarcane Breeding Institute, Regional Centre, Karnal**

Clone Number	Parentage	Sugar yield (t/ha)	Cane yield (t/ha)	CCS (%)		Sucrose (%)		Pol in cane	Fibre (%)	Red rot rating
				10m	12m	10m	12m			
Co 18021	Co 98006 x Co 86011	16.81*	121.15*	11.74	13.8	17.02	19.68	15.1	12.8	MR
Co 18022	CoS 8436 x Co 89003	18.30*	125.55*	12.76	14.5	18.32	20.48	15.7	13.2	MR
Standards										
CoS 767		11.64	86.29	12.31	13.4	17.68	19.11			
CoS 8436		11.34	81.96	12.31	13.8	17.80	19.62			
GM		15.05	106.38	12.98	14.0	18.57	19.92			
CD		2.03	13.73	1.08	0.8	1.14	1.01			
CV		10.17	9.37	5.32	3.6	3.89	3.21			

* Significantly superior over the best standard at P=0.05

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

Breeding sugarcane varieties for tropical region

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

Hybridization (2017 season)

Two hundred and forty six parents were planted in the Arrowing plot during 2016 and flowering was initiated during October IV week, 2017 extended up to December II week (Table 8) About 38.46% of 'Co' canes, 31.43% 'Co' allied clones, 65.0% inbred clones, 28.0% of genetic stocks and 86.0% of CYM clones flowered in the Arrowing plot. A total number of 78 pistil parents and 42 male parents were utilised and a total of 252 crosses were made. Tropical, subtropical, high yielding, good quality parents combining red rot resistance, diverse CYM clones with red rot resistance, genetic stocks for yield, quality, ISH and IGH clones and climate resilient clones were utilized in the crossing program. In addition, fluff from 45 selfs and 41 general collections were collected.

(R. Karuppaiyan, S.Alarmelu, P.Govindaraj, A.J. Prabakaran, A. Anna Durai, C.Appunu, Adhini S.Pazhany, E.Ilayaraja and H.K. Mahadevaswamy)

Table 8. **Details of crosses effected during 2017 crossing season**

Categories	Number of crosses
Experimental Crosses	
Tropical x Subtropical	20
Tropical x Tropical ('Co' and 'Co' allied)	97
Subtropical x Tropical	28
Genetic stocks/ Prebreeding material /CYM clones /Commercials	79
ISH/ IGH	16
Inbreds	4
Proven Crosses	
Tropical x Tropical	8
Total	252

Ground nursery (2018)

A total of 9800 seedlings from 74 bi parental, five poly crosses and four general collections were transplanted in the field. The average seedling survival rate was 72 per cent and the crosses *viz.*, Co 86032 x Co 0209, Co 86032 x Co 0238, Co 775 x Co 1148, Co 0240 x Co 12014, CoM 0265 x Co 11015, Co 16018 PC showed better survival rate.

(G. Hemaprabha, R.M. Shanthi, K. Mohanraj, S. Karthigeyan, V. Sreenivasa, S. Sheela Mary, T. Lakshmipathy, V. Vinu and C. Mahadevaiah)

Ground nursery ratoon (2016-2018)

During 2016, 14,451 seedlings from 164 biparental crosses, 12 GCs and 20 PCs, were transplanted and plant crop was ratooned during 2017. The crop was evaluated for number of millable canes (NMC), cane thickness and HR Brix at 10 and 11 months. At 330 days, 75 genotypes recorded good field stand with HR Brix above 22.0% and 129 genotypes were recorded above 20% respectively. Selection % for the crosses ranged from 7.69% (CoLk 8102 x U09138) to 30.92% (Co 86011 x Co 97015). More than 85.0% of selections recorded >2.6 cm cane thickness and desirable characters *viz*, without split, sheath spines and free from foliage diseases. Among the crosses, 2007-231 x Co 0209, Co 0238 x Co 12014, Co 11015 x Co 97015, Co 99008 x CoT 8201,Co 11015 PC, Co 86011 PC, 2007-231 x Co 10024, 2011-35 x CoA 7602, U09053 x C 0209, Co 10033 x CoPant 97222 and Co 0240 x Co 13015 recorded HR Brix above 21.00% at 300 days. The cross 2007-231 x Co 10024 recorded the maximum Brix of 22.06% followed by 2007-231 x Co 0209 with 21.99% Brix. High quality progenies were

identified with 2007-231 as one of the parent. Genotypes derived from families involving Co 11015, CoC 671, Co 0118 and Co 86032 as one of the parents recorded high early sucrose accumulation. Two clones from Co 11015 GC recorded the maximum HR Brix of > 24.0% at 330 days of planting. More number of selections were from the crosses Co 10033 x CoPant 97222, 2007-231 x Co 10024, Co 86011 x (Co 97015, CoSe 92423), Co 11015 x Co 97015, Co 99008 x CoT 8201 and Co 11015 x Co 94008, Co 11015 x (Co 06022, Co 94005) (Fig. 3). Two thousand eight hundred clones were selected for further evaluation in first clonal trial.

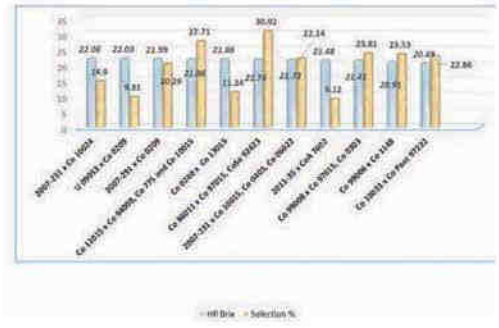


Fig. 3. Promising families in ground nursery

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

Ground nursery (2015-2017)

A total of 13,180 seedlings from 88 bi parental crosses, 14 poly crosses and 11 general collections were evaluated in the ratooned ground nursery. Based on field stand, NMC, cane diameter, HR Brix and a selection intensity of 9.23%, 1,217 selections were made. The selections were planted in first clonal trial in RCBD along with standards. The best crosses which yielded more number of selections are given in Table 9.

***Table 9.* List of families with their percent selection**

Cross	Selection (%)
Co 86032 x Co 0403, Co 11015, Co 0314 PC	34.00
Co 06010 x Co 11015	32.32
Co 8371 x CoV 92102	31.58
Co 86032 x 85R186	24.00
Co 99006 x 85R186	22.20
Co 86032 x Co 94019	16.67
Co 12014PC	17.60
Co 99006 x Co 94008	15.90
CoM 0265 x Co 86011	14.86
CoM 0265 PC	12.00

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

I clonal trial (2017)

Three thousand and one hundred clones were evaluated in first clonal trial for HR Brix, NMC and cane diameter at 300 and 330 days. Among them, 546 genotypes recorded good field stand with HR Brix more than 20 after 330 days of planting and moderately resistant/resistant to red rot disease under CCT method (cf671) of testing. The selected clones recorded >2.5 cm cane thickness and had desirable characters *viz.*, absence of leaf sheath spines and free from foliage diseases. Genotypes derived from crosses with Co 11015, CoC 671, Co 86032, Co 06022, Co 85002, Co 08016, Co 0118 and CP 61-23 as one of the parents had early sucrose accumulation. Among the selections, more than 10 clones from Co 11015 PC (CoT 8201, Co 94005, Co 0311) recorded 24.0% HR Brix and a clone from Co 85002 GC recorded >25% HR Brix at 330 days. The crosses Co 7201 x CoC 671, Co 11015 x Co 94008, Co 8371, Co 0403 x Co 11015, Co 11001 x Co 99006, Co 13010 GC, Co 0240 x Co 11012, CoM 11087 x Co 09010 had more than 10 selections (Table 10). Among the families, CoC 671 x Co 94008, Co 12001 x Co 13015, Co 0323 x Co 11012, Co 13010 GC and Co 0240 x Co 11012 recorded mean HR Brix of 19.30%, 19.20%, 19.64%, 19.10% and 18.10% respectively at 300 days. A total of 1,297 clones were selected and 1032 clones were planted in second clonal trial along with five standards for further evaluation.

Table 10. **Promising families in first clonal trial**

Crosses with more selections	Selection (%)
Co 11015 x CoT 8201, Co 94005, Co 775, Co 97015	15.80
Co 11015 PC	12.70
Co 11015 x Co 94008	9.50
CoM 0265 PC (Co 775, Co 86011, Co 94005)	8.80
Co 11015 GC	8.10
Co 87044 PC (Co 0314, Co 99008, Co 06022)	7.90
Co 8371 x Co 97015	7.80
Co 8353 GC	7.50
CoC 671 x Co 775	6.30
Co 08016 x Co 94005	5.80
Co 7201 x CoC 671	13.00
Co 11015 x Co 94008, Co 8371	12.00
Co 0403 x Co 11015	10.00
Co 86011 x Co 97015, CoSe 92423	7.00
CoTl 85118 x Co 99006	7.00
Co 0403 x Co 99006	11.00
Co 11001 x Co 99006	10.10
Co 13010 GC	13.33
Co 0240 x Co 11012	17.93
CoM 11087 x Co 09010	10.52

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

II clonal trial

Six hundred and fifty five clones along with four standards (Co 86032, Co 99004, CoC 671 and CoM 0265) were evaluated in augmented RCBD for cane yield, juice quality and red rot resistance. Two hundred and nineteen clones recorded higher cane yield than the standard Co 86032 (114.6 t/ha) and 207 clones recorded higher sucrose than Co 86032 (18.47%) at 12 months. Four clones (16-0052, 16-0337, 16-0124, 16-1284) recorded high juice sucrose (>20.50%) at 300 days. Overall, six crosses Co 99006 x Co 06015, Co 11015 x Co 775, Co 0240 x Co 0209, Co 85002 x Co 8209, Co 8371 x Co 2000-10 and Co 0403 x Co 11015 had more selections superior for cane yield and juice sucrose combining resistance to red rot (Fig. 4). Two crosses Co 99006 x Co 06015 and Co 11015 x Co 775 recorded more than 15.0% selections better than the standard Co 86032 indicating their merit in contributing more selections for cane yield and juice sucrose. One hundred and six clones from this trial were promising for cane yield and juice sucrose, with good field stand and red rot resistance and were further promoted to PZVT testing.

Fig. 4. Per cent selections in crosses that recorded higher cane yield than Co 86032

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

Pre-Zonal Varietal Trial

Eighty two genotypes along with four standards (Co 86032, Co 99004, CoC 671 and Co 09004) in RBD were evaluated in the PZVT conducted at Coimbatore. Fourteen elite selections and four genetic stocks have been assigned 'Co' numbers from Co 18001 to Co 18018 (Table 4). Co 18003 recorded the highest CCS yield of 25.15 t/ha compared to the best standard Co 09004 (23.61 t/ha). Two clones Co 18003 (181.46 t/ha) and Co 18015 (179.51 t/ha)

recorded a significant improvement of more than 10.0% for cane yield over the best standard Co 99004 (157.57 t/ha). Co 18008 recorded the highest juice sucrose at 300 days (20.06%) compared to the standard Co 09004 (19.90%) indicating its potential as an early high sugar accumulating clone. Two clones *viz.*, Co 18008 (22.52%) and Co 18018 (22.02%) recorded better sucrose at 360 days compared to the standard Co 09004 (21.70%). Performance of the 'Co' selections compared to the popular standard Co 86032 (Fig. 5) indicated the superiority of Co 18001, Co 18002, Co 18003, Co 18009, Co 18010, Co 18011 and Co 18013 for CCS yield, cane yield and juice sucrose at 360 days.

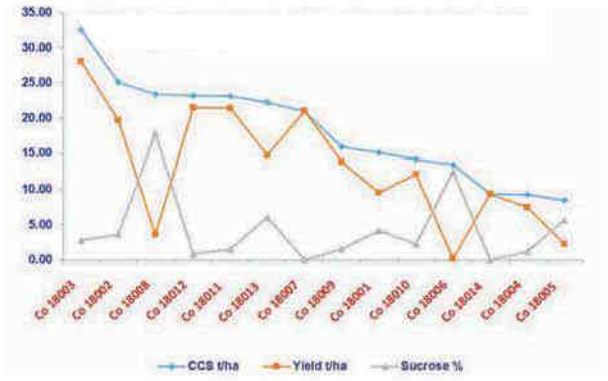


Fig. 5. Percentage improvement of selected Co canes compared to the standard Co 86032

(R.M. Shanthi and T. Lakshmipathy)

Multiplication of Pre-Zonal Varietal Trial (2017 series)

A total of 208 elite clones pooled from different experiments were planted in augmented design along with standards (CoC 671, Co 99004 and Co 86032) for multiplication as well as evaluation during 2017-18. Eight clones (2017-74, 19, 109, 182, 40, 184, 35, 2017-187) recorded four units higher sucrose content (20.62%) than that of the best standard CoC 671 at 300 days. Similarly, eight clones viz., 2017-157 (22.31%), 2017-40 (22.13%), 2017-1 (21.82%), 2017-78 (21.50%), 2017-190 (21.30%), 2017-182 (21.20%), 2017-102 (21.16%), 2017-43 (21.02%) recorded superior sucrose content as compared to the best standard CoC 671 at 360 days. Superior 84 clones were planted in PZVT Trial 2018-19. Observations on germination were recorded and the entry 2017-63 showed highest germination % (94.97) and the lowest germination % was recorded in 2017-43 (36.98).

(S. Karthigeyan and C. Mahadevaiah)

Screening for diseases

Red rot : A total of 3,075 clones under evaluation in crop improvement projects and Kannur comprising clonal trials, PZVT, parental clones, GUK/ WL clones, GU clones, germplasm, climate resilient clones and high biomass hybrids were tested for red rot resistance under controlled conditions against CF06 (Cf671) pathotype. About 1,598 clones were identified as resistant and moderately resistant to red rot.

(P. Malathi)

Smut : Eighty one PZVT entries (2016 series) were evaluated for smut resistance. The profile of the ratings were HS (21 clones), S (15 clones), MS (22 clones), MR (12 clones) and R (11 clones). For the current season (2018-19), 82 clones were planted after challenge inoculation with smut teliospores and are being evaluated for smut reaction along with respective susceptible and resistant standards.

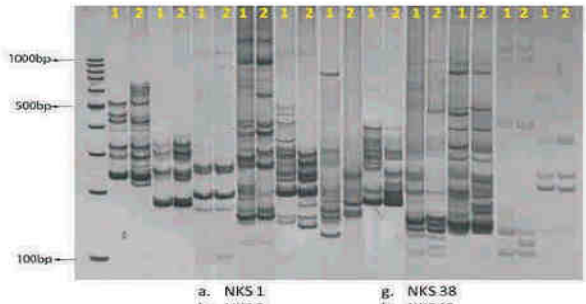
(A. Ramesh Sundar)

Botanical characterisation and DNA finger printing of elite selections and varieties

Botanical description has been given to 14 'Co' canes of 2017 series. A book entitled "Morphological description of Coimbatore (Co) Canes (1993-2016)" containing the botanical description of 528 Co canes developed during 1993-2016 and maintained at the Institute was released during SUCROSYM 2017. Salient features of each Co canes with colour photographs, DNA fingerprints and genealogy of important varieties of the period are provided in the book.

DNA fingerprinting: DNA fingerprinting was done on a routine basis and fingerprinting of entries

under Sweet Bloom Project is in progress. Based on 12 STMS primers, the variety Co 0239 was distinguished from Co 0118 (Fig. 6). In DUS testing, molecular profiling was carried out to resolve the identity of a farmer's variety Siddigiri which resembled Co 92005 in gross morphology. The finger prints of Siddigiri were confirmed to be similar to Co 92005 and not a distinct type. DNA profiling of VSI 12121 was carried out on payment basis.



Lane 1 : Co 0118, Lane 2: Co 0239

Fig. 6. Molecular profiles of Co 0118 and Co 0239

(G. Hemaprabha and H.K. Mahadevaswamy)

Identification and testing of short duration sugarcane clones

A field trial involving four short duration clones (Co 11015, Co 16001, Co 16002, Co 09004) along with three standards (Co 671, Co 8338, Co 86032) was planted in special season (28.7.2017) to assess yield potential, ratooning ability and quality attributes of short duration clones. The crop was harvested at 8th month. Juice analysis at harvest showed superiority of Co 11015 and Co 09004 over the best standard CoC 671. The sucrose % of CoC 671 at 8th month was 17.85% whereas it was 20.11% in Co 11015 and 19.15% in Co 09004. Among the standards, highest cane yield at 8th month was recorded in Co 86032 (82.45 t/ha). The clone Co 09004 recorded 10.75 tonnes higher cane yield/ha (93.20 t/ha) than Co 86032. The first ratoon initiated from 8th month plant crop (March 2018 harvest) is currently under evaluation.

(R. Karuppaiyan and G. Hemaprabha)

Evaluation of elite clones for identifying promising location specific sugarcane varieties KCP Sugars, Vuyyuru, Andhra Pradesh

Twelve elite Co canes *viz.*, Co 13003, Co 14008, Co 13006, Co 11015, Co 15007, Co 14002, Co 15021, Co 16002, Co 0238, Co 13014, Co 09004 and Co 0240 were supplied to KCP Sugars, Vuyyuru, Andhra Pradesh to identify promising entries for coastal region. These clones were multiplied during 2017 and planted in the field in January 2018 for evaluation. Juice analysis was carried out in the multiplication plot and the clones Co 0238 and Co 0240 recorded the highest juice sucrose % of 20.65 and 19.82 respectively. Among the clones supplied, Co 0238 and Co 11015 flowered.

(K. Mohanraj and T. Lakshmipathy)

Maharashtra : Eighteen elite drought tolerant clones (Co 85019, Co 90003, Co 92020, Co 93009, Co 94005, Co 98017, Co 2000-10, Co 05001, Co 05007, Co 06022, Co 13006, Co 08020, Co 09004, Co 10017, Co 10024, Co 0238, Co 13003, Co 14005) were evaluated in five sugar industries in Maharashtra *viz.*, Vasantdada Sugar Institute (Pune), Samarth Sahakari Sakhar Karkhana (Ankushnagar, Jalna), Bhaurao Chavan Samarth Sahakari Sakhar Karkhana (Nanded, Dhyaneshwar), Sahakari Sakhar Karkhana (Newasa) and Sanjivini Takli Sahakari Sakhar Karkhana (Kopargaon, Ahmednagar District). Four entries *viz.* Co 14005 (19.58%), Co 98017 (18.26%), Co 13006 (18.29%) and Co 92020 (18.02%) were superior for juice sucrose compared to the best standards Co 86032 (17.17%) and CoM 0265 (17.91) at 360 days in Sanjivini SSK, Kopargaon. At Dhyaneshwar SSK, 12 entries recorded superior juice sucrose content compared to the best standard. At 360 days, Co 06022 (19.86%), Co 05007 (19.26%), Co 98017 (19.26%), Co 10024 (19.22%) and Co 13003 (19.15%) were the best with better crop stand as compared to CoM 0265 (16.44%) and Co 86032 (17.18%).

(C. Mahadevaiah)

Kolhapur : Twelve Co entries *viz.*, Co 13003, Co 13006, Co 13020, Co 06022, Co 06030, Co 09004, Co 15007, Co 07015, Co 14008, Co 0212, Co 15021 and Co 11015 along with two standards (Co 86032 and Co 92005) were planted in three replications in RBD trial at M/s. Dalmia Sugars Ltd, Kolhapur for identification of promising sugarcane variety for the region.

(V. Sreenivasa)

Karnataka : A total of 246 'Co'canes and improved genetic stocks were evaluated at Sri Nijalingappa Sugar Institute, Belagavi from 2014 to 2018. The clones 2012-88, 2012-91 and Co 14012 recorded significantly higher cane yield (145.18, 138.09 and 120.02 t/ha respectively) and CCS yield (20.62, 18.56 and 15.59 respectively) than the standard Co 86032 (98.34 t/ha cane yield and 12.65 CCS yield) in first plant crop (2015-16). The entries 2012-88 and 2012-91 recorded juice sucrose of 18.94% and 17.84% at 360 days respectively, which were higher than Co 86032 (17.11%). The entry 2012-91 is a moderately flowering clone and 2012-88 is non-flowering clone and appear promising for North Karnataka.

Ratoon performance of these clones was assessed during 2016-17. The clones 2012-88 and 2012-91 recorded significantly higher cane yield (150.28 t/ha and 129.02 t/ha respectively) and CCS yield (21.26 t/ha and 17.03 t/ha respectively) than the standard Co 86032 (111.25 t/ha cane yield and 13.90 CCS yield) at harvest. The entries, 2012-88 and 2012-91 recorded 18.86% and 17.57% sucrose at 330 days respectively. The clone 2012-88 did not flower in ratoon crop as well.

Based on plant and ratoon performance, 2012-91 and 2012-88 were assigned Co-numbers as Co 18023 and Co 18024 respectively (Table. 5).

Evaluation of sugarcane clones for drought tolerance at SNSI, Belagavi

Twenty-two entries viz., Co 85019, Co 92002, Co 92013, Co 92020, Co 90003, Co 93009, Co 94005, Co 95020, Co 98008, Co 98017, Co 10033, Co 0212, Co 0303, Co 06015, Co 06022, Co 07015, Co 08020, Co 12007, Co 13003, Co 13006, Co 14011 and Co 05011 along with two standards CoC 671 and Co 86032 were planted in RBD trial with two replications to identify drought tolerant variety for Belagavi region. Drought treatment was imposed by withholding irrigation on 60th day and continued up to 120 days.

(V. Sreenivasa and H.K. Mahadevaswamy)

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

Ten selected energy canes were evaluated at Sameerwadi and the cane fibre % was recorded maximum in SBIEC 14006 (26.42%) followed by SBIEC 13010 (25.45%) and SBIEC 13005 (25.32%). SBIEC 14006 also recorded the highest cane yield (187.81 t/ha). Among 21 energy canes evaluated, SBIEC 13009 (3672 cal/g) recorded the highest energy value followed by SBIEC 11007 (3485 cal/g) and seven energy canes recorded more than 3000 cal/g. Maximum hemicellulose % was recorded in IA 1167 (31.64%) followed by SBIEC 11002 (29.28%) and the lowest in SBIEC 13009 (22.60%). The energy cane SBIEC 14006 recorded higher lignin (29.20%) as compared to other clones. Higher cellulose was recorded in SBIEC 13008 (38.34%) followed by SBIEC 13005 (38.00%). SBIEC 14006 was ratooned in six acres of land for assessing its ratoon potential.

(P. Govindaraj and M.R. Meena)

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

2016-18 season trials: CAE-early second plant trial with three entries (Co 08020, 29 C 090 and 29C 229) and CAE-midlate second plant trial with three entries (Co 08009, Co 08016 and 29 C 442) were conducted along with the check Co 86032 and local checks at Bannariamman Sugars, Sathyamanagalam. First plant crop of the

previous year trial was ratooned in Bannariamman Sugars and Sakthi Sugars Ltd, Appakudal.

Early II plant trial: Three entries *viz.*, Co 08020, 29 C 090 and 29C 229 along with four standards (Co 86032, CoC 24, CoC 22 and Co 0403) were evaluated in CAE-early second plant trial at Bannariamman Sugars, Sathyamangalam. Co 86032 was the best among the standards with 17.05 t/ha of sugar yield and 138.77 t/ha cane yield. Among the test entries, 29 C 090 with 17.46 t/ha sugar yield and 140.77 t/ha cane yield was comparable with the standard. Juice analysis indicated that all the test entries were on par with Co 86032 for juice sucrose %.

Mid-late II plant trial: Three entries viz., Co 08009, Co 08016 and 29C 442 evaluated along with five standards (Co 86032, Co 0212, Co 91017, and CoC 24) indicated Co 86032 as the best standard with 18.86 t/ha of sugar yield and 146.03 t/ha of cane yield. None of the test entries were significantly superior to the best standard. Among the test entries, Co 08016 for CCS yield (17.46 t/ha) and Co 08009 for cane yield (133.30 t/ha) were better than other test entries in the trial conducted at Bannariamman Sugars, Sathyamangalam.

New nominations for the trial: Co 11015 (CoC 671 x Co 86011), Co 13003 (Co 86011 x CoT 8201), Co 06031 (BGC2 5021 x Co 88027), Co 14016 (Co 86032 x Co 86011), Co 15007 (ISH 100 x Co 0209) were nominated for the forthcoming ART trial to be conducted in different locations of Tamil Nadu at the 26th Crop Scientist Meet on Sugarcane held at TNAU, Coimbatore.

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

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

Hybridization: A total of 645 seedlings from 10 crosses *viz.*, CYM 14-688 x 98 R 278 (95), Trigeneric hybrid (Amphiploid CYM 04-420 x *Tripsacum*) x 98 R 278 (237), Amphiploid CYM 04-420 x CoS 93278 (101), CYM 14-61 x Co Pant 97222 (67), CYM 14 - 94 x Co Pant 97222 (60), Trigeneric hybrid (Amphiploid CYM 04-420 x Tripsacum) x 85 R 186 (72), CYM 13-51 x CoS 93278 (6), CYM 14-710 x Co 94008 (5), Amphiploid CYM 04-420 x Co Pant 97222 (1) and CYM 05-228 x IK 76-91(1) were evaluated. Eighty three promising clones combining high NMC, cane thickness and HR Brix were selected and planted for further evaluation.

Evaluation: A total of 85 cytoplasmically diverse hybrids were evaluated in clonal trial. The hybrid CYMA 10-1040 recorded the highest sucrose content of 21.35% at 300 days while the best standard CoC 671 recorded 22.56%, followed by CYM 13-347 (21.19%), CYMA 09-1433 (20.82 %), CYMA 10-1109 (20.78%) and CYM 13-359 (20.36%).

PZVT: Six promising cytoplasmically diverse hybrids *viz.*, CYM 14-887, CYM 14-884, CYM 14-688, CYM 14-298, CYM 12-437 and CYM 10-784 were advanced to PZVT multiplication.

Maintenance: A total of 473 advanced generation backcross hybrids of sugarcane with *Erianthus arundinaceus* or *S. spontaneum* cytoplasm, hybrid derivatives, parental clones and 83 CD clones were field maintained.

(Adhini S. Pazhany)

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

Yield and quality attributes recorded in sett planted bacterized tissue culture crop: The efficacy of bacterization with single and dual combination of bacterial cultures *viz., Bacillus subtilis, Pseudomonas fluorescence, Gluconacetobacter diaztrophicus, Azospirillum and Methylobacterium* on yield and quality parameters at TC I stage (Sett planted bacterized tissue culture crop) was recorded. At 120 days, number of tillers was high in bacterial combination *Gluconacetobacter* + *Methylobacterium and Pseudomonas* + *Azospirillum* compared to unbacterized tissue culture crop. Data recorded at 10th month indicated that *Gluconacetobacter* +

Methylobacterium and Gluconoactobactor + *Bacillus* had the highest cane height of 242.8 cm and 232.0 cm respectively compared to other treatments and control (193.2 cm) in the sett planted bacterized crop. Among the single and dual combination of bacteria, there was no significant difference noticed for cane thickness and internode length but number of internodes were numerically higher in dual combination *Gluconacetobacter* + *Methylobacterium, Gluconoactobactor* + *Bacillus, Bacillus* + *Azospirillum and Pseudomonas* + *Azospirillum.* Single cane weight was high in *Gluconoactobactor* + *Bacillus* (1.53 kg), *Gluconacetobacter* + *Methylobacterium* (1.5 kg) compared to control (1.2 kg). No significant difference was noticed for Brix but Pseudomonas+ Azospirillum recorded high Brix value (23.0%) followed by *Pseudomonas* + *Methylobacterium* (22.7%) and *Gluconoactobactor* + *Bacillus* (22.1%) whereas 21.7% brix value was recorded in unbacterized crop. In conclusion the crop raised from the setts of the bacterized tissue culture crop *Gluconoactobactor* + *Bacillus* was found to be the suitable bacterial combination to enhance yield and quality of sugarcane crop.

Production of virus free plant through direct regeneration from young leaf whorl: Direct regenerated plants developed from young leaf whorls with ribavarin treatment viz., 10,11 and 12 mg/l were planted in the field. There was no significant difference in terms of NMC, cane height, cane diameter, internode number and length, single cane weight and Brix in 10 month old crop. But there was numerical increase in cane height (207.3 cm), length of internode (13.85 cm) and single cane weight (1.35 kg) in the 12 mg/l ribavarin treated crop compared to 10 mg, 11 mg ribavarin and control. Use of antiviral chemicals ribavarin in culture medium during regeneration of shoots from young leaf segment was found to be an alternate and quick method for establishment of in vitro culture to produce virus-free tissue culture plants.

(D. Neelamathi, A. Selvi and S. Vasantha)

Enhancement of sugarcane germplasm and development of pre-breeding material

(K. Chandran)

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

Newly isolated CENH3 gene was amplified in Co 7201. From the PCR amplified product, probe was prepared and biotin labelled. Freeze dried meiotic slides of Co 7201 with different stages of meiosis was subjected to FISH analysis with CENH3 probe. In majority of the chromosomes, CENH3 gene has localized in the centromeric region. In anaphase, the signal was absent in the lagging chromosomes. The study revealed the role of identified CENH3 in chromosome elimination (Fig. 7 and 8).

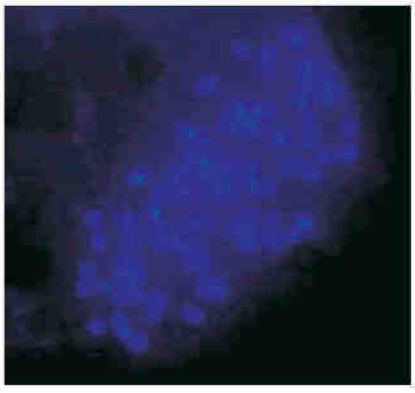


Fig. 7. CENH3 signals in the centromeric region of meiotic chromosomes at Metaphase

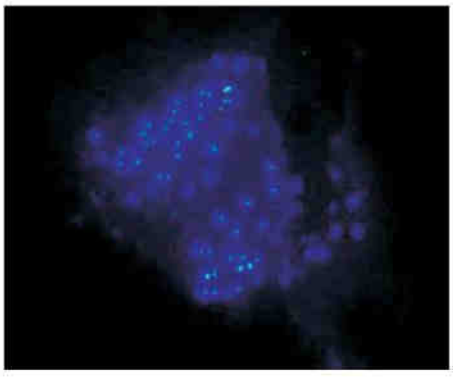


Fig. 8. CENH3 signals in the centromeric region of meiotic chromosomes at Anaphase

(V.P. Sobhakumari and K. Lakshmi)

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

Seedling evaluation of BC_1 and BC_2 hybrids recorded highest mean NMC /seedling (10.3) in the cross of CoLk 8102 x [04-817, Co 8371 x IND 82-228, 2n=40], whereas brix % ranged from 15.2 - 17.1. The cross LG 95053 x 04-746 (Co 1148 x IND 84-338, 2n=60) recorded Brix % in the range of 12.0- 20.1% with a mean of 17.15. Sixty selections were made for further evaluation.

Clonal evaluation of 52 BC_1 and BC_2 hybrids at ECC farm indicated high sucrose from 18.3-19.67% in four hybrids derived with 2n=80. Plant height (291.6 cm) and cane weight (1.7 kg) were maximum in the hybrids of MS 6847 x 04-447 (2n=72). Twenty hybrids were selected for further evaluation.

Forty five hybrids were screened for red rot resistance in which 23 were MR and 3 were R. Among MR, eight hybrids belonged to cytotype 2n=80 and the susceptible parent CoC 671.

Thirty five BC_1 hybrids derived with the cytotypes 2n =40 [CoLk 8102 x (Co 8371 x IND 82-228) and 2n=60 [LG 95053 x (Co 1148 x IND 84-338)] indicated n+n transmission. These hybrids possessed chromosome number from 2n = 90-108. Meiotic studies in 20 hybrids and their parents indicated predominance of bivalents. Secondary association of bivalents was observed in metaphase in the hybrids derived with the cytotype 2n = 40.

Among the 30 hybrids given for resilient trial in AICRP, the hybrids 04-1687,04-1689,04-635 were tolerant for drought and waterlogging, while 04-2097 was drought tolerant and 04-245 was tolerant for waterlogging. Four hybrids were characterized for registration.

At Agali Centre, seven back crosses were made between progenies derived from different cytotypes of *S. spontaneum* x Co canes / *S. officinarum*. They were 17-15-22 (Co 85002 x 04-182 (Co 89029 x *S. spontaneum*, 2n = 112) x Co 8311, 17-15-14 x 04-182 (Co 89029 x *S. spontaneum*, 2n = 112) x Co 775), 17-15-63 [(Co 86032 x 04-774 (Co 1148 x *S. spontaneum*, 2n =80) x 28 NG15 (*S.officinarum*)], 17-15-42 [(MS 6847 x 04-774 (Co1148 x *S. spontaneum*, 2n=80)) x 28 NG 288 (*S.officinarum*)], 17-15-42 [(MS 6847 x 04-774 (Co 1148 x *S. spontaneum*, 2n=80)) x *S.officinarum* : Laukona 15, 17-15-57 [(MS 6847 x 04 -774 (Co 1148 x *S. spontaneum*, 2n =80)) x 28 NG 288 (*S.officinarum*)], 17-15-42 [(MS 6847 x 04-774 (Co 1148 x *S. spontaneum*, 2n =80)) x Co 90006, 17-15-59 [(MS6847 x 04-774 (Co1148 x *S. spontaneum*, 2n =80)) x 28 NG 288 (S.o)], 17-15-42 [(MS 6847 x 04-774 (Co 1148 x *S. spontaneum*, 2n=80)) x Co 89003. The fluff was sown and about 310 seedlings were transplanted in polybags. In addition, 10 backcrosses were made with progenies involving the cytotypes 2n=40, 80 and 60 at NHG and 516 seedlings were raised.

(A. Suganya and R. Karuppaiyan)

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

Pooled analysis of founder parents for drought tolerance: Twenty founder parents were evaluated for their relative drought tolerance in the field condition for consecutive two years during 2015-16 and 2016-17. The pooled analysis showed CYM 08-922 to be a potential drought tolerant parent with highest cane yield, as well as higher relative water content, leaf area index and lower MDA content under drought. With the physiological data and higher cane yield CYM 08-922 was found to be one of the potential drought tolerant parents for breeding drought tolerant varieties in sugarcane.

Evaluation of clones from two way cross populations for drought tolerance: Ninety six clones selected from the two way cross populations along with four drought tolerant commercial varieties viz., Co 86032, Co 06027, Co 06030 and CoM 0265 were planted in a split plot design with two replications in both control and drought. The drought was imposed from 60 to 150 DAP during the formative phase. The clones were screened visually and scored in the scale of 1-4, 1 being tolerant and 4 being highly susceptible during peak stress *viz.*, 45 days and 60 days after

stress imposition (Fig. 9). Eight clones *viz.*, TWC 13, TWC 27, TWC 50, TWC 71, TWC 75, TWC 81, TWC 82, TWC 84 had shown no symptoms or only light tip drying. There was significant reduction in NMC in control as well as drought condition and overall 50.51% reduction was observed in drought compared to control. The reduction in NMC and cane traits *viz.*, cane height, cane diameter, single cane weight for the two-way cross population was significantly lower compared to the mean of drought tolerant checks and vice versa for juice quality traits.

Fig. 9. Screening progenies from two-way cross populations- Field view

Developing four way cross populations: In addition to the 40 crosses made during 2016, 36 new crosses and three poly crosses were made using randomly selected progenies from two way cross populations during the crossing season 2017. The fluff of 79 crosses was sown and 2,530 seedlings were transplanted in field for evaluation and further population development. The cross TWC 28 X TWC 51 had a maximum of 340 seedlings.

Red rot resistance: Among the 96 clones screened for red rot resistance under CCT, 11 were resistant and 33 were moderately resistant. From this population, 45.7% clones were resistant and 35.1% were susceptible to red rot. Thirteen out of 28 clones from the cross Co 95005 x CYMA 09-1369 were found to be resistant to red rot.

(K. Mohanraj, G. Hemaprabha and S. Vasantha)

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

Collection of germplasm

In September 2017, an exploration was conducted in Jharkhand state for the collection of wild and cultivated species of *Saccharum* complex. Damodar, Ganga, North and South Koel, Subarnareka, Jamunia, Auranga Khajua, Usri, Kharkai, Mayurakshi and Barakar were the major rivers surveyed during the expedition. A total of 76 *S. spontaneum* and four *S. officinarum* were collected from 24 districts. They were occurring as very small to large population and mostly found in river beds and field bunds. Invasion of *S. spontaneum* in agricultural field was noticed and farmers found difficult to control the weed. *S. spontaneum* was distributed throughout the state and collections could be made from all the districts and rivers surveyed.

High variability was observed among the *S. spontaneum* collections for various quantitative characters. While plant height varied between 31 and 283 cm with a standard deviation of 50.1 cm, arrow length ranged from 10 to 61 cm. Leaf width varied greatly from 0.1 to 0.4 cm with standard deviation of 0.1 cm. The shortest internode length was observed with IND 17-1924 (3 cm) and the longest internode length was recorded by IND 17-1921 (18 cm).

S. officinarum was cultivated in small extent for chewing purpose and for selling to juice venders. It was also spotted in home garden occasionally. Four *S. officinarum* one each from Rangarh, Kunti, Gumla and Ranchi districts were collected. Stem color varied from purple to red and none of them was in the flowering stage. Most of the canes were 8 month old crop and the height varied between 162 cm and 175 cm and medium in tillering. The cane diameter ranged from 1.90 to 4.10 cm and internode length between 11.50 and 14.00 cm.

(P. Govindaraj and H. K. Mahadevaswamy)

Maintenance at Coimbatore and Wellington

All the 1,962 germplasm accessions *viz.*, *S. spontaneum* (1,451), *Erianthus sp.* (382), *Saccharum* canes (22), allied genera (59) and improved *Erianthus* (48) were maintained in the field in Coimbatore. Seven hundred and seventy nine accessions flowered during June 2017 to December 2018. Replanting of 2,054 wild germplasm accessions for field maintenance was completed including additional new collections of *S. spontaneum* and Erianthus species collected from Punjab and Haryana during 2016.

A total of 50 clones comprising *S. spontaneum* (43) and *Erianthus procerus* (5) from Arunachal Pradesh, a *Erianthus fulvus* and a *Miscanthus* spp. collected from Meghalaya are maintained at ICAR – IARI Regional Station, Wellington, Nilgiris.

(S. Karthigeyan and Adhini S. Pazhany)

Maintenance of commercial hybrids and genetic stocks

A total of 2006 commercial hybrids ('Co' canes) and genetic stocks were planted in field for maintenance as well as utilization in various hybridization programmes. The composition of the clones includes 1,335 'Co' canes, 17 'Co' allied clones, 48 exotic clones, 289 ISH clones, 39 IGH clones, 179 CYM clones and 99 other clones.

(V. Sreenivasa and V. Vinu)

National active germplasm maintenance

National Active Germplasm clones were checked for their growth and establishment in the quarantine. The seed materials received from different centres were submitted to quarantine process and periodic monitoring was done for their growth. At present, about 20 clones are being maintained under quarantine. Index numbers were assigned for 15 clones and planting was done for 240 NAG clones for field maintenance in 2018-19.

(C. Jayabose and S. Alarmelu)

Characterisation, Evaluation and Cataloguing

Characterization: Well established healthy disease free 16 clones were taken for characterization of germplasm clone collected from Punjab and Haryana. Among the 42 morphometric traits except flowering, pollen fertility and chromosome number the remaining parameters were observed and recorded.

Punjab: The tallest clone was IND 16-1809 with a height of 196.3 cm and the shortest was IND 16 -1813 (106.3 cm). Maximum leaf lamina length was measured (166.3 cm) in IND 16-1802 and the minimum was measured (35.3 cm) in IND 16-1804. With respect to nodal character (shape of internode), six clones exhibited bobbin shape, two with obconoid, one clone (IND 16-1821) showed conoidal shape and in the remaining clones the internodes were cylindrical in shape. One clone IND 16-1812 showed arcuate shape ligules and the remaining clones were of deltoid shapes. The maximum HR Brix was recorded in the clone IND 16-1812 with 10.5%. Among the clones studied, the clone IND 16-1812 was distinct from the other clones for its high HR Brix, ligular shape, oval solid stem, heavy waxiness and green (RHS-139 D) coloured dewlap (Fig. 10).

Haryana: Twenty four clones collected from Haryana state were characterized this year. In respect to nodal character (shape of internode), four clones exhibited bobbin shape (IND 16-1749, IND 16-1784, IND 16-1786 and IND 16-1787); three clones (IND 16-1760 IND 16-1765, IND 16-1776) with conoidal shape and remaining clones showed cylindrical shape. Clone IND 16-1792 recorded highest HR Brix of 13.2% followed by IND 16-1790 with 12.8% (Fig. 10).

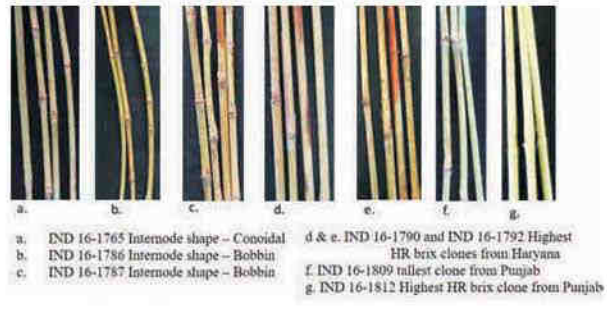


Fig. 10. Internode shape recorded in sugarcane germplasm collected from Punjab and Haryana

Flowering behaviour of allied genera of Saccharum: Flowering period was recorded for 12 species which includes 198 clones. In 2016, three clones of *Narenga* flowered in which the clone IND 82-332 flowered during April and ended in the first week of June. The same clones flowered again in first week of July and ended in the second week of August. Six clones of Imperata flowered during this year. Two clones IND 05-1394 and IND 08-1500A which did not flower last year flowered this year. Among the clones of Vetiveria 15 clones flowered during this season and two clones namely 51 NG 02 and IND 81-93 did not flower. Six clones of Sclerostachya flowered during this flowering season whereas last year only two clones flowered. The clones IND 01-1100 and IND 05-1402 consistently flowered for last three years. The clones of Phragmites genera did not flower in the first quarter of flowering period (April to June) but flowering was observed in fourth week of July and continued till second week of November. In *Neyraudia* five clones flowered during this season and flowering initiated two months earlier compared to last year (second week of July). In 2016, 10 clones of *Pennisetum* flowered whereas in 2017, only two clones 28 NG 09 and EPE 752 flowered during first week of December. Sixty three clones of *Erainthus bengalensis* flowered in this flowering season and maximum flowering was observed from September to December. Out of 30 clones of *E. procerus*, 24 clones flowered during September to November. Six clones namely IND 84-353, IND 89-693, IND 90-824, IND 04-1344, IND 04-1346 and IND 04-1347 exhibited early flowering (April to June). All the available clones of *E. elephantinus* flowered during July to October. Out of 12 clones of *E. ravennae* only seven clones flowered (Table 11).

Pollen fertility of allied genera of Saccharum: Pollen fertility was studied for 51 clones of allied genera of *Saccharum* (Table 12). In comparison to last year, high pollen fertility percentage was observed in all the clones of allied genera during this year. Among the studied genera, the lowest pollen fertility percentage was observed in *Erianthus procerus* clone (IND 90-824) with 75.1%. The highest pollen fertility percentage was noticed in *Sclerostachya* (IND 01-1100) with 98.6% (Fig. 11).

Table 11.* Details of flowering in allied genera of *Saccharum

Name of the Genera	No. of clones
Narenga	5
Imperata	6
Vetiveria	17
Sclerostachya	7
Phragmites	4
Neyraudia	5
Pennisetum	2
Erainthus bengalensis	63
E. procerus	24
E. elephantinus	6
E. ravennae	7
Erainthus sp.	52
Total	198

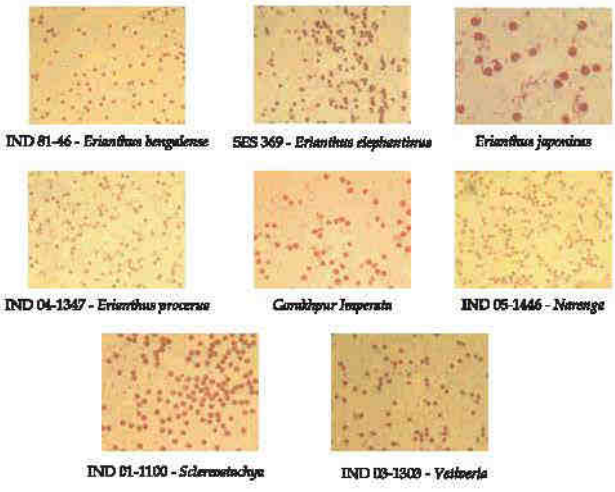


Fig. 11. Pollen fertility of allied genera of Saccharum

Table 12. **Pollen fertility of allied genera of *Saccharum***

S. No.	Clone Name	Pollen Fertility (%)
	Vetiveria	
1	IND 81-54	87.4
2	IND 81-77	92.0
3	IND 81-79	93.8
4	IND 81-53	95.3
5	IND 81-92	82.2
6	IND 81-93	89.9
7	IND 81-94	97.0
8	IND 81-96	94.9
9	IND 81-97	95.5
10	R-71	93.2
11	IND 01-1115	89.3
12	IND 03-1303	89.5
13	IND 09-1531	96.7
14	IND 81-78	96.0
	Sclerostachya	
1	IND 01-1096	98.4
2	IND 01-1100	98.6
3	IND 01-1135	98.5
4	IND 81-21	96.9
5	IND 05-1401	92.3
6	IND 05-1402	97.9

S. No.	Clone Name	Pollen Fertility (%)
	Narenga	
1	ERI 8-6	90.8
2	IND 05-1446	88.6
3	IND 82-332	89.4
4	IND 05-1449	83.1
5	NARENGA	89.8
	Imperata	
1	IND 05-1394	93.6
2	IND 08-1500 A	89.0
3	IND 05-1398	94.2
4	IND 03-1257	85.5
5	AG TRICHUR	92.9
6	Gorakhpur Imperata	92.8
	Erianthus elephantinus	
1	SES 369	92.3
2	SES 305	97.0
	Erianthus procerus	
1	IND 04-1347	84.1
2	IND 00-999	93.6
3	IND 90-824	75.1
	Erianthus ravennae	
1	SES 349	89.7

S. No.	Clone Name	Pollen Fertility (%)
	Erianthus species	
1	ERI 3198	87.9
2	IND 90-818	95.1
3	IND 11-1617	92.2
4	IND 89-683	92.6
	Erianthus bengalensis	
1	IND 81-34	84.7
2	IND 81-140	86.9
3	SES 285	95.2
4	SES 362	95.5
5	THAI 13-1	86.5
6	THAI 13-5	94.7
7	IND 81-47	95.6
8	IND 81-46	95.4
9	SES 219	89.0
	Erianthus japonicus	
1	Clone	92.4

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

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

Somatic chromosome number was determined in 60 clones of *S. spontaneum* consisting of the clones from IND-01, IND-02, IND-03, IND-04, IND-05 and IND-15 collections (Table 13). Different cytotypes like 2n = 48, 56, 60, 62, 64, 70, 72, 80 and 112 were identified (Fig.12a and 12b).

Table 13. **Details of chromosome numbers recorded in different clones of *S. spontaneum***

Clone	2n
IND 01-1157	112
IND 03- 1317	64
IND 15-1722	64
IND 01-1159	64
IND 03- 1318	64
IND 15-1725	64
IND 01-1156	56
IND 03-1313	64
IND 15-1729	64
IND 02-1197	64
IND 03-1299	64
IND 15-1737	64
IND 02-1198	48
IND 03-1316	64
IND 15-1740	64
IND 02-1199	64
IND 03-1297	64
IND 15-1745	64
IND 02-1202	64
IND 03-1298	64
IND 15-1705	72
IND 02-1203	62
IND 03-1311	64
IND 15-1706	64
IND 02-1204	64
IND 03-1295	72
IND 15-1708	64
IND 03- 1291	64
IND 04-1359	64
IND 15-1711	60
IND 03- 1292	64
IND 04-1360	64
IND 15-1713	64
IND 03- 1294	64
IND 04-1367	64
IND 15-1714	62
IND 03- 1300	64
IND 04-1393	70
IND 15-1720	64
IND 03- 1304	64
IND 05-1420	70
IND 15-1723	62
IND 03- 1306	64
IND 15-1709	64
IND 15-1724	66
IND 03- 1307	64
IND 15-1716	64
IND 15-1731	64
IND 03-1310	64
IND 15-1719	64
IND 15-1739	62
IND 03- 1312	64
IND 15-1721	64
IND 15-1747	80

Fig. 12a. IND 03-1295 (2n=72)

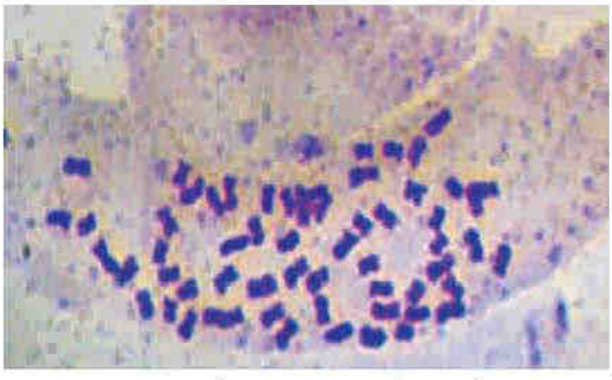


Fig. 12b. IND 04-1367 (2n=64)

(V.P. Sobhakumari)

Floral biological and cytological characterization of *E. arundinaceus*

Ploidy of 30 clones of *E. arundinaceus* was analysed. Compilation of cytological data of 204 clones of *E. arundinaceus* revealed the existence of three cytotypes with 2n = 30, 2n = 40 and 2n = 60. The cytotype 2n = 30 (triploid) was found to occur with less frequency of 6.0% in the clones of India, Pakistan and Burma. The cytotype 2n = 40 showed frequency distribution of 34.0% in Indian and Fiji collections (Fig. 13). Majority of the clones from India, Indonesian Archipelago and Fiji exhibited 2n = 60 (hexaploid) with the frequency distribution of 60.0% (Table 14).

***Table 14.* Distribution of cytotypes of *E. arundinaceus* in different countries**

Country	Cytotypes			Total no. of clones
	2n = 30	2n = 40	2n = 60	
India	5	69	6	80
Indonesia	?	?	94	94
Pakistan	2	?	?	2
Burma	3	?	?	3
Fiji		1	1	2
Others	2	?	21	23
Total	12 (6%)*	70 (34%)*	122 (60%)*	204

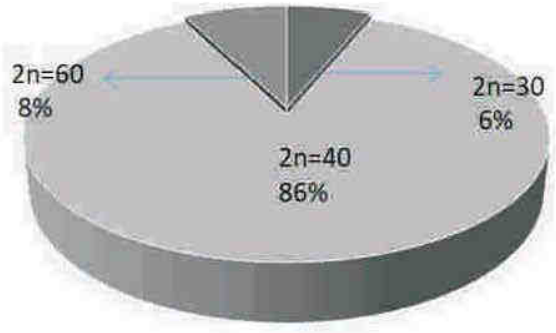


Fig. 13. Frequency distribution of cytotypes of* E. arundinaceus *in India

A preliminary analysis of flow cytometric analysis of released nuclei samples indicated 2C DNA with 4.7 to 8.5 pg / 2C. The clones with 2n = 30, had shown DNA content of 4.7 pg / 2C while the clones with 2n = 40 had 6.9 pg / 2C. The 2C DNA content of the clones with 2n = 60 was found to be 8.5 pg / 2C. Meiosis of 10 clones from Indonesia with 2n = 60 was regular while the clone EA Thornless showed abnormalities with laggards and bridges.

Among the 22 clones observed, prolonged flowering for 3-4 weeks noticed in Mandana, IK 76-005 and IJ 76-476. Dual anthesis was noticed in morning (5.00 am - 7.00 am) and evening (3.00 pm - 8.00 pm). The clone IS 76-202 was sterile.

(A. Suganya)

Evaluation of sugarcane germplasm for biotic and abiotic stresses at Coimbatore

S. spontaneum: Forty three *S. spontaneum* accessions were evaluated under water deficit stress condition to identify the tolerant genotypes by withholding irrigation at tillering stage. Phenotypic observations like plant height, number of tillers per plant and physiological observations *viz.*, relative water content (RWC), cell membrane injury, chlorophyll and carotenoid contents, percent dryness and

drought scoring were recorded periodically. The genotypes IND 08 – 1491, IND 99 – 848, IND 99 – 847, IND 99 – 863, IND 99 – 849, IND 99 – 882, IND 02-1186 and SES 121A were found superior under drought stress condition. All the identified drought tolerant genotypes were planted for further evaluation.

There was a general reduction in chlorophyll and carotenoid content during the stress compared to the period after relieving from the stress except for few genotypes. An increased chlorophyll a/b ratio was observed during the stress compared to the period after recovery. Pair wise correlations between all the traits were calculated. RWC during stress had a significant positive correlation with plant height during stress (0.320*) and after the recovery of stress (0.360*). Carotenoid content during stress exhibited positive correlation with plant height after the recovery from stress (0.324*). A significant positive correlation was observed for chlorophyll 'a', total chlorophyll and carotenoid content during stress with tiller count during stress (0.356*, 0.339*& 0.345* respectively) and tiller count after recovery period (0.436**, 0.420**and 0.413** respectively). Chlorophyll 'a', total chlorophyll and carotenoid content during stress had a significant positive correlation with total dry biomass after harvest at 10th month of the crop (0.343*, 0.326*and 0.320* respectively).

Erianthus arundinaceus: Two hundred and eight clones of *E. arundinaceus* along with the checks Co 99004, Co 06022, Co 86032, Co 0212 and Co 775 were evaluated for water stress tolerance related traits in augmented design. The clones were exposed to water deficit stress at tillering phase by withholding irrigation. Stress progression was monitored through soil moisture content and physiological data for water stress tolerance related traits were measured regularly. Phenotypic observations along with physiological data at 30-40% soil moisture content revealed 15 *Erianthus* clones including SES 153, SES 288, SES 347, IND 04-1335, IND 99-889 and IND 99-890 to be superior and about 20 clones to be moderately tolerant to water stress when compared to other Erianthus clones and *S. officinarum* checks. The identified tolerant and susceptible *Erianthus germplasms* are currently under further evaluation.

(V. Vinu, T. Lakshmi Pathy, H.K. Mahadevaswamy R. Valarmathi and R. Arun Kumar)

Utilisation of sugarcane germplasm resources for broadening the genetic base

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

Evaluation of interspecific hybrids for yield and quality: Ninety-five hybrids (BC2) were evaluated in RBD with two replications for yield and quality parameters at 240, 300 and 360 days for their utilization in breeding. Eleven clones viz., 14-82,14-192,14-162,14-181,14-148,14-163,14-142,14-118,14-166,14-126,14-50 were high tillering types in comparison with the checks Co 86032, CoC 671 and Co 0212. At 240 days, 12 clones recorded HR Brix in the range of 17.50 to 8.01%. Cane weight and height were appreciable in the hybrids in comparison with the parents. At 300 days, six clones recorded juice sucrose above 18.0%. The clone 14-160 with S. barberi cytoplasm recorded the highest juice sucrose of 19.92% in comparison with CoC 671 (19.47%), followed by 14-59 (18.80%). Among the hybrids of improved S. robustum x 'Co' canes, the clone 14-102 was the best with 18.80% sucrose. Eleven clones recorded juice sucrose above 19.80% at 360 days and the clone 14-42 recorded the highest sucrose of 22.71% followed by 14-59 (21.78%), 14-66 (21.86%), 14-171(21.78%) and 14-161(21.06%) (Table 15).

The cross combinations between improved parents and 'Co' varieties showed higher variation for cane weight than 'Co' x improved varieties. Among the hybrids tested for red rot by CCT, 40 were MR, 20 MS, 6R,12 S and 12 HS.The clones with better cane weight, sucrose % and resistance to red rot were selected and nine promising clones *viz.*, 14-171, 14-179a, 14-48, 14-14, 14-57, 14-60, 14-102, 14-160 and 14-50 were forwarded to PZVT testing.

Table 15. **Performance of the hybrid derivatives for yield and quality traits**

Clone	Cane height (cm)	Cane diameter (cm)	SCW (kg)	Brix (300d)	Pol % (300d)	CCS (%) (300d)	Brix (360d)	Pol % (360d)	NMC	Red rot
Co x *S. barberi*										
14-59	185	2.73	1.00	21.00	18.80	13.08	23.73	21.78	50	S
14-179 a	175	2.82	1.08	18.13	15.58	10.63	23.79	21.90	48	R
14-179	185	2.50	0.71	19.28	17.33	12.08	21.55	19.27	50	MS
14-57	210	2.48	1.02	20.63	18.22	12.60	21.23	19.59	52	MS
14-60	185	2.87	1.07	20.24	18.17	12.66	22.27	20.51	58	MR
14-160	220	2.83	1.02	22.03	19.92	13.93	21.60	19.95	61	MS
Improved *S. robustum* x Co canes										
14-171	187	3.21	1.18	18.51	16.68	11.64	21.87	20.06	46	NT
14-48	185	2.75	0.81	18.52	15.81	10.75	20.60	18.37	60	R
14-14	205	2.86	0.98	19.70	16.76	11.38	21.81	19.32	47	MS
14-144	200	2.44	0.75	18.40	15.13	10.09	21.53	19.45	62	MR
14-125	190	2.94	0.84	17.61	14.73	9.91	20.73	18.39	62	MR
14-102	195	3.07	1.00	20.55	18.80	13.21	21.33	19.34	57	MR
Co 86032	225	2.50	1.01	19.12	16.48	11.26	20.70	19.03	46	

Clonal trial (ratoon): In the ratoon trial comprising 183 interspecific hybrids, two back crosses *viz.,* (PIR 001057 x CoC 671) x CoC 671 and (Co 7201 x Pathri) x Co 0209 recorded cross-mean sucrose of 18.52% and 17.99% respectively at 300 days. Eight clones from four crosses recorded juice sucrose above 19.0%. The clone 14-89 from the cross (Co 7201 x Pathri) x Co 0209 recorded the highest sucrose of 20.44% followed by 14-77 (20.40%) from the cross (PIR 001058 x Co 86011) x Co 86011 (Table 16).

Maintenance breeding: A total of 600 breeding stocks of improved *S. officinarum* / improved *S. robustum* / improved *S. spontaneum, S. barberi* / *S. sinense* hybrids and 83 back cross progenies involving Arunachal *S. spontaneum* are maintained.

Table 16. **Performance of backcrosses at 300 days in ratoon crop**

Crosses	Brix (%)	Sucrose (%)	Cane height (cm)
(PIR 001058 x Co 86011) x Co 86011	19.87	17.44	171.59
(PIR 001057 x CoC 671) x CoC 671	20.3	18.52	200
(Co 7201 x Pathri) x Co 0209	20.03	17.99	161
(U09053 x PIR 001058) x Co 0209	18.58	16.14	158

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

Molecular cytogenetic characterization of interspecific and intergeneric hybrids of *Saccharum*

Genomic DNA has been isolated from *Sorghum, Zea, Bamboo, Erianthus procerus, S. officinarum* and *E. bengalensis*. After checking the quality and quantity of the DNA it has been fragmented to 500-1000bp size by sonication. The fragmented DNA was biotin labelled and the efficiency of the labelled probe was tested in the respective species.

Two intergeneric hybrids involving *Sorghum*, i.e. Co 86032 x *Sorghum* and *Sorghum x Saccharum* were subjected to GISH analysis using *Sorghum* as the labelled probe. Ten chromosomes of *Sorghum* were identified in the metaphase as well as in the interphase (Fig.14). Early condensations of the *Sorghum* chromosomes were observed.

S. officinarum x E. procerus F1, BC1 and BC2 were subjected to GISH analysis. In F1- 2n + n, in BC1- n + n chromosome segregation and in BC2 only part of the ten *E. procerus* chromosomes were hybridized (Fig.15).

GISH analysis was done in five hybrids of *Saccharum x Bamboo* (GUK 14-530, 531, GUK 15-386, 387, 390) and no hybridization was obtained with labeled Bamboo probe. Genomic DNA from the female parent, Co 99006, has been isolated, fragmented and labeled with biotin. GISH analysis showed that in three hybrids (GU 14-530, 531, GU 15-387) all chromosomes were hybridized with Co 99006 probe.

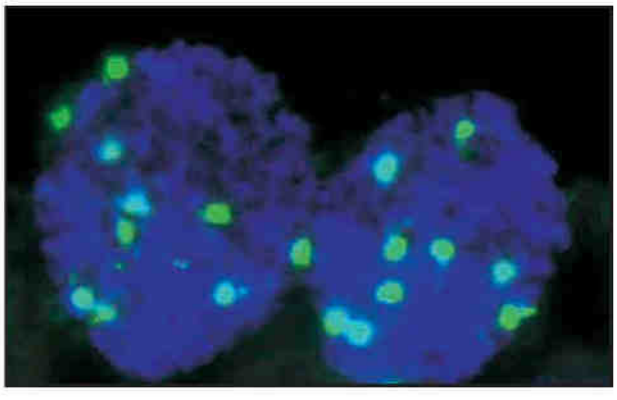


Fig. 14. Co 86032 x* Sorghum *– Interphase with 10* Sorghum *chromosomes

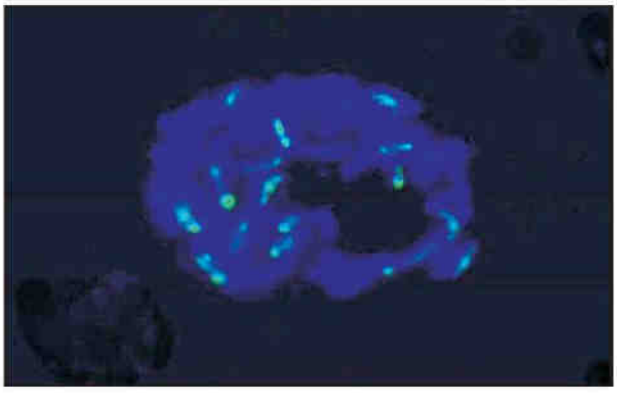


Fig. 15.* S. officinarum x E. procerus *BC1 with 20* E. procerus *chromosomes

(V.P. Sobhakumari)

Germplasm maintenance, hybridisation and offseason nursery (Agali)

Germplasm maintenance: A total of 1,271 accessions of sugarcane germplasm including species clones, 'Co' clones, 'Co' allied, exotic, inter-specific and inter-generic hybrid clones, clones of *Erianthus sp., Sclerostachya* and *Narenga* are being maintained in field.

Flowering in 2017 season: Out of 1,271 accessions maintained at the Centre, 414 flowered in 2017 season with flowering intensity of 32.5%. Forty-seven clones of *S. officinarum* flowered in 2017 (19.36% of total clones). They were Awela 68, Baragua, Chapina, Creoula, Creoula Rayada, Fiji-40, Fiji-62, Fiji-B, IJ 76-314, IJ 76-315, IJ 76-316, IJ 76-422, IJ 76-436, IJ 76-456, IJ 76-474, IJ 76-551, IJ 76-564, IJ 76-567, IK 76-002, IK 76-056, IK 76-060, Keong, Laukona-15, Mahona, Monget Gayam, Naz, NC-94, NG 77-092, NG 77-102, NG 77-142, NG 77-154, 28 NG 15, 28 NG 210, 28 NG 288, 28 NG 288 Sport, 51 NG 161, 57 NG 197, 57 NG 199, Penang, Shamsara, Sinense, SO hybrid, SS 60-1, Sugar Doctor, Mis-3, Vespertina and White Transparent. In *S. robustum*, IJ 76-545 alone flowered. In *S. barberi*, five clones (Dhaulu, Khatuia, Kuswar Aligarh, Manjuria, Mankia) and in *S. sinense*, seven clones (Kavangire, Khakai, Kheli, Maneria IMP 1648, Tekcha, Uba ReUnion, Uba white) flowered. Intensity of flowering was high in ISH and IGH clones (53 out of

69 clones flowered). In 'Co' canes and 'Co' allied clones, 162 out of 489 clones flowered. Fifteen percentage of clones of *E. arundinaceus* and all the clones of *E. bengalensis, E. elephantinus, E. procerus* and *E. ravennae* flowered in 2017. One clone of *Erianthus fulvus*, brought from Wellington flowered but very late in the season (February 2018). Duration of flowering in *S. officinarum* was from 22 September to 27 November 2017. Tip emergence was first noticed in Naz, Monget Gayam and White transparent while IJ 77-092 and NG 77-092 were the last clones to flower. In *S. barberi, S. sinense* and *S. robustum*, tip emergence was observed during 12-28 October 2017. In 'Co' and 'Co' allied clones, flowering lasted from 23 September 2017 (CoLk 91238, CoLk 9110) to 20 November 2017 (Co 06033).

Hybridization: Crosses were made for Agali Centre as well as for AICRP(S) Centres participating in the crossing programmes. The number of crosses made for Agali Centre was 71 which includes crosses among commercial variety (CV) x CV (29), CV x *S. robustum* (1), CV x *S. officinarum* (3), *S. officinarum* x CV (4), *S. officinarum* x *S. sinense* (1), *S. officinarum* x *S. officinarum* (4), *S. officinarum* x *S. spontaneum* (1), CV x *S. sinense* (1), *S. sinense* x CV (1), S. officinarum x *S. barberi* (1), *S. barberi* x CV (2), CV x *S. spontaneum* (7) and *S. officinarum* x *E. arundinaceus* (4). Sugarcane breeders from 15 research centres in the country visited Agali Centre and made 55 crosses. The cross combinations chosen by them were of inter-specific or inter-generic in nature such as commercial variety (CV) x *S. barberi*, CV x *S. sinense*, CV x *S. officinarum*, CV x *S. robustum*, CV x *S. spontaneum*, CV x *E. arundinaceus*, *E. arundinaceus* x CV, *E. procerus* x CV, *S. officinarum* x *Erianthus*, *S. officinarum* x CV and few CV x CV. Fluffs of 24 GCs were collected and supplied to them. Intoto 1.24 kg fluff was harvested and supplied to the fluff receiving centres.

Seedling raising: From the fluff of 2016 season crosses, 336 seedlings were raised and transplanted in ground nursery in March 2018.

Clonal evaluation: A total of 755 clones are under evaluation in first clonal nursery, in two batches. The reaction of 150 clone (1st batch) to red rot was assessed through CCT screening. Twenty-nine clones were 'S' to red rot and 3 were 'HS'. Others were either MS, MR or R to the red rot. HR Brix of 150 clones were estimated at 8th and 10th month. Five clones namely, Agl 2017-11, Agl 2017-16, Agl 2017-171, Agl 2017-177 and Agl 2017-243 recorded better juice quality than the standard CoC 671.

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

Sugarcane genomics and molecular markers

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

Forty four microsatellite markers developed for six major sucrose metabolizing enzymes (NI, CWI, PPFK, PFK, SAI and SREBF) were applied to a germplasm panel of 26 Indian 'Co' canes, nine *S. officinarum*, three *S. spontaneum* clones, two *E. arundinaceus* derivatives and one inter-specific hybrid clone. The population structure inferred by a model based bayesian approach using the STRUCTURE 2.3 software revealed *K=6* clusters. Each cluster was characterised by a set of allele frequencies at each locus and was represented by different color segments as indicated in figure and the highest Δ K corresponds to the optimal K (Fig.16). Structure analysis based on SSR allelic data revealed the presence of three different populations in the selected core set. Low sugar genotypes (27-41) fell into a separate group (Red colour) while the high sucrose genotypes distributed into two groups (Blue and green). The allelic pools are identified by different colours and although a genotype might belong to a particular allelic pool, it can also represent percentage of other allelic pools as observed in 1-26 indicating the diverse nature of the genotypes. Of the 41 genotypes, 34 (82.93%) have more than 0.80% membership in any given three

clusters. The remaining seven genotypes shared similar membership coefficients for at least two groups indicating admixture. Mean value of alpha was 0.1019 indicating that most of the high sucrose genotypes originated from few ancestral species clones emphasize the fact that only few *S. officinarum* clones frequently appear in the pedigree of Indian 'Co' canes.

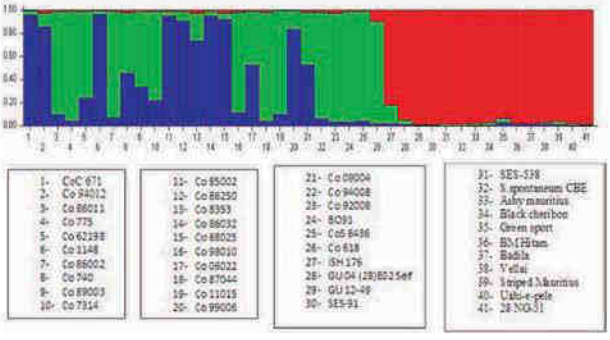


Fig. 16. Model based clustering of 41 sugarcane accessions using STRUCTURE

(R.M. Shanthi and G. Hemaprabha)

Functional genomics for water deficit stress in sugarcane

Analysis of RNA seq data was done for the two varieties Co 06022 and Co 8021 to sort the candidate genes that are differentially expressed in drought stress. The fold change of the differentially expressed genes (DEGs) ranged from 13.00 to 1.00. At two days of stress the number of transcripts expressed was 70,610 of which 11,846 were upregulated and 9760 were down regulated. Total number of transcripts that were upregulated in the drought induced transcriptome of the tolerant variety Co 06022 as compared to the susceptible variety at six days of stress was high (8,030) when compared to ten days of stress where the number of upregulated transcripts reduced considerably (3499). GO classification of DEGs revealed more number of oxidative stress response, hydrogen peroxide catabolic process and stress responsive transcripts in susceptible cultivar. Heme binding, peroxidase activity and metal ion binding were more pronounced in molecular function.

Validation of genes implicated in drought was carried out by qRT-PCR in Co 06022 and Co 8021. The expression levels of LEA was high in the shoots and leaves of both varieties as compared to their control. The leaves of Co 06022 showed more expression in comparison to Co 8021. For NAC and WRKY shoots of Co 8021 and leaves of Co 06022 showed higher expression in comparison with their controls. AP2-EREBP showed higher expression on both shoots and leaves of both varieties when compared to their controls.

Small RNA sequencing was performed in control and drought stressed samples of two varieties viz., Co 8021 and Co 06022. Small RNA library was prepared and amplified. Entire library was size selected on a PAGE gel for ~20 to ~40 bp size RNA, which majorly represent mature miRNA population. Sequencing by Illumina NextSeq500 generated a total raw reads of 11 to 18 million. Sequences that were >=16 bp and <=35 bp length were used for further analysis. Total number of sequences remaining after length range filtering (16-36) ranged from 10 to 16 million reads. All reads were checked for ncRNA such as rRNA, tRNA, snRNA and snoRNA. The unaligned reads to ncRNAs were used for known miRNA prediction. Total number of known miRNA detected ranged from 390 to 463. Total number of known miRNA detected with read count >=50 ranged from 77 to 102 and total number of known miRNA detected with read count >=10 ranged from 148 to 167. Homology search of the miRNAs was done against *viridiplantae* and abundant miRNA families were identified. Known miRNAs with copy number >=10 were considered for target prediction and potential gene targets were identified

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

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

Novel Micro RNAs of sugarcane, *Erianthus* sp and *Saccharum spontaneum* under oxidative stress

About 654 novel miRNAs associated with oxidative stress were predicted in sugarcane among them some of the species specific miRNAs showed significant differential expression under oxidative stress response. Seventeen unique miRNAs and 1175 unique targets were identified, many of them are related to plant stress tolerance, including genes encoding disease resistance protein, RNA-dependent RNA polymerase, centromere protein homolog, putative ABC transporter, pleiotropic drug resistance protein 11, protein transport inhibitor response 1, Mn-specific cat ion diffusion facilitator transporter and Squamosa promoter-binding-like protein. The pathway enrichment analysis of miRNAs and their target genes showed sucrose metabolism pathway with highest significance. miRNA gma-miR166k was found to be expressed abundantly only during the stress condition in sugarcane cultivar, *Erianthus* and *S. spontaneum* and its target genes appear to play a conserved role in oxidative stress response.

Identification and isolation of stress tolerant gene: Primers were designed using available sequence information from EST database to amplify different genes responsive for oxidative stress tolerance from *Erianthus* sp. Gradient PCRs were performed with the NAC67iF, NAC67iR, NAC67iiF, NAC67iiR, NAC67mF1, NAC67mR1, NAC67mR2, NAC67miF2, NAC67miR2, NAC4i F1, NAC4i R1, NAC4i R2, NAC4 iiF1, NAC4iiR1 primers with *Erianthus* DNA as template to standardize the Tm. Expected amplification of 1.92 kb was obtained from NAC 4i (F/R) primer pair. The fragments were gel eluted and sequenced.

Maintenance of calli: Sugarcane and tobacco calli were maintained by sub culturing every 15 days. Calli were regenerated in MS media with IAA and kinetin.

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

Precise genome editing system in sugarcane CRISPR-Cas: Altering the flowering behaviour of sugarcane

Flowering and non-flowering clones – Isolation and expression of genes

Total RNA was isolated from 180 days old flowering and non-flowering canes *viz.*, BO 91, Co 1148, Co 86002 (flowering) and Co 7420, Co 7405 and Co 7609 (Non-flowering). Integrity and quantity of the RNA samples were checked by Nano-drop. First strand cDNA conversion using cDNA kit (Thermo scientific) was performed and normalisation of cDNAs was done using housekeeping genes. Three primer pairs DLF1 (Delayed Flowering 1), TFL 1 (Terminal Flower 1) and ID 1 (Indeterminate growth 1) were designed using Primer3 software expected gene amplification were obtained by PCR. The PCR fragments were gel eluted and sequenced. The amplification was confirmed using BLAST analysis. Quantitative PCR was carried out using SYBR green PCR master mix (Applied Biosystems). A marked variation was observed among the flowering and non-flowering clones.

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

Differential gene expression studies on *Saccharum spontaneum* in response to salinity stress tolerance

Planting material of 14 *S. spontaneum* clones along with salinity stress tolerant (Co 89029) and susceptible (Co 89003) 'Co' canes were collected and planted in pots for multiplication, after 45 days they were replicated into another set of pot culture to conduct salinity stress treatment. Morphological observations were recorded as dropping of leaves and tip drying in 10% salinity, while it was negligible in 2.5 and 5.0% treatment (Fig. 17). Based on physiological data recoded on Nitrate reductase (NR), chlorophyll stability index (CSI), relative water content (RWC) and proline content it was identified that there were no much difference between 2.5 % and 5.0 % in the level of expression of ions and osmolytes. The plants at 10% stress never revived after stress when irrigated with normal

water therefore we have identified that 10% salinity to be lethal. Nitrate reductase reduces gradually with the increase of salinity stress concentration, which might be a physiological response in order to decrease growth and extra biomass in *S. spontaneum* during stress (Fig. 18). While the proline content increased with the increase in salinity stress which is in accordance with the previous reports in green gram, mulberry and canola. Similarly, RWC and CSI decreased with the increase in salinity stress concentration. Three salinity responsive genes, Na+ /H+ exchangers (NHX 250 bp), salt overly sensitive (SOS 500 bp) and Responsive to ABA (RAB 750 bp) were cloned using heterologous primers, sequenced and BLAST analyses were carried out (Fig. 19a). Molecular analysis through Real Time PCR for the expression studies revealed that the transcription factor MYB showed increased expression under 2.5 % stress gradually decreased at 5% and 10 % which would have switched on the salinity stress responsive genes (Fig. 19b).

***Fig. 17. Morphological observation of the salinity stress (2.5%, 5.0 %, 10%) of* S. spontaneum**

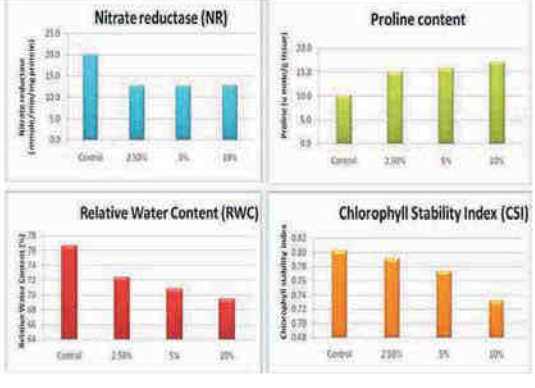


***Fig. 18. Physiological observation of the salinity stress (2.5%, 5.0 %, 10%) of* S. spontaneum**

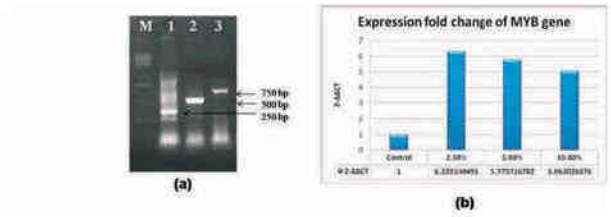


***Fig. 19. (a) Gel showing PCR amplification using NHX, SOS and RAB gene specific primers. Lane M: DNA 1kb ladder, Lane 1, 2, 3* S. spontaneum *with NHX, SOS and RAB primers respectively. (b) Real time expression of MYB during salinity stress in* S. spontaneum**

(K. Lakshmi and S. Vasantha)

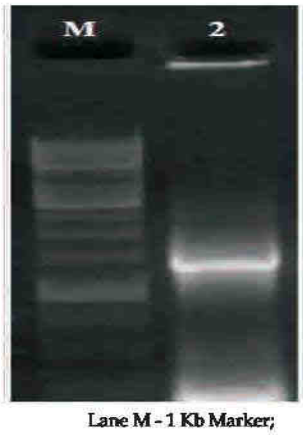
Gene discovery and genetic transformation in sugarcane

Gene Discovery: With a view to isolate abiotic stress responsive genes from *Saccharum complex*, cDNA was used as template to clone the candidate genes. *Glyoxylasel (GLY I), Glyoxylase II (GLY II)* and *Glyoxylase III (GLY III)* were cloned from species *Saccharum* commercial hybrid Co 86032 using gene specific primers designed from *Sorghum bicolor* and *Zea mays*. Coding sequence length of genes are *EaGLY I* – 687 bp, *EaGLY II* – 1011 bp and *EaGLY III* – 1164 bp.

Genetic Transformation: The actin cytoskeleton plays a critical role in plant development by regulating a number of fundamental cellular processes like cell division, cell expansion, organelle motility and vesicle trafficking. Actin cytoskeleton is regulated by a complex of proteins known as Arp2/3 (Actin-Related Proteins) complex and plays an important role in actin polymerization. Scar/WAVE complex activates the Arp2/3 complex which in turn activates the actin polymerization. BRICK is a one of the five subunits present in Scar/WAVE complex. To elucidate the role of BRICK gene in drought stress, full length BRICK gene, of size 1400bp, was isolated from wild sugarcane and cloned in pCAMBIA1305.1 vector driven by Port Ubi882 promoter by replacing β-glucuronidase (GUS) and CaMV 35S promoter, respectively. Presence of BRICK gene was confirmed in *Agrobacterium*

(Fig.20). By *Agrobacterium* mediated transformation Port ubi882+BRK was transformed in commercial sugarcane (Co 86032). After several round of stringent selection putative transgenic plants (V0 generation) were obtained. A total of 29 PCR confirmed sugarcane transgenic events were obtained and were taken to next generation (V1). These 29 transgenic events along with untransformed sugarcane of 90 days after planting were subjected to water stress by withholding the irrigation.

Different physiological parameters such as relative water content (Fig. 21), cell membrane injury, photosynthetic efficiency, chlorophyll content were recorded before stress, 10th day of stress and 15 days after re-irrigation. Along with these physiological parameters, gas exchange parameters namely photosynthesis rate, stomatal conductance and transpiration rate were also recorded on 5th and 10th day of drought stress. Based on these parameters and relative expression study using real time PCR it was seen that four events were showing better tolerance. Photosynthetic efficiency and relative water content was 35% to 40% and 10% to 25% higher than untransformed control respectively during water stress. Similarly, in all the parameter it can be clearly seen that transgenic events gave better results during water stress than that of untransformed control plants.



Lane M - 1 Kb Marker;
Lane 1 - BRK 1 amplicon (1400 bp)

***Fig. 20. PCR amplification of BRK1 in Port ubi882-BRK1 in* Agrobacterium**

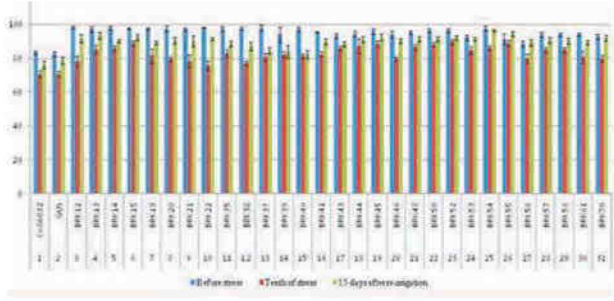


Fig. 21. Relative water content in transgenic events compared to untransformed control Co 86032 and transgenic event with GUS reporter gene

(C. Appunu)

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

Promoter is a regulatory region of DNA located upstream towards the 5' region of a gene that largely regulate gene expression at the transcriptional level are crucial for improving our basic understanding of gene regulation and will expand the toolbox of available promoters for use in plant biotechnology. The widely used constitutive 35S cauliflower mosaic virus (CaMV 35S) promoter drives expression of an interested gene in most parts of the plant. The development and improvement of gene expression for rapid, efficient, predictable and high-throughput need an efficient promoter other than CaMV 35S promoter. In view to isolate tissue specific promoter, the Pi transporter gene was isolated from *Erianthus arundinaceus*, a wild relative of sugarcane. Upstream walking of gene by Random Amplification of Genomic Ends (RAGE) technique resulted in cloning of 1Kb fragment putative promoter region. This fragment was sequenced and performed in silico analysis. The analysis revealed the presence of a TATA box, CAAT box, numerous potential cis-acting elements, tissue-specific expression motifs, light-responsive elements, MYB binding sites, ABRE-related sequence, sugar responsive element, PHR1-binding element and root specific expression motifs etc (Fig. 22). After confirming the presence of promoter region specific motif, the fragment was

named as EriPht promoter. Conserved motif analysis reveals many motifs were specific to EriPht promoter (Fig. 23). In order to validate the function, the two constructs of EriPht promoter were prepared like with and without 5'UTR region. In both the constructs, reporter gene GUS (β-glucuronidase) was driven by EriPht promoter. Tobacco and sugarcane transformation are in progress for functional validation of these constructs. To identify the core region of the EriPht promoter that control the expression pattern in different tissues and organs at various developmental stages in plants, deletion studies were also initiated. This would provide a detailed analysis of different domains in the EriPht promoter and their expression pattern, ten different 5'-deletion mutants (with and without 5'UTR) was constructed.

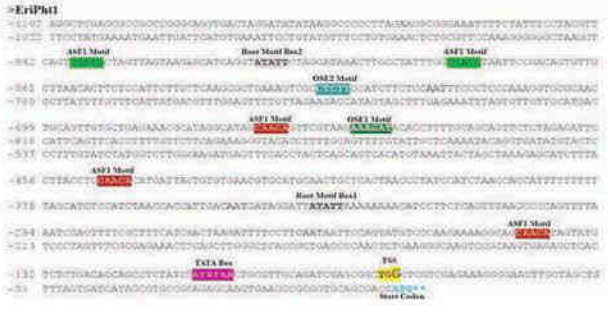


Fig. 22. Presence of root specific motif in EriPht promoter sequence

Fig. 23. Conserved motif analysis of EriPht promoter sequence

(C. Appunu)

Cloning and characterization of lignin genes in an *E. coli* expression vector

The total RNA was isolated from *Erianthus* and converted into cDNA. Cinnamyl alcohol dehydrogenase (CAD) specific primers were designed and PCR was performed with a proof reading enzyme. The expected amplicon of size 1094 bp (Fig. 24) as single fragment was obtained which was cloned into TA cloning vector to facilitate a sub-cloning in pET series. To perform sub-cloning gene specific primers with restriction sites was designed such as CD Forward 5' TTGAATTCATGGGGAGCCTGGCGT 3' and TGAAGCTTTCAGTTGCTCGGCGCATC with KpnI and Hind III in their forward and reverse primers respectively. Insilico translation analysis was studied to check the ORF of the CAD protein using Expasy tool. CAD proteins are Zinc-containing 'long-chain' alcohol dehydrogenases (365 amino acids) with Consensus pattern: "GHEVVGEVVEVGPEV" at position 68-82. The expected PCR fragment size of 1.1 kb was gel eluted and subjected to double digestion with Kpn I and Hind III, as well as the vector pET 28a. Then the insert (Size 1.1 kb) and the vector pET was gel eluted and checked for their concentration. A ligation was set up with pET and CAD in the ratio of 1:3 at 100oC for 16 hours of incubation. The next day this ligated mixture was transformed into *E. coli* with InsTA cloning kit. The resultant colonies were confirmed through colony PCR and restriction digestion for the gene. Presently the construct pET: CAD is being transformed into BL21 host for protein expression.

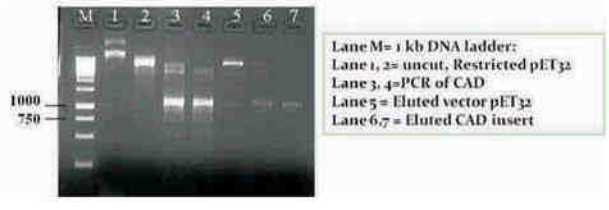


Fig. 24. PCR amplification of CAD from **Erianthus**

(K. Lakshmi)

MULTI-DISCIPLINARY PROJECTS

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

(Bakshi Ram and G. Hemaprabha)

Inbreeding

Statistical analysis of molecular data: The molecular data of 33 selected inbred lines belonging to three parental groups (Co 1148, Co 775 and Co 7201) generated with 15 STMS primers were analysed with STRUCTURE 2.3.4 software in order to assess the genetic uniformity. The number of subpopulations within each group was estimated by Structure harvester. In Co 1148 group with four generations, four subpopulations were observed with the parent (Co 1148) forming a separate cluster (Fig. 25). Among these, the second sub population consisting of S5 and S6 generation selfs of 1148-S4-242 exhibited high Fixation index (Fst) of 0.88, low gene flow (Nm=0.03), indicated high probability of identical individuals i.e. These were more genetically closer compared to total population. Similarly, in Co 775 group with two subpopulations, 775-12 and 775-12-18 also indicated more genetic relatedness (Fst= 0.72, Nm = 0.10). These selfs will be used for hybridization to study progeny uniformity. Further studies are in progress with the available selfs to identify selfs with high levels of homozygosity.

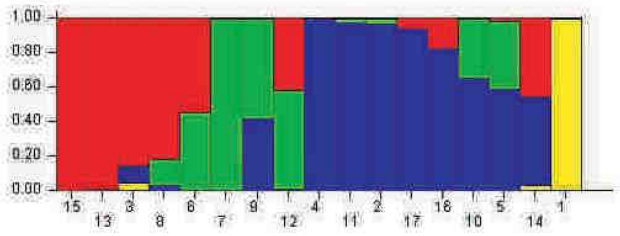


Fig. 25. Population structure of 17 inbreds in Co 1148 group divided into 4 subpopulations

Morphological variability among newly developed inbreds: One hundred and thirty two selfs of five sub-tropical sugarcane genotypes *viz.*, CoH 70, BO 128, BO 130, LG 99122 and LG 99183 were studied along with that of a tropical 'Co' cane (S1 progenies of Co 775) for rind colour variation. The selfed S1 progenies of LG 99122 exhibited wide variation for rind colour followed by selfs BO 128 in six categories. Co 775 followed by CoH 70 progenies showed lesser variation for rind colour (Fig. 26)

Fig. 26. Rind colour variation in selfed progenies of tropical and sub-tropical varieties of sugarcane

Evaluation of inbreds of economic traits and flowering

Brix and cane diameter: Among 279 inbreds under maintenance as ratoon crop, 25 inbreds recorded above 23% Brix at 270 days. Among these were sixth generation inbreds of Co 1148. They were six each of 1148-S4-237 and 1148-S4-252, four of 1148-S4- 242. Cane diameter was above 3.0 cm in 13 inbreds. Flowering was moderate and 47% inbreds flowered during 2017.

Red rot resistance: One hundred and three inbreds were evaluated for their resistance to red rot pathogen. Ten selfs 775-12-21, 775-12-1, 775-12-4, 775-12-21, 775-5, 775-68, 1148-13-11-2-242-5-230, 1148-13-11-2-242-3, 86032-126, 86032-128, MS68/47-28, 94019-44, 0402-47 and 0304-127 were found to be resistant to red rot, while four inbreds viz.,1148-S4-248-1-72, 1148-13-11-2-252-191, 1148-13-11-2-252-205 and 775-5-134 were highly susceptible to red rot. Among the rest, 35 were moderately resistant, 12 moderately susceptible, 22 susceptible and four were highly susceptible.

Selfing: 51 selfs were effected involving 'Co' and 'Co' allied canes, early generation and advanced generations. A total of 378 inbreds were planted for their maintenance and further study.

(G. Hemaprabha, A. Annadurai, T. Lakshmipathi and K. Chandran)

Chromosome elimination

In order to induce point mutation in the centromeric related gene (CENH3) seeds as well as embryogenic calli of Co 775 were subjected to different

concentrations of Ethyl methane sulfonate (EMS). The mutants are being maintained in the glass house and whole genomic DNA was isolated from leaf samples of 110 mutant plants. The isolated DNA was purified and quantified for TILLING (Targeting Induced Local Lesions In Genomes). Gradient PCR was performed for standardization of PCR programme for the formation of hetroduplex and homoduplex for the gene CENH3. The PCR conditions through advantage PCR have been standardized and for first thirty samples PCR has been performed and stored for further analysis (Fig. 27).

Fig. 27. Amplification of CENH3 gene with Advantage 2 PCR

Fig. 28. CEL1 nuclease extraction from celery plant (a) Celery seeds sown and germinated (b) Grown and transplanted from pots to soil and maintained in glass house (c) Stem tissues harvested from three months old plants (d) celery juice extracted (CJE) using a juicer (e, f) celery juice measured and proportionate TRIS + PMSF added (g) The supernatant subjected to dialysis against TRIS buffer

Celery plants were raised and conventional method for isolation of a single strand nuclease (CEL 1) from its stem had been initiated. The extracted celery juice was dialyzed in dialysis tube (Spectra/Por® 10 000 MW cut-off) against TRIS buffer for the isolation of S1 nuclease (Fig. 28). Mismatch cleavage by CEL1 endonuclease enzyme will be used to identify mutations in double-stranded DNA fragments using agarose gel assay.

(V.P. Sobhakumari and K. Lakshmi)

Wide hybridization

In NHG, four wide crosses were made between commercial cane varieties (Co 0237, CoN 05071, CoJ 64, CoPb 9018) x Maize / *Sorghum* to generate haploid. The fluffs were sown on 17 March 2018. Sixty seedlings were obtained and its chromosome number is yet to be verified. At Agali Centre, 17 inter-generic crosses were made. They were: *S. officinarum* (Laukona 15, 28NG 288) x *Sorghum*, *S. officinarum* (Badila, 51NG 161, Laukona 15, 59NG 199, Shamsara) x Maize, *S. officinarum* (IK 76-056) x *Neyrudia*, *S. officinarum* (IJ 76-315) x *Phragmatis*, *S. officinarum* (IK 76-002) x *Vettiveria*, *S. officinarum* (NG 77-142) x *Narenga*, *S. officinarum* (51NG 161) x E. procerus, *S. officinarum* (Chapina, IK 76-002) x *E. arundinaceus* (IK 76-99), *S. officinarum* (NG77-154, Sinense) x *E. bengalensis* (IND 01-1090), *S. officinarum* (Laukona 15) x *Panicum* sp. Fluff was sown in May, 2018.

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

Evaluation of hybrids

Tropical (Coimbatore)

Sowing of fluff of thirteen different combinations was taken up during September, 2017 (Table 17). Seedlings were planted along with their parents in ground nursery during December, 2017. Five crosses exhibited high tillering and early cane formation at 120 days. Seven crosses have sufficient seedlings available for scoring with regard to cane morphology, yield and quality traits.

Table 17. **Inbred progenies under evaluation in ground nursery**

Group	Parentage
S2 xS5	775-5-136 x 1148-13-11-2-252-169
S2 x S5	775-5-136 x 1148-13-11-2-252-161
S2 x S6	775-5-136 x 1148-13-11-2-242-1-68
S2 x S6	775-12-276 x 1148 -13-11-2-242-1-40
S2 x S5	775-12-26 x 1148-13-11-2-252-194
S2 x S5	775-5-118 x 1148-13-11-2-252-179
S2 x S4	7201-136-76 x 1148-13-11-2-237
S2 x S6	775-12-20 x 1148-13-11-2-237-2-61
S6 x S4	1148-13-11-2-252-33-359x1148-13-11-2-237
S5 x S2	1148-13-11-2-242-7 x 775-5-147
S4 x S6	1148-13-11-2-254 x 1148-13-11-2-237-2-61
S1 x S5	775-102 x 1148-13 -11-2-242-14
S1 x S5	775-102 x 1148-13-11-2-252-179

(R.M. Shanthi, S. Alarmelu, R. Karuppaiyan and V. Vinu)

Evaluation for diseases

Studies were carried out under in vitro condition to identify the control measures for frequently occurring four sugarcane true seed/seedling borne fungal pathogens *viz. Curvularia* sp, *Alternaria* sp, *Fusarium* sp. and *Helminthosporium* sp.

Assessing antagonistic potential of biocontrol agents against seed/seedling borne pathogens: Three fungi *viz. Trichoderma* SR4, *Trichoderma* SR5 and *Trichoderma* SR6 and 3 bacterial strains, SR1, SR2 and SR3 were isolated from sugarcane rhizosphere soil and used for assessing antagonistic potential against 4 pathogens by dual culture technique. The results are presented as mycelial growth inhibition (%) of fungal pathogens by biocontrol agents when compared to control. Among six antagonists tested the bacterial strain SR1 exhibited consistent and best performance by inhibiting mycelial growth of *Curvularia* sp, *Alternaria* sp, *Fusarium* sp. *and Helminthosporium* sp. to the tune of 72.7%, 68.0%, 74.3% and 65.3%, respectively. The fungal antagonists *Trichoderma* SR6 and SR4 showed moderate mycelial growth inhibitory activity, while the bacterial strain SR3 showed best performance against only *Fusarium* sp. by inhibiting 81.0% mycelial growth. The other two antagonists *viz., Trichoderma* SR5 and bacterial strain SR2 did not show any antagonistic activity against all tested pathogens.

Assessing in vitro efficacy of commercial fungicides against seed/seedling borne pathogens: In vitro efficacy of five fungicides *viz.,* Tilt (Propiconazole 25% EC), Contaf 5E (Hexaconozole 5% EC), Taqat (Captan 70% + Hexaconazole 5% WP), Saaf (Carbendazim 12%+ Mancozeb 63% WP) and Kavach (Chlorothalonil 75% WP) were tested against *Curvularia* sp, *Alternaria* sp, *Fusarium* sp and *Helminthosporium* sp with three different concentrations (0.025%, 0.05% and 0.1%). Among five fungicides, Tilt was found more effective in controlling 100.0% mycelial growth of all four fungi even at the lowest concentration of 0.25% (Fig. 29). All the three tested concentrations of Taqat had shown complete mycelial growth inhibition to *Alternaria* sp., *Curvularia* sp., and *Helminthosporium* sp. whereas only 0.1% concentration showed 100.0% mycelial inhibition of *Fusarium* sp. Similarly, all the concentrations of Saaf were 100% effective to *Helminthosporium* sp. and *Fusarium* sp. and only 0.1% was 100.0% effective to *Curvularia* sp. The fungicide Contaf exhibited 100% mycelial growth inhibition of Helminthosporium sp, while it was only moderately effective to other three fungi. Among the tested fungicides, Kavach had shown least efficacy to all four pathogens.

Fig. 29. Efficacy of commercial fungicides against seed/seedling borne pathogens

(V. Jayakumar and K. Nithya)

Agronomic practices for seedlings/settlings

Standardizing agro-techniques for true seed seedling with special reference to intra-row spacings and planting depths : With the objective of developing agro-techniques for true seed seedling a field experiment was laid out in split plot design with three planting materials (true seed seedling, tissue culture seedling and bud chip settling) as main plot and two intra-row spacings (45 and 60 cm) and three planting depths (2.5, 5.0 and 7.5 cm) as sub plot treatments, and was replicated thrice during 2016-17. The crop after harvest was ratooned during March 2017. In first ratoon crop, true seed seedling planted at 2.5cm depth was found beneficial and recorded the highest NMC (88553 NMC/ha) and ratoon yield (83.63 t/ha).

Integrated weed management in true seed seedling with new generation herbicides: Weed management experiment in split plot design with three replications was initiated during February, 2018. The experiment consisted of 18 treatment combinations with three planting materials (true seed seedling, bud chip settling and setts) in main plot and six integrated weed management practices in sub-plot. Seedling nursery of Co 12014 was raised from the fluff. In main field 45 days old true seed seedlings were transplanted along with bud chip settlings and setts at 120 cm row spacing. Major weed flora observed in the experimental field were *Cynodon dactylon L., Brachiaria reptans, Cyperus rotundus, Trianthema portulacastrum, Parthenium hysterophorus, Euphorbia hirta, Datura metel, Phyllanthus niruri, Digera arvensis, Commelina benghalensis Cardiospermum helicacabum* and *Portulaca oleraceae.* Pre emergence application of atrazine followed by one hand weeding thirty days after true seed seedling transplanting recorded highest weed control efficiency of 77.35 % at 45 days after planting. New herbicide molecules like topramezone, tembotrione and halosulfuron methyl at the tested dose did not show any phytotoxic symptoms in sugarcane seedlings.

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

Drip irrigation and fertigation

A field experiment to study the performance of true seed seedlings raised in wide row under drip fertigation system in comparison with single bud seedling and sett raised sugarcane and to evolve optimum fertilizer dose for drip fertigation of true seed raised sugarcane crop was planted on 1st March 2018 with three fertilizer doses *viz.*, 331:80.0:117; 502:137.5:275 and 673:195.0:433 kg $N:P_2O_5:K_2O$/ha. Sett planted plots had 63.9% germination and the true seed and settling plots showed 94.7 and 99.6 per cent establishment at 30 DAP. Sett planted plots had the highest tillers (155,517/ha) at 60 DAP followed by true seed seedlings (124,846/ha) and the least was in single bud settling (83,025/ha).

(A. Bhaskaran)

Seed processing, packaging and storage

During 2017-18 hybridization season, open pollinated fluff collections of 166 clones were made. Defuzzing was done by hammer milling. The data analyses revealed that the mean weight of fluff from each arrow has been 7.91g and the weight of fluff/arrow ranged from 1.28 g (Co 06006) to 17.77 g (Co 7535). Mean 100-seed weight of seed fluff has been 75.42 mg and 100 seed weight among 166 clones ranged from 36 to 96 mg. The mean germination percent of seed fluff has been 11.10 and it ranged from 0 to 88 among 166 clones. From defuzzed seed, mean 100-seed weight of defuzzed seed has been 74 mg and ranged from 46mg (Co 11003) to 97 mg (Co 11001).The mean germination percent of defuzzed seed has been 9.83 and it ranged from 0 to 80 (CoPb 10183) among 166 clones.

(N. Rajendra Prasad)

All India Coordinated Research Project (Sugarcane)

(Bakshi Ram and P. Govindaraj)

Peninsular Zone

Initial Varietal Trial

IVT trial comprising 37 entries and three standards were evaluated in Alpha Design for yield and quality traits at 180, 240, 300 and 360 days. Among the standards CoSnk 05103 was the best for NMC followed by Co 86032 and CoC 671. Among the entries Co 13021, Co 14004, Co 14030, MS 14082, Co 14025 and CoN 14074 had high NMC. At 240 days

the entry PI 14132 (17.03% sucrose) was numerically superior for quality in comparison with CoC 671(16.29%). For juice quality at 300 days, CoC 671 was the best standard with juice sucrose of 20.29% followed by Co 86032 and CoSnk 05103 which recorded sucrose of 16.52% and 15.93% respectively. Among the entries, PI 14131 with the maximum sucrose value of 20.04% was numerically superior to Co 86032 followed by Co 14032 (19.21%), PI 14132 (19.08%) and Co 14002 (18.97%) and were identified as early maturing clones from the trial. At harvest, CoSnk 05103 was the best standard with the highest yield of 133.56 t/ha. Co 14016 was the best entry with the maximum cane yield of 156.14 t/ha followed by MS 14082 (150.68 t/ha) and were significantly superior to the best standard. The entries CoSnk 14103 (137.22 t/ha), Co 13021(136.56 t/ha) and Co 14002(135.35 t/ha) were significantly superior to the next best standard Co 86032 (117.74 t/ha) and numerically better than CoSnK 05103. For quality, CoC 671 was the best check with 21.94% sucrose and none of the entries were significantly superior. PI 14131 (21.48%), PI 14132 (21.37%), Co 14004 (20.84%), Co 14032 (20.60%) and Co 14002 (20.58%) were promising entries for quality and significantly superior to the next best check Co 86032 (19.29%). Among the clones tested for smut, seven were R and 10 clones were MR.

(S. Alarmelu and H.K. Mahadevaswamy)

Advanced Varietal Trial I Plant

Eight test clones (Co 12007, Co 12008, Co 12009, Co 12012, Co 12019, Co 12024, CoM 12085 & VSI 12121) and three standards (Co 86032, CoC 671 and CoSnk 05103) were evaluated in the first plant crop of Advanced Varietal Trial. Co 12009 was the only entry that recorded superior CCS yield over the best standard CoC 671 (15.28 t/ha). However, five clones (Co 12007, Co 12009, Co 12024, CoM 12085 and VSI 12121) were superior compared to the better standard Co 86032 (14.43 t/ha).

Among the standards, CoSnk 05103 was the best for cane yield (114.68 t/ha) followed by Co 86032 (108.0 t/ha). Co 12012 (124.54 t/ha) was the only entry that was statistically on par with the best standard CoSnk 05103 and also significantly superior to the better standard Co 86032. Five other test clones (Co 12007, Co 12009, Co 12024, CoM 12085 and VSI 12121) in this trial were numerically on par with the better standard Co 86032 for cane yield. None of the entries was found superior for juice sucrose as compared to the best standard CoC 671 (21.01%). However, Co 12008 recorded the maximum sucrose (19.75%) followed by VSI 12121 (19.58%) and Co 12007 (19.45%) (Table 18).

***Table 18.* Performance of entries in AVT I Plant**

Clone	CCS yield (t/ha)	Cane yield (t/ha) 360 d	CCS (%) 360 d	CCS (%) 300 d	Sucrose (%) 360 d	Sucrose (%) 300 d	NMC ('000/ha) 360 d	Single cane wt. (kg) 360 d
Co 12007	14.98	109.16	13.72	12.72	19.45	18.08	105.83	1.27
Co 12008	13.66	98.30	13.88	12.31	19.75	17.66	110.92	1.35
Co 12009	15.34	112.91	13.57	12.24	19.25	17.38	89.71	1.48
Co 12012	14.13	124.54	11.35	10.19	16.54	15.00	128.31	1.22
Co 12019	12.27	97.67	12.57	11.28	18.00	16.25	121.37	0.89
Co 12024	14.74	110.45	13.35	11.91	18.91	16.94	107.39	1.29
CoM 12085	15.11	111.90	13.51	11.84	19.13	16.86	83.47	1.62
VSI 12121	15.08	109.24	13.80	12.02	19.58	17.23	94.29	1.33
Standards								
Co 86032	14.43	108.00	13.36	12.07	19.08	17.21	102.95	1.27
CoC 671	15.28	102.61	14.84	12.92	21.01	18.43	89.76	1.46
CoSnk 05103	14.29	114.68	12.45	10.77	17.84	15.56	118.14	0.86
Mean	14.48	109.04	13.31	11.84	18.96	16.96	104.74	1.28
SE (m)	0.65	4.16	0.21	0.33	0.29	0.43	5.50	0.04
CD	NS	12.36	0.64	0.99	0.86	1.26	16.34	0.10
CV	7.79	6.61	2.79	4.88	2.64	4.34	9.09	4.79

(R.M. Shanthi and K. Elayaraja)

Advanced Varietal Trial (Early)

Five entries *viz.*, Co 11001, Co 11004, CoM 11081, CoM 11082 and CoM 11084 and three standards (Co 85004, Co 94008 and CoC 671) were evaluated in Advanced Varietal Trial (Early) II plant. CoC 671 was the best among the standards with 16.70 t/ha of sugar yield and Co 85004 recorded the highest cane yield of 129.18 t/ha. Among the test entries Co 11001 was the best with 14.90 t/ha sugar yield and 126.19 t/ha cane yield. Juice analysis indicated that CoC 671 was the best standard for juice sucrose (18.96 %). Co 11004 with 19.72% was superior to the best standards for juice sucrose content. In AVT (Early) Ratoon crop, the standard Co 85004 (112.63 t/ha) was the best for cane yield followed by the entry CoM 11082 (111.82 t/ha). CoM 11082 recorded the highest CCS yield of 13.67 t/ha at harvest while the best standard Co 85004 recorded 13.58 t/ha. CoM 11082 (17.49%) also recorded the highest juice sucrose at nine months while the best standard CoC 671 recorded 19.25%.

The pooled mean of CCS yield, cane yield, CCS % and sucrose % at harvest in two plant crops and one ratoon crops are given in Table 19. The entry CoM 11082 recorded the highest CCS yield of 15.95 t/ha which was numerically superior (0.39% improvement) to the best standard Co 85004 (15.89 t/ha). The standard Co 85004 recoded the highest cane yield of 129.33 t/ha and none of the entries was superior to it. The standard CoC 671 recorded the highest CCS of 13.88% and sucrose content of 19.71% while the best entry Co 11004 recorded 13.19% and 18.82% respectively.

Table 19. **Mean performance of early entries in two plant and one ratoon crops**

Entry	CCS (t/ha)	Cane yield (t/ha)	CCS (%)	Sucrose (%)
Co 11001	13.89	114.60	11.96	17.09
Co 11004	12.12	90.11	13.19	18.82
CoM 11081	8.99	71.41	12.42	17.67
CoM 11082	15.95	124.22	12.78	18.28
CoM 11084	9.88	78.19	12.56	17.93
Standards				
CoC 671	15.12	108.46	13.88	19.71
Co 94008	11.52	97.97	11.65	16.76
Co 85004	15.89	129.33	12.21	17.46

(Adhini S. Pazhany, A. Anna Durai and T. Lakshmipathy)

Advanced Varietal Trial (Mid-late)

Six test entries (Co 11005, Co 11007, Co 11012, Co 11019, CoM 11085, CoM 11086) and two standards (Co 86032 and Co 99004) were evaluated in RBD with three replications. Among the test entries, Co 11007 recorded the highest CCS yield of 14.24 t/ha followed by Co 11019 (14.04 t/ha), CoM 11086 (14.01 t/ha) and the best standard Co 86032 recorded CCS yield of 13.12 t/ha. For cane yield, Co 11019 recorded the highest cane yield of 120.95 t/ha and significantly superior over the best standard Co 86032 (100.59 t/ha). Co 11007 recorded the highest juice sucrose (19.73%) and CCS (13.85%) and was significantly superior over the best standards. Among the test entries, Co 11007 showed more than five percent improvement for CCS (6.21%) and sucrose (6.59%) and was numerically superior for CCS t/ha and cane yield over the best standards.

In ratoon crop, Co 86032 (15.34 t/ha) was the better standard for commercial cane sugar yield. Among the entries, Co 11012 (15.23 t/ha) was the top ranking entry for CCS yield followed by Co 11005

(14.66 t/ha). Co 86032 (104.41 t/ha) was the better standard for cane yield and Co 11005 (104.80 t/ha) performed better than this standard. Co 99004 was the better standard for CCS (15.50 %), juice sucrose (21.61 %) and brix (22.15 %). None of the test entries was superior to the standard Co 99004 for juice characters.

Mean performance of the entries in two plant and one ratoon crops indicated that the entry CoM 11086 recorded the highest CCS yield of 14.38 t/ha and showed 5.07 per cent improvement over the best standard Co 86032 (13.68 t/ha). The entry Co 11005 recorded highest cane yield of 113.41 t/ha which was 9.07% superior to the best standard Co 86032 (103.99 t/ha) followed by Co 11019 (7.91% improvement), CoM 11086 (6.80% improvement) and Co 11007 (3.24% improvement). The entry Co 11012 recorded the highest CCS% of 13.48% and numerically superior (0.12 % improvement) than that the better standard Co 99004 (13.46 %). Co 99004 was the better standard for sucrose content (19.21 %) while both of the entries *viz.*, Co 11007 and CoM 11085 recorded sucrose content of 19.01% (Table 20, Fig. 30 and 31).

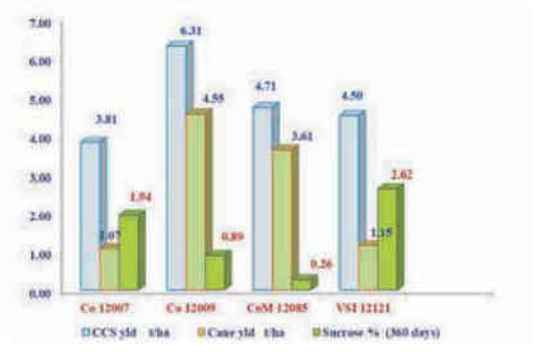


Fig. 30. Percent improvement of potential AVT clones over the popular standard Co 86032 at harvest

Fig. 31. Per cent improvement in 2P+1R crop of AVT midlate selected clones for CCS (t/ha), Cane Yield (t/ha) and Sucrose (%)

***Table 20.* Mean performance of midlate entries in two plant and one ratoon crops**

Entry	CCS (t/ha)	Cane yield (t/ha)	CCS (%)	Sucrose (%)
Co 11005	13.69	113.41	12.07	17.22
Co 11007	14.24	107.36	13.32	19.01
Co 11012	13.56	100.61	13.48	19.15
Co 11019	13.81	112.21	12.40	17.75
CoM 11085	12.45	93.09	13.41	19.01
CoM 11086	14.38	111.06	13.03	18.57
Standards				
Co 86032	13.68	103.99	13.16	18.65
Co 99004	12.60	94.09	13.46	19.21

(S. Karthigeyan and C. Mahadevaiah)

Multiplication and exchange of seed material

Sixteen series 'Co' and 'Co' allied clones Co 16006, Co 16009, Co 16010, Co 16017, Co 16018, CoM 16081, CoM 16082, CoR 16141, CoR 16142, CoVSI 16121, CoN 16071, CoVC 16061, CoVC 16062, Co 11015 and PI 16131 accepted for AICRP trial were multiplied at ICAR-SBI, Coimbatore and were supplied to seven participating centres in the peninsular zone (Mandya, Perumallapalle, Powerkheda, Pugulur, Rudrur, Sameeravadi and Thiruvalla) for initial multiplication and subsequent conduct of trial.

The thirteen series entries *viz.*, Co 13002, Co 13003, Co 13004, CoN 13071, CoN 13072, CoSnk 13101, CoSnk 13102, MS 13081, Co 13005, Co 13006, Co 13008, Co 13009, Co 13011, Co 13013, Co 13014, PI 13132, PI 13131, CoT 13366, CoSnk 13106, CoSnk 13105, CoSnk 13104, CoSnk 13103, CoN 13074, CoN 13073, CoM 13082, Co 13020, Co 13018 and Co 13016 which were evaluated during the year 2016-17 in IVT were also multiplied for conducting AVT trial during the year 2018-19.

(K. Mohanraj, V. Sreenivasa and V. Vinu)

Physiological parameters

Screening of AVT entries for salinity tolerance

Eight AVT clones (Co 12007, Co 12008, Co 12009, Co 12012, Co 12019 and Co 12024, CoM 12085, VSI 12121) were screened for salinity tolerance in micro plots along with CoC 671 and Co 86032 as standards. Soil electrical conductivity was raised to 8dS/m and maintained by irrigating with salt water. Relative performance of the genotypes in terms of cane yield and sugar yield was assessed by plotting the cane yield under treatment against yield under normal condition. Similarly, for sugar yield also the relative performance was worked out. Co 12008, Co 12009 and Co 12012 were rated tolerant and CoM 12085 as moderately tolerant to soil salinity at an EC of 8d S m^{-1}.

Screening AVT entries for drought tolerance

Ten AVT entries pertaining to 2010 series ('Co' canes only) and 6 AVT entries pertaining to 2011 series ('Co' canes only) were planted in strip plot design along with 2 resistant standards (Co 86032 and Co 99004). Drought stress was given during formative phase of the crop by withholding irrigation. The percentage of soil moisture depletion was worked out at 30, 60 and 90 days after drought treatment through gravimetric method as 30.5%, 41.5% and 62.5% over control respectively.

Drought treatment induced 21.5%, 32.10%, 25.0% and 20.50% reduction in shoot population, plant height, LAI and SPAD value respectively. Under drought conditions, Co 10015, Co 10026, Co 11001 and Co 11004 comparatively recorded maximum shoot population and plant height respectively. Results of 12th month juice quality parameters indicated that, drought induced 18.0, 22.7, 6.30 and 25.0 percent reduction in brix%, sucrose%, purity% and CCS% over control. Under drought Co 10026 recorded higher brix%, sucrose%, purity%, and CCS% over control respectively. Data on yield and yield components was recorded in control and drought treated plots. Rating for drought tolerance was given based on the cane and sugar yield both under control and drought situation. Among the 10 clones of 2010 series, the clones Co 10026 and Co 10015 were rated as drought tolerant. The clones, Co 10027, Co 10031, Co 10004 and Co 10024 were rated as moderately drought tolerant. The clones, Co 10033, Co 10017 and Co 10005 were rated as susceptible under drought condition. Among the 2011 series, Co 11001 and Co 11005 were rated as drought tolerant. The clones Co 11009, Co 11004 and Co 11007 were rated as moderately drought tolerant and Co 11012 was rated as susceptible under drought situation.

(R. Gomathi)

Jaggery and fibre characters

In IVT, the lowest fibre percentage was recorded in CoN 14072 with the value of 10.43% and the highest value in Co 14026 (15.86%). Fibre % among the entries in AVT - I Plant was lowest in Co 12007 (12.11%) and the highest fibre % was recorded in Co 12009 (15.79%). In AVT-I Plant (Early) Ratoon, the lowest fibre percentage was found in the variety

CoM 11081 (9.5%) and the highest value in the standard Co 94008 (13.47%) while in AVT-(Midlate) Ratoon the lowest fibre weight percentage was recorded in the variety CoM 11085 (11.68%) and the highest value in Co 11007 (13.76%). The lowest and the highest fibre percent in cane was found in CoM 11081 (8.36%) and in Co 94008 (13.72%) respectively in AVT-II Plant (Early). In AVT - II Plant (Midlate) the lowest fibre weight percentage was found in the standard Co 86032 (12.86%) and the highest value in Co 11007 (14.19%). High jaggery yield per litre was 258.5 g for CoC 671 and 167.6g for Co 12012

(I. Rajendran)

Nutrient uptake and nutrient use efficiency

AVT 2016-17 Co entries: Co 11001 was efficient in terms of reciprocal N, P and K use efficiency when compared to the other AVT early maturing entry (2016-17), Co 11004. The standard, Co 85004 was more P efficient than all AVT early Co entries and standards. The standard, CoC 671 was more K efficient than all AVT early Co entries and standards (Table 21). Co 11019 was efficient in terms of reciprocal N, P and K use efficiency when compared to other AVT midlate Co entries (2016-17), Co 11005, Co 11007, Co 11012 and the standards, Co 86032 and Co 99004 (Table 22).

Table 21. **Nutrient uptake and nutrient use efficiency of AVT Early Plant I Co entries (2016-17)**

Entry	Nitrogen		Phosphorus		Potassium	
	Uptake (kg N/ha)	RIE (kg N/t)	Uptake (kg P/ha)	RIE (kg P/t)	Uptake (kg K/ha)	RIE (kg K/t)
Co 11001	180.89	1.32	33.98	0.248	262.54	1.92
Co 11004	197.74	1.68	30.49	0.258	232.87	1.97
Co 85004	254.14	1.75	32.89	0.225	287.65	1.97
Co 94008	179.83	1.56	31.64	0.273	237.30	2.05
CoC 671	175.90	1.41	32.33	0.259	217.72	1.74

Table 22. **Nutrient uptake and nutrient use efficiency of AVT Midlate Plant I Co entries (2016-17)**

Entry	Nitrogen		Phosphorus		Potassium	
	Uptake (kg N/ha)	RIE (kg N/t)	Uptake (kg P/ha)	RIE (kg P/t)	Uptake (kg K/ha)	RIE (kg K/t)
Co 11005	237.52	1.67	23.44	0.164	148.74	1.31
Co 11007	273.83	1.96	24.63	0.176	219.21	1.75
Co 11012	211.81	2.05	20.38	0.191	208.42	1.70
Co 11019	163.24	1.41	20.11	0.169	149.68	1.28
Co 86032	203.36	1.90	29.11	0.274	179.03	1.53
Co 99004	236.18	2.03	26.36	0.221	281.95	1.94

(C. Palaniswami and A. Vennila)

Evaluation and identification of climate resilient ISH and IGH genetic stocks

Second set of 30 new ISH/IGH clones viz., ISH 502, ISH 512, ISH 513, ISH 516, ISH 519, ISH 524, ISH 526, ISH 528, ISH 534, ISH 535, ISH 536, ISH 542, ISH 545, ISH 548, ISH 554, ISH 558, ISH 564, ISH 567, ISH 584, ISH 585, ISH 587, ISH 590, ISH 594, IGH 806, IGH 816, IGH 823, IGH 829, IGH 833, IGH 834 were selected based on crop stand, juice quality parameters, red rot resistance and genome composition of the clones. These clones were sent to seven AICRP(S) centres for initial multiplication and further evaluation under drought (Sankeshwar, Pune, Lucknow and Karnal) and water logging (Motipur, Pusa and Pantnagar) conditions.

(P. Govindaraj)

Identification of pathotypes / races in red rot pathogen

Seven new isolates from Tamil Nadu *viz.*, CfPI1110 Kothangudi, CfPI1401 Kadaganur, Cfv09356 Keerangudi, Cf86027 Nathakadu, Cf2001-13 Perambakkam, Cf06022-Kuthalam and Cf99006 Mundiampakkam along with two reference pathotypes CF06 and CF12 were tested on 19 differentials. The isolate CfPI1110-Kothangudi totally lost its virulence, hence exhibited R reaction on 15 differentials. The reaction of Cf86027 was similar to the isolate CfPI1110. The new isolates showed less virulence than reference pathotypes, however three new isolates *viz.*, Cf2001-13-Perambakkam, Cf06022- Kuthalam and Cf99006-Mundiampakkam exhibited different reaction on many differentials. The differential CoSe 95422 exhibited Intermediate reaction to three isolates and two reference pathotypes this season. Unlike previous season, this time both the reference pathotypes CF06 and CF12 showed similar disease reaction on all the differentials. Pathogenic reactions of the isolates indicated some changes induced by the environmental factors prevailed during the period.

(V. Jayakumar and R. Selvakumar)

Evaluation of Zonal varieties for resistance to red rot

Red rot: Thirty-seven entries of IVT were evaluated for red rot resistance by plug and nodal methods against CF06 and CF12 pathotypes. Since the disease development during the season was erratic the trial is being repeated.

Smut: Out of 37 entries including two check varieties evaluated for smut resistance, 17 were R/MR to smut and six behaved as MS and the rest were S/HS to the disease.

Yellow leaf disease: Thirty-seven IVT entries and 19 AVT entries were monitored for the YLD severity on 0-5 scale. Among the IVT and AVT entries, 36 were apparently free from the disease symptoms and probably R to the disease, however further observations are required. The disease severity in rest of the entries were in the category of MS to MR. None of the entries exhibited severity scores of more than 3 and only five of them exhibited severity grade of 3.

Assessment of elite ISH clones for resistance to red rot: Out of 26 ISH/ IGH genotypes screened against three new isolates of *C. falcatum* from Tamil Nadu, five were resistant to all the three isolates and others exhibited a variable reaction.

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

Survey for sugarcane diseases

Surveys for sugarcane diseases were conducted in Tamil Nadu state. Red rot was noticed in the varieties CoC 24, PI 1110, PI 1401 and Co 06022 in different districts except in Western and Southern regions. Smut was observed in the varieties CoSi 6, PI 1110, CoC 24, CoC 22, CoV 94101 and Co 97009 (MC 707) in almost all the regions except Western region. Wilt was observed in SI 308, SI 309, CoC 24, Co 86032, Co 06022, CoV 92102 and CoV 09356 throughout the state at moderate level, however severe incidences were recorded in Co 06022 and CoV 09356. YLD was observed in Co 86032, CoV 09356, Co 06022, Co 06030, CoC 24, PI 1110, PI 1401,

CoV 92102, CoV 94101, Co 0212, PI 951946 and PI 061346 in all the districts in varying intensities. Severe degeneration due to YLD was observed in all the popular varieties under cultivation. GSD was also observed in varying intensities across the varieties and regions. Pokkahboeng was observed in SI 308, Co 06022, Co 06030, CoV 09356, SI 339 and Co 86032. Its severity was felt in varieties like PI 1110, Co 06022 and CoV 09356. Rust and foliar diseases were recorded in Co 06022 and CoC 22. Leaf fleck caused by *Sugarcane bacilliform virus* (SCBV) was found in all the regions especially in CoC 24, Co 0212, CoV 92102, Co 06030 and CoV 09356. This disease is rampant and gives a pale canopy in all these varieties, more so in Co 0212.

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

Management of yellow leaf disease through meristem culture

Detailed field experiments were conducted to assess the impact of YLD on cane growth and yield by comparing the crops planted with virus-infected and virus-free planting materials of the popular varieties Co 86032 and Co 0238 and a new clone Co 11015. It was found that the virus-free plants have recorded significantly high values in sett germination, plant growth/yield parameters such as number of stalks, cane diameter, cane length, number of internodes, cane weight and juice yield. It was found that due to virus infection, cane and juice yield are reduced in the range of 18.5-40.7 and 42.1-50 per cent, respectively in the varieties in the plant crop.

(R. Viswanathan)

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

Shoot borer: Out of 37 entries under IVT, one entry (CoN 14072) was LS to shoot borer, 14 entries were MS and 22 entries were HS. CoN 14072 had the lowest number (5538) of bored plants/ha and the entry CoSnk 14101 had the highest number of bored plants /ha. Cumulative incidence of the borer varied between 13.64 in CoN 14072 to 78.48 in the entry Co14004. Under AVT-I Plant, two entries showed HS reaction and the other two showed MS reaction to the borer. Incidence was at the lowest (19.6%) in CoC 671 and the maximum incidence was recorded in Co 86032 (65.8%). Number of bored plants/ha was the least (8923) in CoC 671 and highest (27160) in Co 86032. Cumulative incidence of the borer varied between 19.6 to 65.8%. In AVT-Early II Plant, out of seven entries, six were highly susceptible and only the check CoC 671 showed MS reaction to the borer. The lowest incidence (19.6%) was recorded in CoC 671 and the highest incidence of 67.2% was recorded in the entry Co 11001. The lowest number (8923) of bored plants/ha was in CoC 671 and the highest number (37345) was recorded in the entry Co 94008. In AVT-Midlate II Plant, five entries were MS and two entries were HS to shoot borer. Cumulative incidence of the borer varied between 19.7 in Co 99004 to 65.8% in Co 86032. Lowest number (10802) of bored plants/ha was in the entry Co 11005 whereas the highest (27160) was recorded in Co 86032.

Internode borer: Out of 10 entries in AVT-I Plant, internode borer incidence was maximum in the genotype CoM 12085 (93.3%) and minimum (50.7%) in Co 12009. All the genotypes recorded more than 50% incidence of the borer and falls under the susceptible category. Intensity of the borer was maximum in the genotype Co 12019 (5.7%) and the lowest (2.8%) was in the genotype Co 12012. Among the eight entries under AVT-II Plant (Midlate), INB incidence was maximum in the genotype CoM 11085 which also has recorded the maximum intensity of the borer. Minimum incidence (64%) of the borer was in the genotype Co 11005, however, minimum intensity of the borer was in the genotype Co 11019 (3.1%). Overall incidence of the borer was very high across the genotypes and falls under highly susceptible category. Incidence of INB was maximum (90%) in the check Co 94008 under AVT – II Plant (Early) category which also recorded the maximum intensity of the borer. Minimum (70%) incidence of the borer was in the entry CoM 11084

which also recorded minimum intensity of attack. Overall, incidence of the borer was very high in all the entries and falls under highly susceptible category. Out of 40 entries under IVT, maximum incidence of INB was in Co 14027 (86%) and the minimum incidence was recorded in the genotype CoT 14111 (38%) which also had the minimum intensity of the borer attack. The genotype VSI 14122 recorded the maximum intensity (6.3%) of borer attack. Across the entries the incidence of the borer was very high and falls under highly susceptible category. INB incidence in AVT Ratoon, comprising 11 entries, varied from 52% (Co 11007, Co 11012, Co 99004) to 80% (Co 86032). Minimum intensity of the borer was in the genotype Co 11007 (3.2%) and the maximum intensity was recorded in the genotype CoM 11086 (5.43%). Overall the incidence of the borer was high in all the entries hence, falls under highly susceptible category.

Top borer: Top borer incidence, recorded at the time of harvest, in IVT entries numbering 40 was very low ranging between nil to 16%. Maximum incidence (16%) of the borer was in CoSnk14103 and 22 genotypes recorded nil incidence of the borer. In AVT-II Plant, top borer incidence was very low ranging between nil to 6%. Considering overall incidence of the borer very low, categorizing the genotypes as resistant needs further verification. In AVT – II Plant, mean top borer incidence was very low being less than 10% making all the entries resistant. Co 85004 was free of the borer, whereas maximum incidence of 8% was recorded in two entries Co 11001 and the check CoC 671.

(K.P. Salin, J. Srikanth, P. Mahesh, M. Punithavalli and L. Saravanan)

Survey and surveillance of sugarcane insect pests

The pest survey at different locations of the state indicated that major borer pests were shoot borer and internode borers. Incidence of top borer was less than 10% and the sucking pests were generally of minor occurrence which included woolly aphid, whitefly and mealy bug. High incidence of white grub was noticed in some pockets of Sathyamangalam and Dharmapuri districts.

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

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

Incidence of top borer was < 5% in 7th month crop and incidence of internode borer was > 30% in 12th month crop. Only traces of other pests such as mealybug, woolly aphid and whitefly were recorded.

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

Fluff Supply and National Hybridization Programme

National Hybridisation Garden (NHG) with cafeteria of 607 parents for the breeders of 24 participating centres of fluff supply programme was maintained in healthy and diseases free condition. All the parental clones in NHG were observed for their flowering behaviour. The flowering was delayed by more than 15 days and the first flowering was noticed in LG 99122 and CoLk 7901 on 20 October, 2017 followed by CoJ 46 on 25 October 2017. The data on flowering of parental clones were collected and the same were hosted and updated at weekly interval in the institute website. Decreasing trend of flowering was noticed among the parental clones in NHG. Out of 607 parents, only 263 flowered and the per cent of clones flowered during 2017 was 43.33% against 52.46% during 2016 and 58.26% during 2015 flowering season.

Among 24 participating centres of Fluff supply / National Hybridization programme, 21 centres attended the crossing programme 2017-18. Hybridization work was initiated on 4th November 2017 and concluded on 8th December 2017. Out of 263 parents flowered during 2017 flowering season, 103 females and 69 male parents were utilised for generating genetic variability for different

agronomic traits. Co 98008 was the frequently used female parent in the crossing programme. This was followed by Co 0238 (19 crosses) and CoC 671 (18 crosses). Other female parents which were used for more than 10 crosses were Co 1158 (11), Co 86002 (11), CoLk 8102 (11), CoS 8436 (11), Co 98010 (12), CoA 13327 (12), CoH 110 (12) and CoN 05071 (12). Similarly, Co 62198 was the most frequently used male parent because of its longer duration of flowering making the flowers available to the breeders of both tropical and subtropical regions. This was followed by Co 1148 (31), BO 130 (24), CoH 70 (24), CoPant 97222 (23) and CoS 88216 (20) which were utilized more than 20 times in the crossing programme. Maximum number of bi-parental crosses was effected by the Shahjahanpur centre (36) followed by Pusa (34). The centres were facilitated to make 453 bi-parental crosses and 2 selfs at NHG, ICAR-SBI, Coimbatore. Besides bi-parental crosses, eight poly crosses, 187 general collections of open pollinated fluff (GCs) were also made available for these centres. Further, 12 centres were facilitated to effect 55 bi-parental crosses and 24 general collections at National Distant Hybridization Facility (NDHF) available at ICAR-SBI RC, Agali.

The Parental Diversity Index (PDI) and Parental Utilization Index (PUI) of crosses effected by the 21 centres were analyzed by classifying the source of the parental clones into eight categories *viz.*, Parents developed by ICAR-SBI (Coimbatore canes), parents from the particular centre, parents from the zone in which the respective centre is located, parents from other four zones, exotic parents and interspecific hybrids. Accordingly, the PDI range was found to from 56.94% (Shahjahanpur) to 85.71% (Nayagarh) which was significantly higher than that of crosses effected during 2016 where the two centres had PDI of less than 50.0% (Seorahi - 47.1% and Navsari- 47.4%). Pattern of utilization of parents by the Pune centre effecting number of crosses with higher PDI is depicted in Figure 32. The PDI and PUI of the crosses done by the participating centres during 2017 flowering season is presented in Table 23.

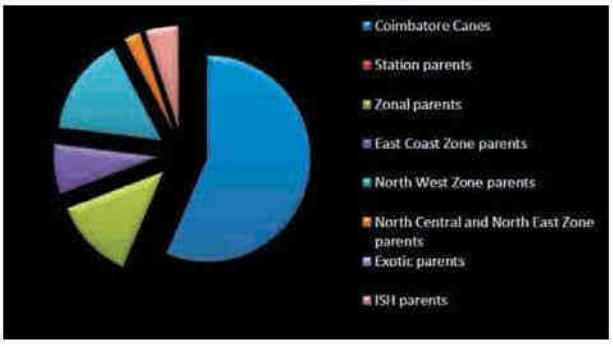


Fig. 32. Utilization pattern of parental clones by the Pune centre

***Table* 23. Parental Diversity Index and Parental Utilization Index of crosses done by the fluff receiving centres during 2017-18**

Peninsular Zone		
Centre	PDI	PUI*
Mandya	79.16	49.48
Navasari	72.22	54.17
Padegaon	70.00	61.25
Perumalapalle	78.13	48.83
Pune	84.78	63.59
Rudrur	77.78	58.33
Sankeshwar	75.00	56.25
Thiruvalla	82.35	51.47
North West Zone		
Faridkot	77.08	57.81
Kapurthala	66.67	50.00
Lucknow	65.91	49.43
Shajahanpur	56.94	57.81
Pantnagar	77.08	42.70
Uchani	70.00	52.50
East Coast Zone		
Anakapalle	67.24	58.83
Cuddalore	72.41	63..36
Nayagarh	85.71	64.29
Vuyyuru	75.00	37.50
North Central Zone		
Motipur	57.5	43.13
Seorahi	60.71	45.54
Pusa	58.82	44.12

* PUI nearing PDI indicates utilization of parental from all classes of parents

Table 24. **Number of crosses effected and quantity of fluff supplied to the participating centers**

Centre	Crosses effected at NHG		Crosses effected at NDHF		Poly-crosses		General collections		Total quantity of fluff (g)
	No.	Fluff weight (g)	BC+GC	Fluff weight (g)	No.	Fluff weight (g)	No.	Fluff weight (g)	
Peninzular zone									
Mandya	12	158.0	3+0	47.0	3	16.0			221
Navasari	18	280.0	3+0	51.0	3	16.0	10	134.5	481.5
Padegaon	25	497.5	5+4	148.0	3	16.0	7	79.0	740.5
Perumalapalle	16	352.5			3	24.0	12	179.0	555.5
Pune	23	432.0	5+0	137.0	3	18.0	4	54.0	641
Rudrur	18	419.5			3	18.0	14	307.5	745
Sankeshwar	16	203.5	2+7	106.5	3	17.0	5	82.0	409
Thiruvalla	17	400.5	2+1	41.0	3	15.0	10	174.5	631
Total									**4424.5**
East Coast Zone									
Anakapalle	29	489.0			3	18.5	21	233.0	740.5
Cuddalore	29	492.0	3+6	119.5			16	349.5	961
Nayagarh	7	117.0			3	18.0	10	146.5	281.5
Vuyyuru	12	181.0			3	15.0	9	94.5	290.5
Total									**2273.5**
North West Zone									
Faridkot	24	370.0	0		5	35.0	15	291.0	696
Kapurthala	27	621.5	5+0	77.0	5	37.0	25	481.0	1216.5
Uchani	20	285.0	2+3	61.0	5	28.0	18	394.0	768
Lucknow	22	387.5	2+0	30.0	5	35.0	57	944.0	1396.5
Shajahanpur	36	755.5	4+0	47.5	5	30.0	40	719.0	1552
Pantnagar	8	223.0	3+0	45.0	5	37.0	14	178.0	483
Total									**6112**
North Central and North East Zone									
Motipur	20	480.5	7+0	113.0	5	37.0	10	238.0	868.5
Seorahi	28	659.0	3+0	89.0	5	32.0	8	252.0	1032
Pusa	34	802.0	6+3	137.0	5	32.0	34	639.5	1610.5
Burlikson	6	127.0					16	394.0	521
Bethudahari	6	132.5					12	295.0	427.5
Total									**4459.5**
Grand total	**453**	**8866.0**	**55+24**	**1249.5**	**8**	**494.5**	**187**	**6659.5**	**17269.5**

BC= Bi-parental crosses; GC= General collections

The germination potential of the crosses / selfs / open pollinated fluff collected from NHG was assessed. Higher number of germinates per gram of fluff was noticed in the bi-parental crosses *viz.*, Co 98008 x CoPant 97222 (400), Co 98008 x CoA 13327 (360), CoV 89101 x CoS 90269 (360), CoM 6806 x CoC 1148 (324) and Co 98008 x Co 775 (308). Among general collections, CoL 29 (480), CoS 07233 (336), CoPant 8829 (320), Co 98003 (304), LG 99118 (272) and BO 137 (224) recorded relatively higher number of germinates per gram of fluff.

Fluff weighing 17.26 kg of crosses made at NHG and NDHF during 2017 flowering season was supplied to the 23 participating centres of fluff supply programme. The fluff was also sent to Bethudahari and Buralikson centres on special request. Maximum quantity of 6.11 kg of fluff was sent to North West Zone followed by North Central and North East Zones (4.46), Peninsular Zone (4.42) and East Coast Zone (2.27). Number of crosses / selfs made and quantity of fluff supplied to different fluff receiving centers during 2017-18 is given in Table 24.

NHG 2018-19 was planted with 595 parents including 15 introductions *viz.*, LG 08443, LG 09487 and LG 11001 from Lucknow, CoP 16436, CoP 16437, CoP 16438, CoP 16440 and BO 156 from Pusa, CoC 08336 and CoC 13339 from Cuddalore, CoH 10262 from Uchani, CoS 03251 from Shahjahanpur, CoSe 03234 from Seorahi and 2009 R 74 and 2010 R 854 from Rudrur.

(A. Anna Durai, Adhini S. Pazhany and N. Rajendra Prasad)

Agronomic performance of elite sugarcane genotypes

The experiment was laid out in split plot design with two replications. A total of 16 elite sugarcane genotypes consisting of eight early (Co 11001, Co 11004, CoM 11081, CoM 11082, CoM 11084, Co 85004, CoC 671 and Co 94008) and eight mid-late (Co 11005, Co 11007, Co 11012, Co 11019, CoM 11085, CoM 11086, Co 99004 and Co 86032) with 125 % RDF were planted with two spacings (120 and 150 cm). Germination count at 30 days after planting was taken wherein mid late genotype Co 11005 (70.09 %) and early genotype Co 85004 (70.76 %) recorded higher germination. However, at 45 DAP, mid late genotype Co 11012 (86.025 %) and early genotype Co 11001 (70.48 %) recorded higher germination. Juice analysis done at 10 month after planting revealed that amongst eight elite early sugarcane genotypes, CoC 671 recorded the highest sucrose % (19.08), purity (93.45 %) and CCS % (13.54). For cane yield at harvest, new elite early sugarcane genotype Co 11004 recorded the highest canes yield of 64.41 t/ha at 120 cm rows spacing over the rest of entries. In case of mid-late elite sugarcane genotype Co 11012 showed better juice quality parameters over new test entrie at 10th month whereas CoM 11085 recorded highest sucrose % (19.37), Purity (89.09 %) and CCS % (13.45) with 70.83 t/ha cane yield at 12th month. Planting of elite sugarcane genotype Co 11019 at 120 cm row spacing was found beneficial over rest of elite mid late entries. During 2018 crop season planting of 11 elite sugarcane genotypes was done and germination count was taken at 30 and 45 DAP wherein CoSnk 05103 with average germination count of 58.76 % showed better agronomic crop stand over the rest of the test entries.

(A.S. Tayade, A. Bhaskaran, P. Govindaraj and S. Anusha)

EXTERNALLY FUNDED PROJECTS

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

Maintenance breeding: One hundred and eighty nine reference collections of tropical sugarcane varieties were planted at DUS Centre, Coimbatore during February, 2017. Each entry was planted in two rows of 3m length and with a row to row spacing of 0.9m. In addition, the seed material of four Farmers' Varieties (FV) namely DESI- I, DESI-II, Kudrat Ka Karishma and Kaptan Basti from SBI-RC, Karnal were raised in polybags and transplanted in field for multiplication and maintenance. All the varieties

were maintained free of pests and diseases. DUS reference varieties (190) have been planted during second week of February, 2018 for maintenance during 2018-19.

DUS test for FV/NV: During 2017-18, first year DUS test was conducted for farmer's variety Kaptan Basti along with reference varieties Co 356, Co 740 and Co 8208 and observations as per the DUS test guidelines have been completed. The farmer's varieties namely Meitei Chu Angougba, Meitei chu Angangba, DESI-2 and Kudrat Ka Karishma were planted in polybags in February 2018 along with reference varieties namely Thirumadhuram, Co 419, 2000 V 59, Pounda, Co 356, IJ 76-567, 51 NG 115 G, Co 740, 28 NG 59, Red sport, NG 77-232, NG 77-015, MiaMoi, Fiji B and Tanjore Pongal were transplanted in field in April 2018 for DUS testing. Observations on DUS guidelines was recorded in farmer's variety Kudrat Ka Karishma.

Characterization of reference varieties: Data on 27 morphological descriptors were recorded as per the DUS testing guidelines issued by the PPV & FR Authority in twenty one reference varieties *viz.*, Co 213, Co 243, Co 244, Co 281, Co 331,Co 87271, Co 91002, Co 92005, CoV 05356, CoSnK 0361 CoSnk 03754, POJ 2878, CoC (24), CoJn 86-600, CoN 03131, CoN 05071, CoN 05072, 2000 V 59, 2000 V 160, 2002 V 48 and 2003 V 46 and incorporated in database.

(S. Alarmelu and C. Jayabose)

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

The seed production programme at the Institute was well organised and the indents for both breeder seed cane and tissue culture plants received in advance were supplied. All the on-going activities initiated during last year had strengthened the seed programme so as to deliver large quantity of seeds with high genetic purity and adequate quality to the indenters.

Maintenance breeding: Maintenance breeding and multiplication of nucleus clones of all released varieties in seed chain from the Institute *viz.*, Co 86032, Co 0212, Co 06030, Co 06022 and Co 0403 were continued and the newly released variety, Co 09004 has been added in the programme. The nucleus clones are being maintained under the supervision of the breeders as a continuous activity. The selected canes were micropropagated to supply disease free plantlets for further multiplication as breeder seed.

Breeder Seed production : Breeder seed multiplication was taken up using the initial source of the tissue culture plants produced from the nucleus clones, both at the Institute and a progressive farmers' field. The varieties included were Co 86032, Co 06030, Co 0212 and the newly released variety Co 09004. About 28.54 tons of breeder seed thus produced have been supplied to the selected farmers to undertake the quality seed production during September 2017 under the guidance from ICAR-SBI, Coimbatore in addition to the indents from sugar factories. A total of 22.58 tons of breeder seed have been multiplied and supplied during January 2018 to the selected seed farmers for further multiplication as quality seed for supply during September 2018.

Farmers' participatory quality seed production : The awareness and demand for large quantity of quality seed cane coupled with the limited resources availablity in the Institute provided an opportunity to explore the other alternatives under ICAR Seed Project. The seed requirements received from sugar factories for supply during September 2017 and March 2018 were consolidated and the production was taken up in two phases; January – September 2017 (2017-Phase I) and September 2017-March 2018 (2017-Phase II). After ascertaining the field conditions, suitability, infrastructure, expertise and resources available, progressive farmers have been selected to undertake this seed production activity. Accordingly, planting was done at Veerapandi, Vellamadai, Neelampur and Narasimhanaickanpalayam of Coimbatore district and Vaiyapurigoundenpudur of Tirupur district. The crop was monitored by a team of Breeders time to time and most of the demands

received for quality seed cane have been fulfilled. While a total quantity of 620.480 tons of quality seed cane were produced and supplied to the indenters during September 2017 (2017-Phase I) with the net revenue of Rs. 3,10,240/-.

Further, the Institute has received a total indent of about 650 tons of seed cane for supply during September 2018 (2018-Phase I). About 13 acres have been planted at Thoppampatti, Narasimhanaickanpalayam, Vellamadai and Neelampur of Coimbatore district during February 2018 accordingly and the seed crop is being monitored.

(A.J. Prabakaran and S. Karthigeyan)

Micropropagation

Through apical meristem tip culture, the varieties Co 86032, Co 0212, Co 0238, Co 06022, Co 09004 and CoV 09356 were multiplied and a total of 53435 tissue culture plants were supplied to 14 sugar factories of Tamil Nadu, Maharashtra and Odisha. Tissue culture plants were also supplied to progressive farmers of Tamil Nadu, Karnataka, Kerala and quality disease free plants were utilized for breeder seed production programme at ICAR-Sugarcane Breeding Institute, Coimbatore and Regional Centre, Karnal.

In vitro culures of varieties Co 0212, Co 09004, Co 0238, Co 86032, CoV 09356 and pre released varieties Co 11015 were virus indexed and found be free from SCYLV, SCMV, SCSMV and phytoplasma GSD. A total of 167 virus free mother culture flasks of variety Co 86032, Co 0212, Co 0238 were supplied to private tissue culture laboratory of Tamil Nadu, Chattisgarh, Gujarat and Uttar Pradesh.

(D. Neelamathi and R. Valarmathi)

Enhancing sugar productivity in Tamil Nadu through Institute-Industry participatory approach

Identification of location specific variety

Co varieties: A total of twenty promising genotypes (Co 0238, Co 0240, Co 06031, Co 09004, Co 11015, Co 13001, Co 13003, Co 13006, Co 13014, Co 13018, Co 13020, Co 13021, Co 14008, Co 14016, Co 14026, Co 15005, Co 15007, Co 15021, Co 16001 and Co 16002) were sent to sugar factories.

Nine sugar factory locations selected for evaluation during 2017-18:

1. Bannari Amman Sugars Ltd., Alathukombai, Sathyamangalam, Erode 638401
2. Dharani Sugars & Chemicals Ltd., Karaipoondi, Polur, Thiruvannamali 606803
3. EID Parry (India) Ltd., Nellikuppam Sugar Factory, Cuddalore 607105
4. Kothari Sugars & Chemicals Ltd., Vetriyur, Sathamangalam, Ariyalur 621707
5. Ponni Sugars (Erode) Ltd., Odapalli, Cauvery RS, Erode 638007
6. Rajshree Sugars & Chemicals Ltd., Mundiambakkam, Villupuram 605601
7. Sakthi Sugars Ltd., Sivaganga Unit, Jothinagar, Padamathur, Sivaganga 630561
8. Thiru Arooran Sugars Ltd., Tirumandangudi, Papanasam Tk, Tanjore 612301
9. V.V. Sugars Pvt. Ltd., Udumbiyum Village, Veppanthattai, Perambalur 621 212

Performance of varieties: Twenty varieties were evaluated along with Co 86032 and local standards in a replicated trial during 2017-18. Harvesting was completed in all factory locations before end of February 2018. Data were compiled and analyzed. Varieties were classified based on sucrose accumulation and cane yield at harvest. Overall, Co 13014, Co 11015, Co 14016 and Co 06031 performed better than Co 86032 for yield and quality at harvest (12 months). Varieties with more than 10 t/ha cane yield and higher sucrose % than Co 86032 (12 months of planting) were identified as suitable for particular locations. Location specific varieties suitable for different crushing times are given factory wise in Table 25.

Table 25. **Varieties identified for crushing at different maturity periods**

Sugar Factory	Varieties identified for crushing at		
	240 days	300 days	360 days
Bannari Amman Sugars	Co 06031, Co 11015 Co 15007	Co 06031, Co 11015, Co 13006 Co 13018, Co 14016, Co 15007	Co 06031, Co 11015, Co 13018 Co 13018, Co 14016, Co 15007
Dharani Sugars	Co 11015	Co 11015	Co 06031, Co 11015, Co 13014
EID Parry (India)	Co 11015, Co 13001 Co 16001	Co 11015, Co 13001, Co 16001	Co 11015, Co 13001, Co 13014 Co 13018, Co 13001, Co 16001
Kothari Sugars	Co 09004, Co 13001 Co 15005, Co 16001	Co 09004, Co 13001, Co 15005 Co 16001	Co 09004, Co 13001, Co 16001
Ponni Sugars	Co 09004, Co 11015 Co 13001, Co 16002	Co 09004, Co 11015, Co 13001 Co 13003, Co 15005, Co 15001 Co 16001, Co 16002	Co 09004, Co 11015, Co 15007 Co 16001, Co16002
Rajshree Sugars	Co 11015	Co 11015	Co 11015, Co 13003, Co 15007
Sakthi Sugars	Co 11015	Co 11015	Co 11015
Thiru Arooran Sugars	Co 11015	Co 13001	Co 0238, Co 09004, Co 11015, Co 13003, Co 14016, Co 15005, Co 16001
V.V. Sugars	Co 09004	Co 09004, Co 11015, Co 14016	Co 11015

Variety Co 11015 combines high yield and quality, and was found suitable for harvesting, starting from eight months onwards in six factory locations and thus considered as a short duration variety. Varieties Co 13001 and Co 16001 were found suitable for harvesting starting from 8 months onwards at E.I.D (Parry), Nellikuppam factory location. Varieties Co 06031, Co 13014, Co 13018, Co 14016 and Co 15007 were found suitable for harvesting after 12 months of planting.

Identification of location specific variety (2018-2019): Second plant crop trial was laid out in all sugar factory locations for further evaluation. First plant crop was harvested and field was ratooned to evaluate the ratooning potential of 'Co' varieties.

Multiplication of second set of clone for location specific variety trial: The promising clones *viz.*, Co 12009, Co 14002, Co 14005, Co 14025, Co 15015, Co 15018, Co 16009, Co 16010, Co 16018, Co 17001, Co 17003, Co 17004, Co 17012, Co 17013, Co 17014 and Co 18009 were planted for multiplication. These clones will be supplied to all nine factory locations during June-July 2018.

Survey of pests and diseases during 2017-18: Surveys were carried out during July – August 2017 (I Survey) and February – March 2018 (II Survey) for recording the incidence of sugarcane pests and diseases:

Survey of sugarcane diseases

Overall, the disease scenario indicated that the diseases YLD, red rot and smut were common in north and coastal districts of the state whereas, YLD, smut and wilt were common in the central districts. The delta and southern districts had occurrences of

YLD and smut. The districts in the western zone had severe YLD incidences. GSD and pokkah boeng were found in all the regions across the varieties. Red rot was noticed in the varieties CoC 24, PI 1110, PI 1401 and Co 06022 in different districts except in western and southern regions. However, the incidences were confined to the susceptible varieties and the situation indicated that most of the cane areas were free from the disease. Smut was observed in the varieties CoSi 6, PI 1110, CoC 24, CoC 22, CoV 94101 and Co 97009 (MC 707) in almost all the regions except western region. Wilt was observed in the varieties SI 308, SI 309, CoC 24, Co 86032, Co 06022, CoV 92102 and CoV 09356 throughout the State at moderate level. YLD was observed in the varieties Co 86032, CoV 09356, CoC 24, CoV 92102, CoV 94101, PI 1110, PI 1401, Co 06022, Co 06030, Co 0212, PI 951946 and PI 061346 in all the districts in varying severities. Severe degeneration due to YLD was observed in all the popular varieties under cultivation. GSD was also observed in varying intensities across the varieties and regions. Pokkah boeng was observed in SI 308, Co 06022, Co 06030, CoV 09356, SI 339 and Co 86032. Its severity was felt in varieties like PI 1110, Co 06022 and CoV 09356. Rust and foliar diseases were recorded in Co 06022 and CoC 22. Leaf fleck caused by Sugarcane bacilliform virus (SCBV) has been found in all the regions especially on the varieties Co 0212, CoV 92102, CoV 09356, CoC 24 and Co 06030.

Survey of incidence of insect pests

Incidences of major pests *viz.*, shoot borer, internode borer, top borer, white grub, woolly aphid, whitefly and mealy bugs were recorded along with details of variety, crop condition, plant protection measures adopted etc.

Western Region: Shoot borer (SB) incidence noticed during the first survey was less (<5%). Internode borer (INB) was the major pest noticed during this period, the incidence of which varied between 10 to 12% at different locations. White grub (up to 5/m^2) was the other dominant pest especially at Bannari Amman Sugars, Sathyamangalam, an endemic area to the pest. During the second survey. INB continued to be the predominant pest causing up to 7.2% incidence. Other sucking pests such as woolly aphid, whitefly and mealy bug were found to be in patches or in traces only.

Central Region: Shoot Borer was the predominant pest noticed during the first survey causing up to 60.0% damage in some pockets of Kothari Sugars, Ariyalur, followed by INB causing 5 to 50% damage. Among the sucking pests, woolly aphid was noticed in patches up to 80% in some fields of EID Parry, Pudukottai. Natural enemies such as Dipha aphidivora were found to be quite active in these patches preventing further spread of the pest. Mealybug was also noticed at levels ranging from nil to 35.0% incidence in some locations.

During the second survey, top borer was noticed at a very low level of <5.0% at V.V. Sugars, Perambalur. Mealybug in some patches could be seen as high as 52.5%. Incidence of woolly aphid was not recorded.

Delta Region: High incidence of SB (40 - 50%) was noticed during the first survey at Thiru Arooran Sugars, Thirumandangudi, and the incidence of INB was up to 10.0%. Woolly aphid incidence ranged from 20.0 to 80.0% at Sree Ambika Sugars, Tuhili, whereas other sucking pests were not observed.

During the second survey, INB incidence was relatively high ranging from 9.8 to 60.0% at Thiru Arooran Sugars, Thirumandangudi. Top borer incidence was low at 5.0% (Thiru Arooran Sugars, Chittur). Sucking pests such as woolly aphid and mealybugs could be noticed in patches up to 25.0% and 30.0% respectively.

Northern Region: Major pests noticed in the North during first survey were SB, INB and woolly aphid. High incidence of SB up to 60.0% in some pockets of Bannari Amman Sugars, Kolunthampattu was noticed. INB incidence ranged from 5.0 to 25.0%. High incidence of white grub (up to 6.2/m^2) was noticed in some fields of Bannari Amman Sugars, Vengur. Woolly aphid was noticed only in patches.

During the second survey, SB incidence, though slightly came down to 42.0% in some fields of Bannari Amman Sugars, Kolanthampattu. INB incidence remained at moderate level of 11.0 to 23.0%. Sucking pest incidence was not observed during this period.

Coastal Region: First survey indicated low incidence of SB (up to 14.0%) and moderate incidence of INB (2.8 to 24.0%). Among the sucking pests, only woolly aphid was noticed in patches and in some fields of Rajshree Sugars, Gingee, up to 80%. High incidence (11.6/m^2) of white grub was noticed in a field of the same factory. Second survey indicated that SB and INB incidences had gone high, i.e. 44.8 and 50.0% respectively. Low top borer incidence of 8.0% was noticed in some fields of E.I.D. Parry, Nellikkuppam. High woolly aphid incidence of 86.4% was noticed in some pockets of the E.I.D Parry, Pondicherry.

Southern Region: Low incidence of SB and INB was noticed during the first survey in this region. Severe whitefly was noticed in some fields of Sakthi Sugars, Sivaganga. Other sucking pests were not noticed. In the second survey. However, woolly aphid was noticed in patches at Rajshree Sugars, Theni, whereas other sucking pests were present in traces. Overall, the survey indicated that major borer pests noticed in the survey were SB and INB. Sucking pests were generally of minor occurrence which included woolly aphid, whitefly and mealy bug.

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

Genetic control and genomic selection for important traits in sugarcane and comparison of elite Indian and Australian germplasm

Phenotyping for drought tolerance related parameters for the bi parental population involving CoM 0265 x Co 775 (drought), BO 91 x Co 775 was carried out. Drought was imposed by withholding the irrigation at 90 DAP for three months. Parameters like chlorophyll fluorescence, chlorophyll content, leaf temperature, scoring for green phenotype were done three times - One at before starting of the stress (pre stress observation), second at middle of stress period (45 days after imposition of drought) and third at 80 days after imposition of drought. The parameters like wax content, proline content, Nitrate reductase assays were done for the bi-parental population BO 91 x Co 775. Red rot screening was done for the BO 91 x Co 775. Brix were estimated at 9th month after planting for the cross Co 1148 x Co 775 population. The brix content was estimated for BO 91 x Co 775, CoM 0265 x Co 775, Co 86002 x BO 91 at 10 months. Juice analysis (sucrose and Pol %) and yield parameters like single cane weight, number of internodes, cane height, and stalk diameter were recorded for all four populations. Flowering behaviour was recorded for all the clones and the data on Brix and Pol % were analysed using best linear unbiased prediction method using R and SAS. The clones with high BLUPs (both at control and drought conditions) were identified. The second plant crop of populations BO 91 x Co 775 (108) (three replications), Co 86002 x BO 91 (two replications), CoM 0265 x Co 775 (two replications), Co 1148 x Co 775 (single replication) were planted and the initial data on germination, tiller count was recorded. Further drought has been imposed for the population of BO 91 x Co 775. After imposing stress leaf temperature was measured for all the populations. DNA isolation was carried out for CoM 0265 x Co 775 (107 clones) and Co 1148 x Co 775 (112) and purified.

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

Identification of new genetic resources for drought tolerance from Erianthus, a related wild genus of sugarcane through GWAS

To identify new genetic resources from *Erianthus* for drought tolerance, 208 clones of *E. arundinaceus* along with the 'Co' cane checks (Co 99004, Co 06022, Co 86032, Co 0212, and Co 775) were screened for drought in the field condition. Drought stress was imposed by withholding irrigation at the tillering phase. After 85 days of drought exposure at 30-40% soil moisture content about 15 *E. arundinaceus* clones were found to be tolerant and about 20 clones to be moderately tolerant (Fig. 33). The selected tolerant and susceptible species clones of Erianthus are under further screening at both field and pot conditions.

To understand the genetic diversity of *Erianthus* germplasm 208 clones were surveyed using 30 SRAP (Sequence Related Amplified Polymorphic) primer combinations. DNA was isolated from 208 germplasm lines of *Erianthus* and used for PCR amplification using 30 combinations of SRAP markers consisting of ten forward and six reverse primers. The allelic data was stored and used for kinship analysis. Data analysis was carried out using DarWin to assess the pattern of grouping. Dissimilarity index was worked out based on simple matching; clustering was done by WARD method using Software DARWin 6.0. The analysis generated clone specific grouping with six major clusters. All IS, IJ, IK and IMP collections from Indonesia, Thailand and Burma showed separate cladding while the Indian collections SES and IND clustered separately. Few clones of IJ were found to clade in between IND and SES collections.

Fig. 33. Erianthus clones along with Co canes (Co 0212, Co 775, Co 99004, Co 86032) after 85 days of drought exposure at 40% soil moisture content

(R. Valarmathi and H.K. Mahadevaswamy)

5.2 DIVISION OF CROP PRODUCTION

5.2.1 AGRONOMY, MICROBIOLOGY AND FARM MACHINERY AND POWER

Development of cropping systems and improved agronomic practices to enhance sugarcane productivity

Characterization of rhizosphere of selected sugarcane genotypes

Response to root injury was studied in three popular commercial hybrids *viz.*, Co 06022, CoC 671 and Co 86032 in hydroponic system. The injury was inflicted by longitudinal slicing of primary root (2 cm) up to root tip using sterile surgical blade. The root injury has resulted in differential response among varieties. Up to 3 days of injury there was no change in coloration. A dense red/pink pigmentation was observed in CoC 671. The secondary root initiation showed differential time lag in the varieties studied. In Co 06022, secondary roots appeared after 10 days of injury while, in Co 86032 and CoC 671, it took only 3 days (Fig. 34).

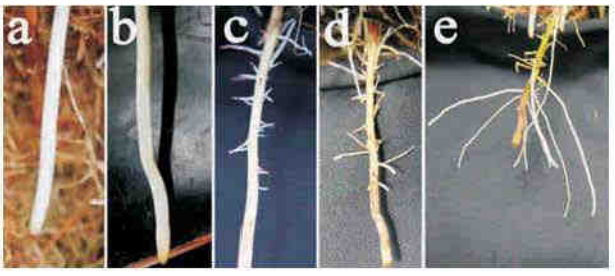


Fig. 34. Response of CoC 671 to root injury (a. before injury b. root with injury, c. three days after injury, d. 5 days after injury and e. 10 days after injury)

Two varieties *viz.*, Co 99004 and Co 85019 were used to study the effect of Poly Ethylene Glycol (PEG) on sugarcane in the hydroponic medium. PEG is known to induce desiccation stress in crop plants. PEG 5.0% and 10.0% seemed to be a shock for the sugarcane plants. By 48 hours of treatment in both the doses, the young leaves showed drying and desiccation. The variation in the root morphology appeared not influenced by stress, because as the drying of the leaves were so sudden and thus it could not have affected the morphometric

characters of roots. The proline content in the study varied from 3 to 10 µmoles per gram of fresh tissue in Co 85019 while in Co 99004 it varied from 3 to11µmol g^{-1}. The proline content in the treatments increased more than two-fold. The leaf epicuticular wax content increased from control (1µg cm^2) to treatment (4 to 5 µg cm^2) in both varieties. The peroxidase activity increased in both the varieties (Co 85019 and Co 99004) from control to treatment by two fold. It was observed that the root peroxidase activity was slightly higher than the leaf activity.

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

Development and promotion of tools and machinery for sugarcane mechanization

Performance evaluation of IISR model disc type ratoon management device: IISR model disc type ratoon management device and IISR model two row trench type sugarcane cutter planter were purchased from ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow with the collaboration of AICRP (Farm Implements and Machinery), Agricultural Machinery Research Centre (AMRC), Tamil Nadu Agricultural University, Coimbatore (Fig. 35). IISR model disc type ratoon management device was tested and evaluated at ARC, TNAU. A modification in the PTO shaft of the RMD unit was done to mount the unit smoothly with tractor for the efficient functioning of the machinery. The device was used to perform stubble shaving and off-baring in the ratoon crop (Fig. 36) in the Institute. The field identified was made into two blocks and the first block was subjected to stubble shaving and off-baring using the RMD device. In the second block, stubble saving and off-barring were performed manually. The sprouting of the ratoon crop is under observation and the trial is in progress.

Fabrication of manually operated sugarcane settling planting tool: Fabricated manually operated sugarcane settling planting tool to plant sugarcane settlings in the field in standing posture. The tool is made up of stainless steel with a delivery pipe, hand lever and a jaw. The operator can stand straight (no need to bend down) for planting the settling making the process easy. Settlings are gently pulled manually from the protray and dropped from the opening provided at the top of the delivery pipe. The settling can be planted by opening the jaw provided at the bottom by operating the hand lever.

Fig. 35. Evaluation of IISR-Sugarcane Cutter Planter at TNAU, Coimbatore

Fig. 36. Field evaluation of IISR-Ratoon Management Device at ICAR-SBI, Coimbatore

(T. Arumuganathan, C. Palaniswami and V. Venkatasubramanian)

Development of improved planting material of sugarcane by priming with plant growth promoting bacteria and other substances

Free living, root associated and phyllosphere bacteria were isolated from 10 sugarcane varieties. Preliminary cultural and biochemical characterization indicated that these isolates belong to genera *Beijerinkia* (7 Nos), *Derxia* (4 Nos.), *Azotobacter* (4 Nos.), *Azospirillum* (12 Nos.), *Gluconacetobacter* (8 Nos.) and *Methylobacterium*

(9 Nos.). Selected 10 isolates representing *Beijerinkia, Derxia, Azotobacter, Azospirillum, Gluconacetobacter* and *Methylobacterium* isolates @ 0.1% were treated to single bud and bud chips of 10 varieties for 15 m at -200 Hg m^{-1} pressure using sett treatment device. The germination percentage was observed two weeks after planting. The results indicated that Co 86032 has recorded higher germination percentage of 60.1% followed by Co 8371 (58%) and inoculation of *Methylobacterium* had produced vigorous seedlings than other isolates. Preliminary studies were done on the effect of 26 isolates on tissue culture rooted plants of Co 86032 in the hardening stage. The results at 45 days after planting indicated a differential response of isolates for root length, root weight and shoot weight. Twelve isolates recorded higher root length, five for root weight and six for shoot length compared to control.

(K. Hari, P. Geetha, G.S. Suresha, P. Malathi, D. Neelamathi and N. Rajendra Prasad)

Weed management in sugarcane under wide row planting

The study aims at evaluation of pre, post and combination of pre and post-emergence herbicides for efficient weed management in sugarcane under wide row planting. A field experiment was conducted during March 2017 in randomised complete block design with 13 treatments replicated thrice. Treatments were (1) Atrazine 1.5 kg ha^{-1} pre emergence (3 DAP) fb 2,4-D amine 1.0 kg ha^{-1} 60 DAP, (2) Ametryne 2.4 kg ha^{-1} PE (3 DAP) fb 2,4-D amine 1.0 kg ha^{-1} 60 DAP, (3) Ametryne 2.4 kg ha^{-1} EPOE 20 DAP, (4) Ametryne 2.4 kg ha^{-1} + 2,4-D amine 1.0 kg ha^{-1} 20 DAP, (5) Ametryne 2.4 kg ha^{-1} EPOE (20 DAP) fb 2,4-D amine 1.0 kg ha-1 60 DAP, (6) Ametryne 2.4 kg ha^{-1} + 2,4-D amine 1.0 kg ha^{-1} 20 DAP fb HW 60 DAP fb Metribuzin 1.25 kg ha^{-1} + 2, 4-D amine 1.0 kg ha^{-1} after earthing up, (7) Ametryne 2.4 kg ha^{-1} EPOE at 20 DAP fbHW 60 DAP, (8) Ametryne 2.4 kg ha^{-1} EPOE at 20 DAP fb Metribuzin 1.25 kg ha^{-1} + 2, 4-D amine 1.0 kg ha^{-1} 60 DAP, (9) Topramezone 21.0 g ha^{-1} + Atrazine 250 g ha^{-1} EPOE (20 DAP) fb 2,4-D amine 1.0 kg ha^{-1} 60 DAP, (10) Topramezone 25.2 g ha^{-1} + Atrazine 250 g ha^{-1} EPOE (20 DAP) fb 2,4-D amine 1.0 kg ha^{-1} 60 DAP, (11) Topramezone 29.4 g ha^{-1} + Atrazine 250 g ha^{-1} EPOE (20 DAP) fb 2,4-D amine 1.0 kg ha^{-1} 60 DAP, (12) Three hand weedings at 30, 60 and 90 DAP and (13) Unweeded control. The mean germination in all the plots at 45 DAP was less than 40.0 per cent due to adverse weather. All the herbicides at the tested dose did not exhibit any phytotoxic symptoms in sugarcane variety Co 86032. Major weed flora observed in the field was *Datura metel, Digera muricata, Cleome gynandra, Parthenium hysterophorus, Amaranthus spinosus, Trianthema portulacastrum, Cyperus rotundus and Cyanadon dactylon*. The observations on weed parameters at the early stage of the crop growth showed that herbicides tested gave good control of broad leaved weeds. There was profuse growth of grassy weeds particularly *Cyanadon dactylon* during second flush of weed growth and *Cyanadon dactylon* dominated over sugarcane. None of the herbicides tested was effective in controlling *Cyanadon dactylon*. For controlling *Cyanadon dactylon*, directed spot application of glyphosate using hooded nozzle (7.5 ml per litre of water) was found effective.

(S. Anusha and P. Geetha)

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

Capturing of field images of sugarcane crop using drone and processing of field images using MATLAB software: A Quadcopter Drone (DJI-Phantom 3 model with 4K resolution – FC 330X camera) was used to capture the field images of the sugarcane crop leaves. The drone was allowed to hover around the different fields at the Institute and images of healthy sugarcane leaf and sugarcane leaf with red rot disease symptom were recorded. The field images of the sugarcane leaves were processed using

MATLAB software for defining the colour value through RGB values, L*a*b* values, Hue saturation value (HSV) and YCbCr values to clearly distinguish the red rot disease symptom leaves from healthy one based on the digital colour value. RGB values (R 90 to 200, G 110 to 210, B 75 to 200), L*a*b* values (50 to 70, -25 to 0, 0 to 25), Hue Saturation Value (S 0.2 to 0.3, V 0.4 to 0.7) and YCbCr values (Y 100 to 200, Cb 110 to 130, Cr 110 to 130) were recorded for normal/healthy sugarcane leaf images.

In red rot disease symptom, RGB values (R 60 to 200, G 60 to 210, B 50 to 150), L*a*b* values (30 to 80, -40 to +40, -10 to 40), Hue saturation value (S 0.1 to 0.4, V 0.4 to 0.5) and YCbCr values (Y 20 to 200, Cb 100 to 130, Cr 100 to 170) were obtained through image processing of red rot disease affected leaf images (Fig. 37).

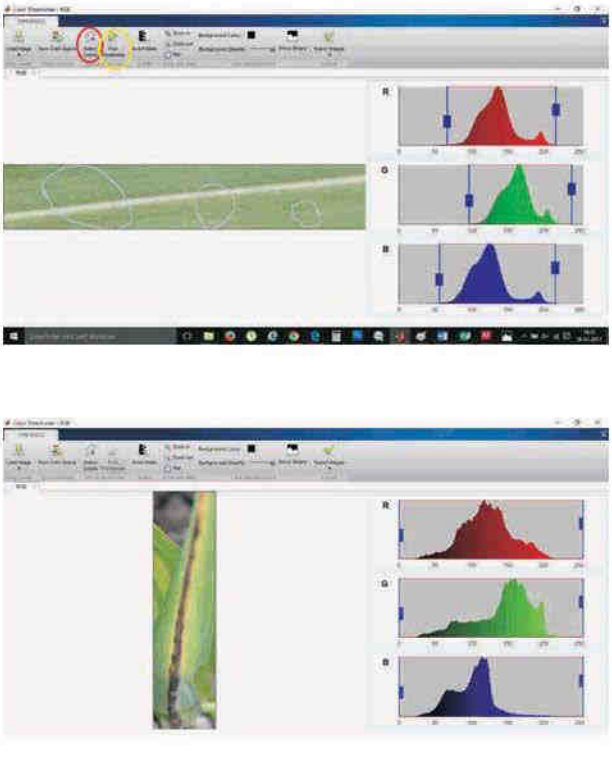


Fig. 37. Image processing in MATLAB Software

Determining the vegetation index / indices for field images of sugarcane crop captured using multispectral spectral camera equipped with the Drone: The vegetation indices namely Normalized Difference Vegetation Index (NDVI), Normalized Difference Red Edge Index (NDRE) and Optimized Soil Adjusted Vegetation Index (OSAVI) for field images of sugarcane crop captured using multispectral camera (Mica Sense- Red Edge) equipped with Drone (DJI- Inspire 1) were mapped using the softwares PIX4D and MICA SENSE-ATLAS. The NDVI algorithm takes advantage of the fact that green vegetation reflects less visible light and more near-IR, while sparse or less green vegetation reflects a greater portion of the visible and less near-IR. The range of values obtained is between −1 and +1. Only positive values correspond to vegetated zones; the higher the index, the greater the chlorophyll content of the target. NDRE is an index that can only be formulated when the red edge band is available in a sensor. High values of NDRE represented higher levels of leaf chlorophyll content than lower values. Soil typically has the lowest values, unhealthy plants have intermediate values, and healthy plants have the highest values. OSAVI maps variability in canopy density and it is robust to variability in soil brightness. This index is best used in areas with relatively sparse vegetation where soil is visible through the canopy and where NDVI saturates (high plant density). The soil adjustment coefficient (0.16) is selected as the optimal value. OSAVI values can range from -1 to 1. High OSAVI values indicated denser, healthier vegetation whereas lower values indicated less vigour (Fig. 38).

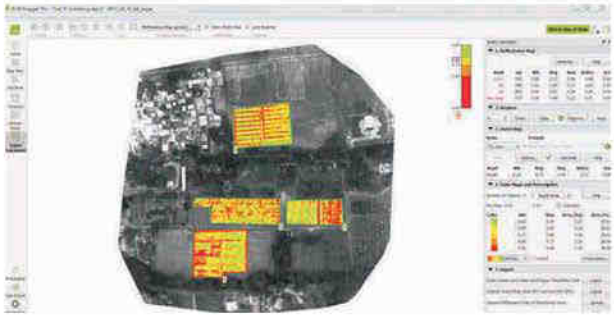


Fig. 38. NDVI map of selected sugarcane fields at ICAR-SBI, Coimbatore

(T. Arumuganathan, A. Bhaskaran and P. Malathi)

5.2.2 PLANT PHYSIOLOGY

Enhancing physiological efficiency of sugarcane

Evaluation of physiological efficiency of commercial hybrids and species clones of *Saccharum* for water use under water limited conditions

A field trial was conducted in a split plot design with two replications and 33 varieties, main plot being irrigation treatments and varieties as sub-plot. The irrigation treatments were Control (I_1) - normal irrigation, I_2: 50% reduction in irrigation water quantity and I_3: 50% irrigation by reducing number of irrigations. The crop was irrigated normally up to 60 DAP to ensure uniform population. The treatments were imposed after 60 days and continued till harvest.

Soil moisture depletion: During formative phase, soil moisture depletion was recorded on daily basis for a complete irrigation cycle (20 days) in all the treatments. Soil moisture depletion was from 21.8% on day one after irrigation to 11% on tenth day after irrigation in control. In I_2, soil moisture was 20.3% on day one and reduced to 10.1% on tenth day. In I_3, soil moisture on day one after irrigation was 20.7% and on 19th day after irrigation (a day prior to next irrigation) it was 5.2% (Fig. 39). The soil moisture levels in between periods of irrigations indicate the intensity of stress and consequent response of the varieties.

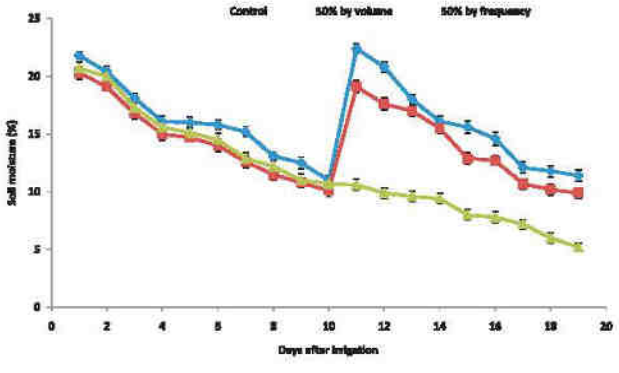


Fig. 39. Soil moisture as influenced by levels of irrigation (Tillering phase)

Physiological traits: Chlorophyll fluorescence, an indirect measure of photochemical efficiency decreased in all the varieties in 50% irrigation treatments (I_2, I_3). Mean chlorophyll fluorescence was 0.746, 0.687 and 0.654 in I_1, I_2 and I_3 respectively. Chlorophyll fluorescence had a positive correlation with water productivity and cane yield (r=0.425) (Fig. 40a).

Canopy air temperature difference (CATD) represents the transpirational cooling effect, varied significantly among irrigation treatments as well as varieties. Canopy air temperature difference showed a significant and positive correlation with yield (r=0.450) (Fig. 40b). Both chlorophyll fluorescence and canopy temperature are adaptive traits shown to respond to moisture stress. Canopy temperature (Tc), is highly sensitive to environmental variables and its dynamics, therefore, is crop-specific.

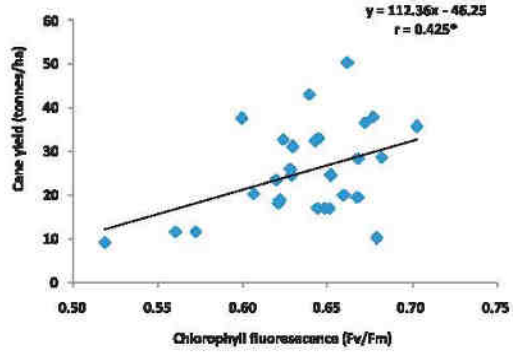


Fig. 40a. Regression curve for chlorophyll fluorescence vs cane yield

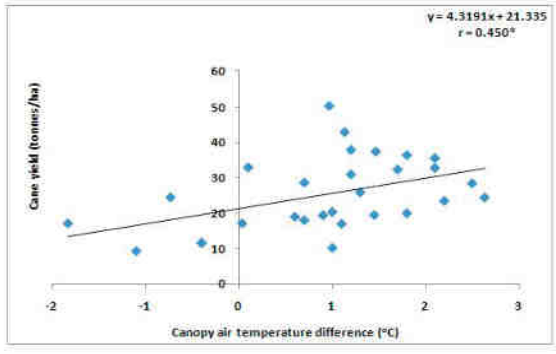


Fig. 40b. Regression curve for CATD with cane yield

Biomass production: The mean total above ground biomass declined by 29% and 41% in I_2 and I_3, at harvest, wherein the reduction in water supplied was 50% and 52% less than control. Reduction by both quantum and frequency of irrigation significantly impacted biomass production. Between the reduced irrigation treatments, I_3 which combined deferred irrigation and reduced volume had severe impact with substantial reduction in biomass production as well as cane yield (Fig. 41). Biomass production at different growth stages *viz.*, formative phase (60-150 days of crop age), grand growth phase (150-240 days of crop age) and maturity phase (240- 360 days of crop age) suggests that I_2 had lesser impact than I_3. The irrigation treatment involving reduced volume at regular frequency seems to facilitate growth and biomass production. Cumulative consumption of water in the individual treatments and overall biomass produced on cane yield basis (dry) further, confirm the above trend.

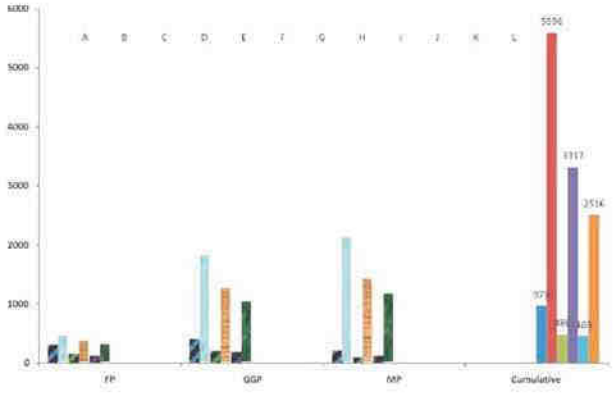


Fig. 41. Water utilized in relation to biomass production. Water utilized (lakh L), biomass g/m²

A-Water I_1, B- Biomass I_1, C-Water I_2, D-Biomass I_2, E-Water I_3, F-Biomass I_3, G-Total Water I_1, H-Total cane yield I_1, I-Total Water I_2, J- Total cane yield I_2, K-Total Water I_3, L-Total cane yield I_3.

Cane yield at harvest: Cane yield varied significantly among varieties as well as irrigation treatments with Co 8371 registering highest mean yield of 58 t/ha followed by Co 85019 and CoLk 8102. Cane yield declined by 41% and 55% in I_2 and I_3 respectively, as compared to control (Table 26). Cane yield reductions were matching with the quantum of reduced irrigation water. Varieties Co 10026, Co 86010, Co 8371, Co 86249, CoLk 8102, Co 99004, Co 85019, yielded high in both the treatments (I_2 and I_3). Twelve varieties recorded higher cane yield than the varietal mean in I_2 suggesting existing varietal potential for exploitation.

Sucrose % juice: The interaction effect of irrigation treatments with varieties was significant for sucrose% juice despite insignificant variation in irrigation treatments alone (Table 26). The decline in sucrose % juice perhaps, is the outcome of slackened sucrose metabolism under reduced water availability. Drying off is a terminal process to reduce vegetative growth and consolidate sucrose, while reduced irrigation supply throughout crop growth stages, affects growth and yield. The slackened physiological and metabolic machinery results in reduced sucrose as well as biomass and therefore economic yield.

Irrigation water use efficiency: Irrigation water use efficiency was more or less similar in I_1 and I_2, implying that the volume of irrigation water has direct influence on cane yield and with reduction of the number of supplemental irrigation, the IWUE also declined (Table 26).

Varieties with improved IWUE have greater scope in sugarcane agriculture, as irrigation water is getting scarce. Co 85019, Co 13006, Co 99004, CoLk 8102, Co 86249, Co 10026 and Co 86010 had improved IWUE by registering significantly higher IWUE than varietal mean in both the reduced irrigation treatments.

In this experiment, IWUE varied from 3.54 t cane ML^{-1} (I_3) to 5.28 t cane ML^{-1} (I_2), the varietal mean for irrigation treatments. Restricted irrigation, atmospheric evaporative water demand and the available soil moisture appeared to influence the WUE of the varieties to a greater extent.

Table 26 . **Cane yield, irrigation water use efficiency, water productivity and sucrose% as influenced by irrigation levels and sugarcane varieties**

Treatments	Cane yield (t/ha)	IWUE (t/ha.cm)	Water Productivity (kg/m^3)	Sucrose (%)
Irrigation levels				
I1 (100%)	54.85	0.455	3.25	14.8
I2 (50% quantity)	32.23	0.448	2.68	13.4
I3(50% Frequency)	24.47	0.349	2.07	12.7
CD at 5%	**5.53**	**0.08**	**0.480**	**NS**
Sugarcane clones				
Co 95020	39.20	0.46	2.88	12.8
CoV 92102	39.00	0.46	2.88	14.2
CoM 0265	37.49	0.41	2.65	13.1
Co 2001-13	37.36	0.41	2.65	12.4
CoC 671	34.29	0.35	2.31	16.2
Co 0218	41.78	0.48	3.05	15.0
ISH 100	34.83	0.38	2.44	12.3
Co 8208	37.96	0.40	2.62	15.9
Co 94008	35.49	0.41	2.59	14.6
Co 62175	39.35	0.44	2.79	12.0
Co 8338	20.99	0.23	1.47	16.7
Co 91010	18.67	0.21	1.33	-
Co 010026	45.74	0.54	3.39	13.8
Co 85002	31.32	0.36	2.26	13.4
Co 86010	40.85	0.48	3.02	15.0
Co740	29.24	0.33	2.12	14.5
Co8371	58.44	0.66	4.18	11.7
ISH 229	24.98	0.29	1.83	10.1
Co 86249	44.68	0.52	3.28	12.7
CoLk 8102	49.64	0.60	3.72	13.8
BO 91	24.99	0.28	1.79	14.3
Co 99004	47.34	0.52	3.36	15.8
Co 775	37.23	0.41	2.63	13.9
Co 013006	43.83	0.49	3.12	13.8
Co 86011	34.26	0.34	2.28	14.6
Co 1148	40.89	0.46	2.93	10.0
Co 8021	37.96	0.40	2.60	13.4
Co 85019	53.09	0.62	3.92	12.3
Co 86032	39.97	0.44	2.81	14.5
Co 0212	47.53	0.53	3.40	14.1
Co 0238	32.72	0.38	2.38	15.3
Co 7717	28.10	0.31	1.99	12.1
Co 419	17.75	0.19	1.24	13.3
CD at 5%	**5.66**	**0.07**	**0.44**	**1.70**

Table 27. **ANOVA table for the response of sugarcane genotypes under limited irrigations**

Factor	df	F value and its probability				
		Cane yield	Sucrose	IWUE	WP	Fv/Fm
Irrigation (I)	2	301.22**	5.97NS	19.49*	55.66*	53.72**
Varieties (V)	32	21.61**	6.92**	18.33**	19.34**	3.96**
IxV	64	8.87**	1.87**	7.74**	7.97**	3.09**

IWUE: Irrigation water use efficiency (tonnes/ ha.cm) and WP: water productivity (kg/ m^3)

df and NS denotes degree of freedom and non significant respectively. * denotes significant at P≤ 0.05 and ** denotes significant at P≤ 0.01

Water productivity: Water productivity declined significantly with restricted irrigation, implying water quantity applied has a direct influence on yield. Among the varieties, Co 8371 registered high mean WP of 4.18 followed by Co 85019 (3.92), while in I_2, six varieties had significantly high WP (Co 85019, Co 0212, Co 86249, Co 10026, Co 0218 and CoV92102) of above 4. Varietal mean for water productivity was 3.2, 2.7 and 2.1 in control, I_2 and I_3 respectively. Yield reductions in response to reduced irrigation water appear to be high and not proportional to irrigation water used in the treatments (I_2 and I_3). However, some of the varieties (Co 8371, CoLk 8102, Co 85019) recorded high yield for the water consumed in I_2, I_3, while many varieties registered high WP in reduced irrigation treatments (Table 26). Due to recent droughts (2014-17) experienced in peninsular India, research focus is shifted towards IWUE and WP and in this regard, the varieties which yield high with the little available water assume importance. Among the traits, cane yield, IWUE, WP and fv/fm showed significant variability to irrigation treatments as well as among the varieties studied (Table 27). Sucrose % juice at harvest varied significantly among varieties and not among irrigation treatments.

Varietal response to reduced irrigation: The varieties used in the study are promising types with high yield and sucrose content, released during different time period. Varieties viz., Co 8371, Co 85019, Co 86010, Co 86249, Co 95020, Co 99004, Co 10026, Co 13006 and CoLk 8102 with higher cane yield, juice sucrose %, biomass and IWUE have potential to perform well in water limited conditions with better water productivity. Among the growth and physiological traits, chlorophyll fluorescence, canopy temperature and biomass production responded sharply to the limited water situations.

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

Evaluation of MIDAS on yield and quality of sugarcane

Shoot population: Shoot population during formative phase (up to 150 days) ranged from 1.91 lakhs/ha to 2.35 lakhs/ha respectively in control and T_4 (Table 28). The same trend was observed at grand growth stage also. The improvement in stalk population was significant among treatments. Both chlorophyll content and chlorophyll fluorescence ratio varied significantly among the treatments. Perhaps the prolonged moisture deficit and atmospheric drought influence variation in chlorophyll fluorescence, which is a common physiological response observed in drought conditions. Total biomass (dry matter production) showed significant improvement at maturity phase (300 days), while variation in LAI was not significant. Biomass (dry) drastically reduced in ratoon crop as compared to plant crop (about 50.0%) reduction) throughout the crop cycle due to general water deficit and high atmospheric VPD.

Table 28. **Shoot population, biomass and LAI during different growth stages**

Treatments	Shoot population (no/ha)		Biomass (kg/m^2)		LAI	
	Formative Phase	Grand Growth Phase	Formative Phase	Maturity Phase	Formative Phase	Maturity Phase
Control	191481	146667	1.49	3.40	2.5	4.2
T1	207037	153333	1.99	3.90	2.7	5.3
T2	222593	170000	2.18	4.50	3.1	4.7
T3	229259	150000	2.04	4.10	2.5	5.1
T4	235926	183333	1.85	5.50	2.0	4.9
SEd	7100	5375	0.330	0.281	0.485	0.348
CD	16373	18035	(NS)	0.648	(NS)	(NS)

Harvest data: NMC and cane length significantly varied among the treatments (Table 29). NMC was higher than plant crop; however, the cane characteristics were adversely affected. Cane yield ranged from 53.9 (t/ha) in control to 63.02 (t/ha) in T_4. The percentage improvement over control was from 3.37 to 9.12% (T_4). In general, there was drastic reduction in cane yield as compared to plant crop (approximately 50%). This could be attributed to the severe water deficit situation experienced during early growth stages of the crop, i.e. up to the month of May 2018. Mild showers in June and July gave a relief. Despite the crop was under subsurface drip, the bore wells suffered near drying conditions making irrigations a tough task. Sugar yield (calculated) showed an improvement of 2t /ha due to treatment.

Table 29. **Harvest data of ratoon crop**

Treatments	NMC/ha	Cane yield (t/ha)	%change over control	Sugar yield (t/ha)
Control	150000	53.90	-	7.21
T1	166667	57.27	3.37	7.49
T2	186667	58.31	4.41	7.28
T3	156667	60.81	6.91	8.60
T4	200000	63.02	9.12	9.27

Juice quality analysis: Juice analysis during ripening phase showed insignificant variation among treatments at 10th month of age (Table 30). Perhaps the late rains experienced during the season have influenced the vegetative growth and reduced the pace of ripening process. However, at 12th month the full sucrose built up was realized with T_4 recording highest sucrose %. The improvement in juice sucrose % was significant among treatments.

Table 30. **Juice quality of ratoon crop**

Treatments	Juice quality at 10th month				Juice quality at harvest*			
	Brix (%)	Sucrose (%)	Purity (%)	CCS (%)	Brix (%)	Sucrose (%)	Purity (%)	CCS (%)
Control	13.96	12.55	89.99	8.75	22.31	19.46	87.26	13.38
T1	14.06	11.97	85.15	8.13	21.81	19.03	87.23	13.08
T2	13.86	11.04	79.60	7.23	21.14	18.25	86.36	12.48
T3	13.73	10.71	78.00	6.94	22.64	20.30	89.69	14.14
T4	15.10	12.78	84.44	8.65	23.48	21.09	89.87	14.71
SEd:	0.872	1.028	3.195	0.824	0.407	0.398	0.789	0.304
CD:	(NS)	(NS)	(NS)	(NS)	0.93	0.91	1.8	0.70

*(p> 0.05%)

Crop growth rate: Crop growth rate was higher in all the treatments at different stages over control. CGR ranged from 6.5 to 7.8 in control, while in T_4 CGR slackened in the formative phase and increased to a high of over 12g/day. The biomass partitioning at harvest suggests a higher allocation to leaf and sheath, reduces biomass for stalk. In most of the treatments the higher biomass towards leaf and sheath indicates either incomplete ripening /maturation. In contrast, plant crop has shown improved partitioning in treatments with more dry matter in stalk as compared to control. Perhaps this one single trait that is shift in biomass partitioning favors higher yield. The MIDAS-Seaweed concentrates improved cane yield and also sucrose% juice in plant as well as ratoon crop of sugarcane variety Co 86032. Among the four treatments involved, T_4-MIDAS at 2.5l/ha each at 100 days, 70 days and 30 days before harvest improved yield as well as sucrose percent.

(S. Vasantha and D. Puthira Prathap)

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

RNA extraction and mRNA library construction: Based on physiological and biochemical assays, Co 99004 was selected as heat stress tolerant sugarcane variety. Meristematic tissues were collected from three pots (one pot/replicate) of both control and treated samples at formative phase of the crop (150 days). These samples were considered as one biological replicate, immediately frozen in liquid nitrogen and then stored at -80°C for total RNA isolation. Transcriptome sequencing was carried out using IlluminaHiSeq 2500 platform at Sci Genome Labs Private Limited, Kerala.

cDNA library construction and Illumina sequencing: The integrity and the concentration of the total RNA was determined by Nanodrop spectrophotometer and the A_{260}/ A_{280} ratio was calculated to confirm the purity of RNA. For cDNA library construction, the mRNA was fragmented into small pieces using divalent cations at elevated temperature. The cleaved RNA fragments were used for cDNA synthesis. These cDNA fragments were processed by end repair process by addition of a single 'A' base and ligation of the adapters. The product was purified and enriched with PCR to create the final cDNA library. After constructing libraries, they were sequenced on IlluminaHiSeq 2500 platform. Integrity Number (RIN) value of this sample was 9.7. If the RIN is greater than or equal to 8 then it is considered to be good quality. The HiSeq 2500 platform was used to generate 5, 52, 40,382 and 3, 16, 72,900 of raw reads. Before the transcriptome

assembly, the QC report was generated based on the base quality score, base composition and GC distribution.

De novo transcriptome assembly: A transcriptome assembly of 1, 42,859 contigs with a mean GC of 49.64% was generated. Approximately 59.6% of the assembled transcripts were ~200 to >5000 bp in length. The redundancies in the assembly were removed by CD-HIT-EST, after which the assembled transcripts were 118,017 sequences with a mean GC content of 49.44%. The longest sequence in the assembled transcriptome was 21435 bp, which had a similarity of (99%) with a protein of Maturase K from *S. officinarum*, the same has been submitted in NCBI and acquired an accession number (NCBI Acc. No. 49659490). Transcript of length >= 200 bp were considered for transcript expression estimation and annotations.

Differential gene expression analysis and identification of plant metabolic networks: The transcripts with different level fold changes of fragments per kilobase million (FPKM) in response to high temperature stress were compared to FPKM value of the control sample. More than 2 fold changes and adjusted *p* value $p<0.05$ of were identified as differentially expressed genes by DeSeq database. The plant metabolic pathway analysis was performed based on PMN database.

Functional Annotation of transcripts: The assembled transcripts were annotated using in-house pipeline CANoPI. The transcripts were blasted against –NR NCBI database and then functionally annotated through gene ontology annotation, pathway annotation, and gene and protein annotation, organism annotation. The assembled mRNA was queried to non-redundant protein database from NCBI and checked for similarity to existing known protein from various plant genomes. The top hit species for each transcript revealed 36,364 (71.5%), 5,495 (10.8%), 3,752 (7.37%) and 1,192 (2.34%) assembled transcripts were aligned to *Sorghum bicolor, Zea mays, Setaria italica* and *Oryza sativa* subsp. *japonica* respectively. Due to the unavailability of sugarcane genome and gene sequences in public databases, we found only 590 (1.15%) transcripts were mapped to *Saccharum* species. These transcripts were categorized into 'biological process', 30,070 (66.5%), 'molecular function', 43,815 (96.9%) and 'cellular components' 28,367 (62.7%) (Fig. 42 - 44).

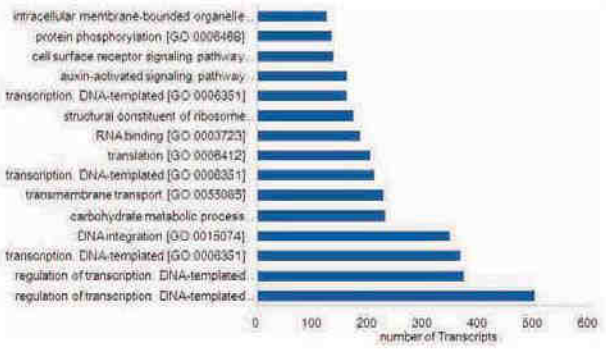


Fig. 42. Top 15 terms in biological process category from GO annotation

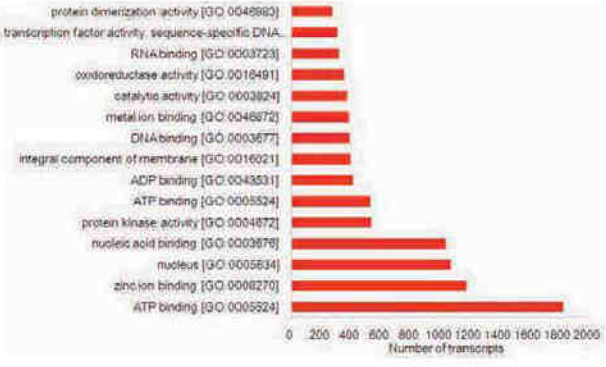


Fig. 43. Top 15 terms in molecular function category from GO annotation

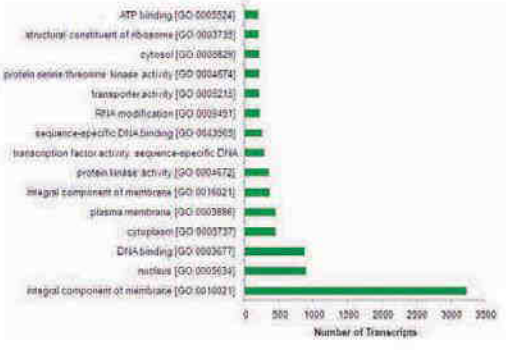


Fig. 44. Top 15 terms in cellular component category from GO annotation

The clusters of orthologous groups (COG): A total of 6901 (5.84%) transcripts were annotated and classified into 50 functional categories according to their putative functions. The most of the transcripted grouped under 4692 (67.9%) hypothetical/unknown function or with no similarities to previously reported sequences/ genes, denoted as with 'S', which indicates the presence of putative novel genes that are reported here for the first time and may be specific to sugarcane.

KEGG orthology classification: From the KEGG annotated transcripts, 4,247 transcripts were grouped into KEGG biochemical pathways (Fig. 45). Major KEGG biochemical pathways groups were 'Genetic Information Processing' (1,603 transcripts), 'metabolism' (1,248 transcripts), 'Cellular processes' (689 transcripts) 'Environmental Information Processing' (599 transcripts), and 'Unclassified' (108 transcripts). Among the categories, 37.7% transcripts were grouped in the genetic information processing which included folding, sorting and degradation, translation, transcription and replication and repair. The second largest percentage of transcripts was distributed in 'metabolism' (29.38% transcripts) and it was grouped into various sub categories such as carbohydrate metabolism, amino acid metabolism, energy and lipid metabolism and so on. 'Cellular processes' is one of the major KEGG biochemical pathways, 16.22% transcripts were classified under this category.

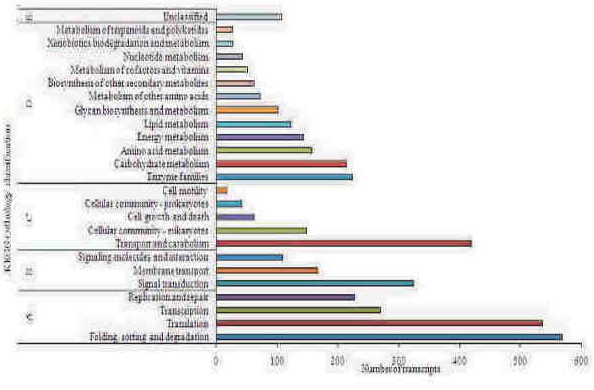


Fig. 45. KEGG orthology classification

Gene expression analysis: Identified the up regulated genes detected in the treatment and control were clearly separated in hierarchical clustering analysis. Hierarchical clustering of DE transcripts associated with metabolic pathways, biosynthesis of secondary metabolites, carbon metabolism, glyoxylate and dicarboxylate metabolism, glycine, serine and threonine metabolism, alanine, aspartate and glutamate metabolism, glycolysis/ gluconeogenesis, carbon fixation in photosynthetic organisms, pyruvate metabolism and so on (Fig. 46-48). Further, these results proved that the thermo-tolerance diversity between treated and control was regulated by tolerant genes.

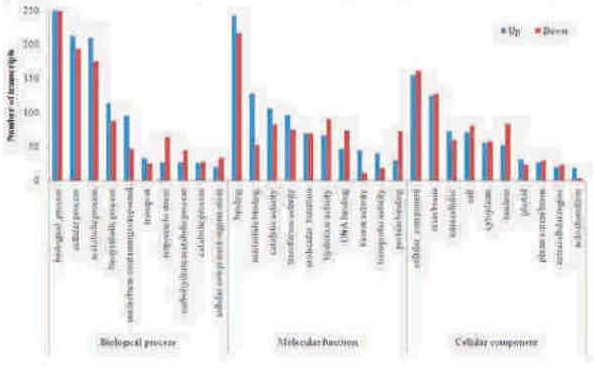


Fig. 46. GO term distribution of differentially expressed Up and Down regulated transcripts

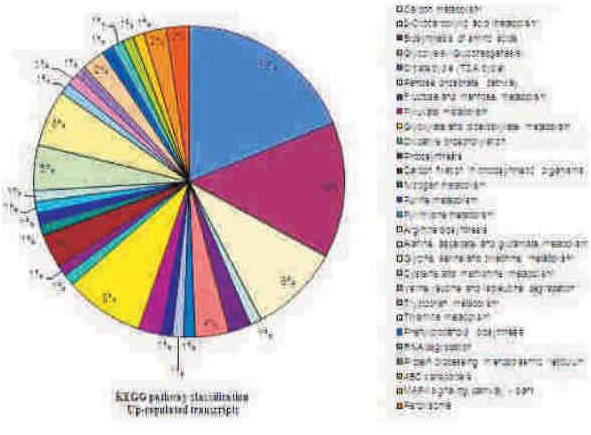


Fig. 47. KEGG pathway classification differentially expressed up regulated transcripts

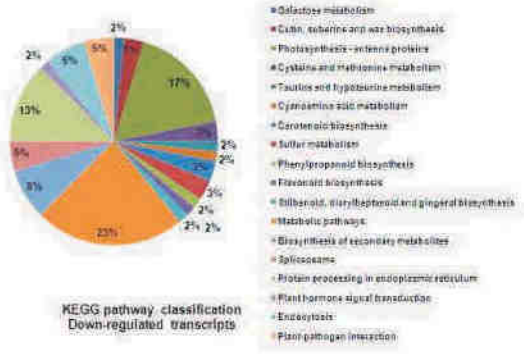


Fig. 48. KEGG pathway classification differentially expressed down regulated transcripts

2-DE results: Based on the physiological and biochemical analysis results, Co 99004 (heat tolerant), Co 0315 (susceptible) and SES 150 (wild) were selected for the 2-D gel electrophoresis. Total proteins were extracted from sugarcane meristematic tissues; both qualitative and quantitative difference were observed in SDS-PAGE (1D) and Bradford assay respectively. The SDS-PAGE (1D) analysis showed discrete banding pattern, free from any contaminants that might interfere in 2-DE study. SDS-PAGE (1D) also showed unique banding pattern for different treatments. About five additional bands were observed in the heat resistant sample when compared to control. Thus, the quality of the extracted proteins samples were confirmed and subjected to 2-DE analysis.

A total of 306, 352, 296, 332, 300 and 328 protein spots were detected in 2-DE gel from Co 99004 (Heat tolerant), Co 0315 (susceptible) varieties and SES 150 (Wild) species of control and treated respectively. A total of 23 differentially expressed proteins were up-regulated when crop exposure to high temperature stress while reaming 23 spots down regulated under heat stress condition.

Proteins up-regulated at heat stress: Out of 46 differentially expressed proteins, 23 proteins were up-regulated in Co 99004 heat tolerant genotypes and it included 11 proteins newly expressed under heat stress condition. Twenty-three peptide sequences with significant MASCOT scores were identified as previously characterized or hypothetical proteins of tolerant sugarcane genotypes. Twenty-two proteins and one was hypothetical proteins were predicted from SWISS PROT and NCBI database. Under heat stress condition, up-regulated proteins were poly [ADP-ribose] polymerase 2-B, REF/SRPP-like protein cpx, palmitoyltransferase ZDHHC13, Putative F-box/kelch-repeat protein, Putative cyclin-dependent kinase F-2, Thioredoxin O2, BnaC05g49490D, 50S ribosomal protein L16, hypothetical protein, Rhodanese-like domain-containing protein 4, chloroplastic, Dirigent protein, MYB family transcription factor, Protein POLLENLESS 3, putative defensin-like protein 40 and protein TIFY 11d.

Proteins down-regulated at heat stress: Among the differentially expressed proteins, 23 proteins down regulated at heat stress condition. All the peptide sequence with significant MASCOT scores was homologous to previously characterized proteins of sugarcane genotypes. The proteins down regulated under heat stress condition were transcriptional regulator HosA, cytochrome c oxidase copper chaperone 1, protein phosphatase 2C, dihydroflavonol-4-reductase, probable F-box protein, peroxidase 1, auxin-responsive protein, RNA polymerase sigma factor sigE, chloroplastic/mitochondrial, anexin D7, serine/threonine-protein kinase, GCK-like protein, stress-response A/B barrel domain-containing protein and dolichyl-diphospho oligosaccharide - protein glycosyl transferase subunit STT3B. Twenty-one were predicted proteins and two were hypothetical proteins were predicted from SWISS PROT and NCBI database.

Gene ontology (GO) terms of DE proteins: On the basis of Gene Ontology (GO) analysis, 23 up regulated proteins were categorized into 43 GO functional subcategories, which were summarized into three main categories: cellular process, metabolic process and biological process were most abundantly represented with 22, 18 and 10 proteins,

respectively. 3D structure of ten up regulated proteins and its C-terminal, N-terminal end, ligands and conserved domains were predicted by fully automated protein structure homology-modeling server-Swiss Model, accessible *via.,* Expasy web server and NCBI database respectively (Fig. 49-51).

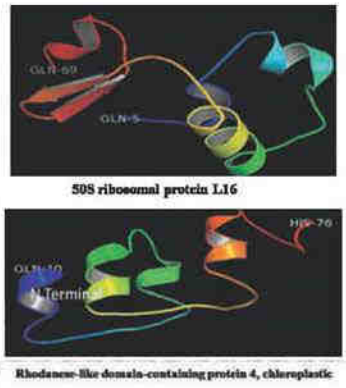


Fig. 49. 3D structure of 50S ribosomal protein and Rodanese like domain containing protein

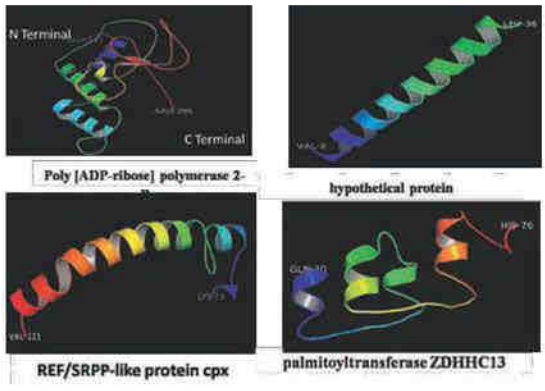


Fig. 50. 3D structure of polymerase, hypothetical, REF & SRPP proteins

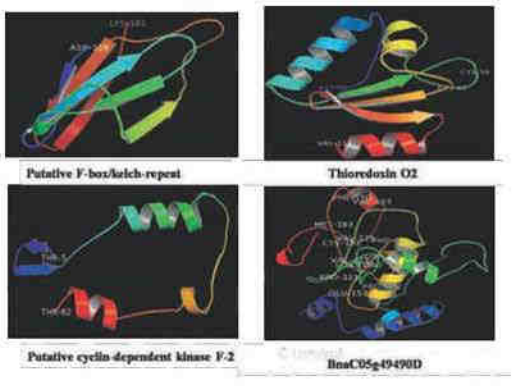


Fig. 51. 3D structure of F-box kelch, thioredoxin, KinaseF-2 and BnaC05g4949OD

(R. Gomathi)

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

Plant crop: The results of the study indicated that foliar application of seaweed formulations significantly improved the shoot population (15.9%), plant height (23.7%), LAI (25.1%), SPAD value (19.6%) and total dry matter production (TDMP) (19.9%) compared to control plants at GGP. The seaweed extract formulations of LBS 6 @ one ml/L recorded comparatively higher yield attributes *viz.,* internodes length (24.7%), cane length (26.2%), cane thickness (16.2%), single cane weight (10.0%) and cane yield (105.5 t./ha.) compared to control. It was found that sugarcane cane yield was increased significantly by 23.5% over control. This treatment also recorded higher economic net returns (Rs. 1, 13,702. ha-1) and benefit cost ratio (1.60).

Ratoon crop: The effect of seaweed formulations on the growth and development, quality and yield response of ratoon sugarcane of Co 86032 was evaluated by conducting field experiment at Bannari Amman Sugar Factory, Sathiamangalam. The results of the study indicated that, foliar application of seaweed formulations significantly improved shoot population (12.3%), plant height (21.2%), LAI (33.2%), SPAD value (10.3%) and total dry matter production (TDMP) (26.4%) compared to control plants at GGP. However, the juice quality parameters with respect to brix%, sucrose%, purity% and CCS % were recorded at 10th and 12th months of ratoon crop and results showed that treatment influence was found to be non significant. The seaweed extract formulations of LBS 6 @ one ml/L also recorded significantly higher yield attributes *viz.,* internodes length (12.8%), cane length (7.5%), cane thickness (6.1%), single cane weight (6.8%) and cane yield (154.9 t./ha) compared to control. It was found that ratoon sugarcane cane yield was increased significantly by 19.1% over the control. This treatment also recorded higher economic net returns (Rs. 2, 43,706. ha^{-1}) and benefit cost ratio (2.23) (Tables 31-33).

Table 31. **Effect of seaweed biostimulant formulations on growth parameters at different stages of ratoon sugarcane**

Treatments	Shoot population (000' ha^{-1})			Plant height (cm)			Leaf area index (LAI)			SPAD value			Total dry matter production (TDMP) (t/ha^{-1})		
	FP	GGP	NMC	FP	GGP	MP	FP	GGP	MP	FP	GGP	MP	FP	GGP	MP
LDB @ 1 ml/L	162.5	139.2	131.1	122.9	189.3	241.6	3.55	4.34	4.05	37.7	40.6	37.1	38.9	52.3	69.9
LDB @ 0.5 ml/L	158.9	132.7	128.6	118.1	171.4	234.0	3.18	3.31	3.24	36.9	40.1	35.7	26.4	51.1	65.6
LBS 6 @ 1 ml/L	164.6	143.0 (12.3%)	140.7 (11.49%)	125.0	190.3	253.0 (21.2%)	3.73	4.40	4.21 (33.2%)	39.3	42.1	38.4 (10.3%)	41.0	62.1	81.3 (26.4%)
Absolute control	151.6	127.2	126.2	102.5	156.8	208.8	3.07	3.29	3.16	35.7	38.2	34.8	25.3	46.1	64.3
Mean	159.4	135.5	131.6	117.1	176.9	234.3	3.38	3.83	3.66	37.4	40.2	36.5	32.9	52.9	70.2

Table 32. **Effect of seaweed biostimulant formulations on yield attributes and juice quality parameters of ratoon sugarcane**

Treatments	No. of internodes	Internodes length	Cane length (cm)	Cane thickness (mm)	Single cane weight (kg)	Brix (%)	Sucrose (%)	Purity (%)	CCS
LDB @ 1 ml/L	24.4	11.0	267.1	40.6	1.04	21.2	18.7	88.6	13.0
LDB @ 0.5 ml/L	24.7	10.4	256.3	39.9	1.03	19.7	16.9	86.2	11.6
LBS 6 @ 1 ml/L	23.8	11.4 (12.8%)	271.8 (7.5 %)	41.8 (6.1%)	1.10 (6.8%)	21.3	19.0	89.3	13.2
Absolute control	25.1	10.1	252.9	39.4	1.03	19.2	16.2	84.3	10.9
Mean	24.5	10.7	262.0	40.4	1.05	20.3	17.7	87.1	12.2

Table 33. **Effect of seaweed biostimulant formulations on cane yield and economics of ratoon sugarcane**

Treatments	Cane yield (t/ha)	Cost of cultivation (Rs. ha^{-1})	Cost of product and spraying charges (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
LDB @ 1 ml/L	135.7	185240	3100	386712	201472	2.09
LDB @ 0.5 ml/L	133.0	183020	2650	378952	195932	2.07
LBS 6 @ 1 ml/L	154.9 (19.1%)	197718	3100	441424	243706 (26.9%)	2.23 (7.21%)
Absolute control	130.0	178425	0	370423	191998	2.08

(R. Gomathi)

Radiation use efficiency of sugarcane genotype as influenced by water levels and crop geometry

An experiment was conducted in ICAR-SBI during 2016-2017 with 30 sugarcane clones in field conditions under limited irrigation (I_1- Irrigation at 100.0% cumulative pan evaporation, I2-50.0% reduction in volume of water irrigated and I3 -50.0% reduced in frequency). Controlled irrigation was provided to individual varieties and treatment through PVC pipes monitored by water meter. Irrigation was quantified based on pan evaporation, KC value (crop coefficient depending on the age of crop) and area of plots. The total global radiation received during the experimental period (1 December 2016 to 30 November 2017) was 5316 MJ m^{-2}. The cumulative global photosynthetically active radiation (PAR) recorded during the germination phase, formative phase, grand growth phase and maturity phase were shown in Fig. 52. The mean, maximum and minimum daily global solar radiations during the crop period were 348 $Cal.cm^{-2}.d^{-1}$, 478 $Cal.cm^{-2}.d^{-1}$ and 81 $CaLcm^{-2}.d^{-1}$ respectively. Line quantum sensors (LICOR) along with digital data logger (LI-1400) were used to record the light interception and light reflection data during the important phenophases. Also, the biomass was estimated through destructive sampling and the data were used for calculation of radiation use efficiency. Nearly 6.0-8.0% of the PAR reflection was observed from the crop in all the treatments. Genotypes with higher biomass were also recorded with better light interception of more than 70.0% of PAR at maturity phase. Sugarcane under normal irrigated condition showed better light interception compared to limited irrigation. Significant decline in biomass has contributed to the reduction in RUE compared to the light interception under limited irrigated condition.

Among the genotypes, Co 62175, Co 85019, Co 95020, Co 99004 and Co 8371 recorded RUE more than 1.0 g MJ^{-1} under normal condition I_1, while Co 94008, Co 85019, Co 12006, Co 0212, Co 99004 and Co 86249, Co 85019, CoM 0265, Co 13006 and CoLk 8102 were observed with better RUE under limited water condition respectively at I_2 and I_3. Significant correlation was also observed between total intercepted PAR and biomass in all the treatments.

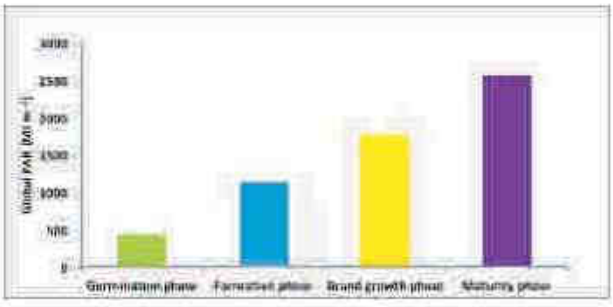


Fig. 52. Cumulative global photosynthetically active radiation (PAR) available for photosynthesis at different phenophases of sugarcane

(R. Arun Kumar and P. Geetha)

5.2.3 SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Natural resource management for enhancing productivity and sustainable sugarcane production

Development of a Decision Support System for sugarcane soil management

The Decision Support System software was updated with a primary module with setup options (Fig. 53) and working DSS module (Fig. 54) was tested on Windows 10 platform. The software was demonstrated to field staff, cane officials and IT personnel of sugar factories and was released for adoption on 12 December 2017 (Fig. 55). Six hundred and seventy soil test results were imported into the Decision Support System, Soil health card and package of practices for sugarcane were generated and sent to the farmers through the sugar factories.

Fig. 53. Primary module of the Decision Support System

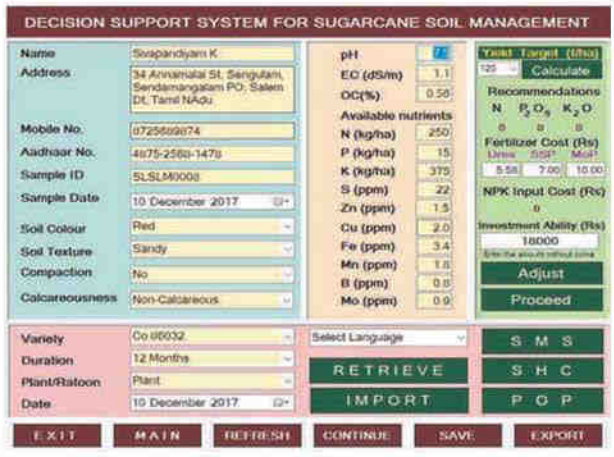


Fig. 54. Working module of the Decision Support System

Fig. 55. Dr.Bakshi Ram, Director, ICAR-SBI releasing the DSS software

A test verification trial which was planted in April 2017 with Co 86032 as the test variety and was harvested in February 2018. The treatments consisted of conventional method of fertilizer application and pocket manuring as two main plots and three fertilizer doses *viz.*, 280:62.5:120; 366:22:56 and 537:80:214 kg $N:P_2O_5:K_2O$/ha each in two (up to 90 DAP at 45 days interval), four (up to 120 DAP at 30 days interval) and six splits (up to 180 DAP at 30 days interval) totalling nine treatments as sub plots in a split plot design. The crop was harvested in February 2018. The NMC ranged between 111111 and 125309/ha but was not influenced by the method of planting and fertilizer doses (Table 34). Pocket manuring gave significantly higher single cane weight (SCW) (0.97 kg) and cane girth (30.16 mm) than conventional fertilizer application (0.89 kg and 27.76 mm, respectively). Increasing dose of fertilizers increased the SCW and cane girth significantly but the number of splits had no effect. The juice quality parameters *viz.*, Brix, sucrose % juice and purity were not influenced by the method of fertilizer application and dose of fertilizers (Table 35). Pocket manuring gave 9.1% higher mean cane yield (114.6 t/ha) than conventional fertilizer application (105.0 t/ha) (Table 36). The highest mean yield of 133.4 t/ha was recorded in 537:80:214 kg $N:P_2O_5:K_2O$/ha applied up to 180 DAP which was on par with the same dose applied up to 120 DAP (131.4 t/ha). Increasing dose of fertilizers and increasing number of split application increased the cane yield significantly. The CCS (%) was not influenced by the treatment but the highest sugar yield of 17.3 t/ha was recorded in 537:80:214 kg $N:P_2O_5:K_2O$/ha applied up to 180 DAP which was on par with the same dose applied up to 120 DAP (17.0 t/ha). The second plant crop was planted in January 2018 with Co 86032 as test variety with same set of treatments in a neutral non saline soil with low N, high P and high K soil. The mean germination at 30 DAP was 57% but was not influenced by the treatments (Table 37). Conventional manuring had the highest number of tillers (148851/ha) than pocket manuring (132579/ha) at 60 DAP. Fertilizer doses did not influence the number of tillers significantly.

Table 34. **Effect of fertilization methods and doses on the NMC, single cane weight and cane girth in first plant crop of sugarcane variety Co 86032 at 10th month**

Treatments	NMC/ha			Single cane weight (kg)			Cane girth (cm)		
	M1	M2	Mean	M1	M2	Mean	M1	M2	Mean
F1-S1	116667	122222	119444	0.67	0.72	0.69	20.36	23.40	21.88
F1-S2	122840	120370	121605	0.70	0.81	0.76	22.60	24.90	23.75
F1-S3	120988	119753	120370	0.75	0.86	0.80	24.77	27.60	26.18
F2-S1	120370	111111	115741	0.84	0.98	0.91	26.17	31.85	29.01
F2-S2	117901	118519	118210	0.90	0.99	0.94	26.76	31.34	29.05
F2-S3	117901	125309	121605	0.92	0.98	0.95	29.38	31.30	30.34
F3-S1	116667	124074	120370	1.07	1.06	1.07	33.74	32.92	33.33
F3-S2	123457	116049	119753	1.06	1.15	1.10	32.53	33.97	33.25
F3-S3	118519	116667	117593	1.11	1.16	1.13	33.57	34.19	33.88
Mean	119479	119342	119410	0.89	0.97	0.93	27.76	30.16	28.96
Source**	M	T	M x T	M	T	M x T	M	T	M x T
SEd	1010	3737	5084	0.003	0.05	0.07	0.30	0.95	1.30
CD (0.05)	NS	NS	NS	0.013	0.10	NS	1.31	1.93	NS

* F1 = 280:62.5:120; F-2= 366:22:56 and F3 = 537:80:214 kg $N:P_2O_5:K_2O$/ha, S1 = 2 Splits (45th and 90th DAP); S2 = 4 splits (30, 60, 90 and 120th DAP) and S3 = 6 Splits (30, 60, 90, 120, 150 and 180th DAP), M1 = Conventional method of fertilizer application; M2=Pocket manuring

** M = Method of fertilizer application; T = Treatments

Table 35. **Effect of fertilization methods and doses on the juice quality parameters in first plant crop of sugarcane variety Co 86032 at 10th month**

Treatments	BRIX			Sucrose (%)			Purity (%)		
	M1	M2	Mean	M1	M2	Mean	M1	M2	Mean
F1-S1	22.0	20.8	21.4	19.8	18.1	18.9	90.1	87.1	88.6
F1-S2	22.1	21.2	21.7	19.6	18.7	19.1	88.4	88.2	88.3
F1-S3	22.0	20.4	21.2	19.7	18.3	19.0	89.5	89.4	89.4
F2-S1	21.6	19.8	20.7	19.6	17.5	18.5	90.8	88.3	89.5
F2-S2	22.5	20.0	21.3	20.1	17.4	18.8	89.3	87.2	88.2
F2-S3	21.9	21.6	21.7	19.5	19.0	19.2	89.2	87.9	88.5
F3-S1	21.9	20.2	21.0	19.4	17.6	18.5	88.4	87.3	87.9
F3-S2	21.2	22.0	21.6	18.7	19.2	18.9	88.2	87.1	87.6
F3-S3	21.8	20.8	21.3	19.7	17.9	18.8	90.6	86.0	88.3
Mean	21.9	20.7	21.3	19.6	18.2	18.9	89.4	87.6	88.5
Source**	M	T	M x T	M	T	M x T	M	T	M x T
SEd	0.49	0.56	0.89	0.58	0.60	0.99	0.67	1.16	1.68
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

* F1 = 280:62.5:120; F-2= 366:22:56 and F3 = 537:80:214 kg $N:P_2O_5:K_2O$/ha, S1 = 2 Splits (45th and 90th DAP); S2 = 4 splits (30, 60, 90 and 120th DAP) and S3 = 6 Splits (30, 60, 90, 120, 150 and 180th DAP), M1 = Conventional method of fertilizer application; M2=Pocket manuring

** M = Method of fertilizer application; T = Treatments

Table 36. **Effect of fertilization methods and doses on cane yield, CCS (%) and sugar yield in first plant crop of sugarcane variety Co 86032 at 10th month**

Treatments	Cane yield (t/ha)			CCS (%)			Sugar yield (t/ha)		
	M1	M2	Mean	M1	M2	Mean	M1	M2	Mean
F1-2 Splits	77.5	85.6	81.5	13.8	12.4	13.1	10.7	10.6	10.7
F1-4 Splits	86.3	96.7	91.5	13.6	12.9	13.2	11.7	12.5	12.1
F1-6 Splits	88.2	101.0	94.6	13.7	12.7	13.2	12.1	12.8	12.5
F1-2 Splits	99.7	109.2	104.4	13.7	12.1	12.9	13.6	13.2	13.4
F1-4 Splits	103.7	115.8	109.7	14.0	12.0	13.0	14.6	13.8	14.2
F1-6 Splits	110.4	125.0	117.7	13.5	13.1	13.3	15.0	16.3	15.6
F1-2 Splits	120.6	127.5	124.1	13.4	12.1	12.8	16.1	15.4	15.8
F1-4 Splits	128.6	134.2	131.4	12.9	13.2	13.0	16.5	17.6	17.0
F1-6 Splits	130.3	136.4	133.4	13.8	12.2	13.0	17.9	16.6	17.3
Mean	105.0	114.6	109.8	13.6	12.5	13.1	14.2	14.3	14.3
Source**	M	T	M x T	M	T	M x T	M	T	M x T
SEd	0.90	3.73	5.05	0.45	0.47	0.77	0.51	0.64	0.99
CD (0.05)	3.87	7.59	NS	NS	NS	NS	NS	1.29	NS

* F1 = 280:62.5:120; F-2= 366:22:56 and F3 = 537:80:214 kg $N:P_2O_5:K_2O$/ha, S1 = 2 Splits (45th and 90th DAP); S2 = 4 splits (30, 60, 90 and 120th DAP) and S3 = 6 Splits (30, 60, 90, 120, 150 and 180th DAP), M1 = Conventional method of fertilizer application; M2=Pocket manuring

** M = Method of fertilizer application; T = Treatments

Table 37. **Effect of fertilization methods and doses on germination and tillering in second plant crop of sugarcane variety Co 86032**

Treatments	Germination (%) at 30 DAP			Tillers/ha at 60 DAP		
	M1	M2	Mean	M1	M2	Mean
F1-2 Splits	59	55	57	152160	127778	139969
F1-4 Splits	59	57	58	145525	127315	136420
F1-6 Splits	58	55	56	141358	141667	141512
F1-2 Splits	59	55	57	156636	124537	140586
F1-4 Splits	60	53	56	146451	124074	135262
F1-6 Splits	60	55	58	149691	157716	153704
F1-2 Splits	60	58	59	142593	121451	132022
F1-4 Splits	58	56	57	146451	135802	141127
F1-6 Splits	59	55	57	158796	132870	145833
Mean	59	55	57	148851	132579	140715
Source**	M	T	M x T	M	T	M x T
SEd	1.70	3.59	5.07	2567	10717	14518
CD (0.05)	NS	NS	NS	11045	NS	NS

* F1 = 280:62.5:120; F-2= 366:22:56 and F3 = 537:80:214 kg $N:P_2O_5:K_2O$/ha, S1 = 2 Splits (45th and 90th DAP); S2 = 4 splits (30, 60, 90 and 120th DAP) and S3 = 6 Splits (30, 60, 90, 120, 150 and 180th DAP), M1 = Conventional method of fertilizer application; M2=Pocket manuring

** M = Method of fertilizer application; T = Treatments

(A. Bhaskaran and C. Palaniswami)

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

An experiment was initiated in April 2017 to study the soil organic carbon dynamics when treated with organic substrates namely trash compost, FYM, vermicompost and biocompost at the rate of carbon equivalent to FYM @ 25 t/ha. The CO_2 flux was measured periodically and plotted (Fig. 56). Control where no organic manure applied showed lower CO_2 flux (µmol/m^2/sec) than organic substrate treatment. Among the substrates, biocompost showed lower CO_2 flux than other substrates throughout except in October 2017 where this treatment showed the highest flux. In January 2018, effect of cropping along with the manure treatment was initiated and planted single bud setts of the variety, Co 86032. The CO_2 flux and the SOC at 45 DAP was recorded. The CO_2 flux at 45 DAP was higher in cropped plot than that of plot without crop. Control plot showed the lowest CO_2 flux and lowest SOC under no crop as well as with crop. Among the manures, FYM showed the lowest flux with and without crop (Fig. 57a and b). The fractionation of organic carbon in the FYM, vermicompost, biocompost and trash compost yielded fulvic acid and humic acid with varying degree of humification. The ratio of absorbance at 465 and 665 nm was analysed to assess the degree of humification. Biocompost showed higher humification than other organic substances.

Effect of gypsum on SOC dynamics was studied using an experiment with 100% GR (gypsum requirement), 50% GR treatment and a control in alkali soil. CO_2 flux in the control (without gypsum) was higher than that of gypsum treatment (Fig. 58). This supports the hypothesis that the application of gypsum in alkali soils as amendment could promote carbon sequestration in the form of $CaCO_3$. The effect of cropping with gypsum treatment was also initiated in January 2018 with the variety, Co 86032. CO_2 flux at 45 DAP was 3.24, 3.94 and 3.51 µmol/m^2/s in cropped plot with gypsum @ 100% GR, gypsum @ 50%GR and no gypsum treatment, respectively. The CO_2 flux as well as the SOC per cent at 45 DAP were higher in cropped plot than that of plot without crop (Fig. 59a and b).

An experiment to study the effect of sugarcane genotypes on soil carbon dynamics was initiated by planting 31 sugarcane genotypes.

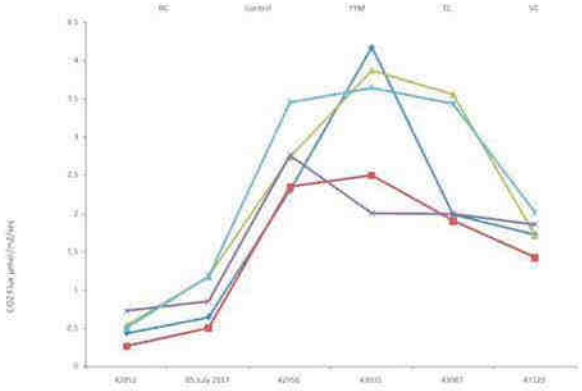


Fig. 56. Variation in CO_2 flux (µmol/m^2/sec) in the organic substrate treated micro-plots during 2017-2018

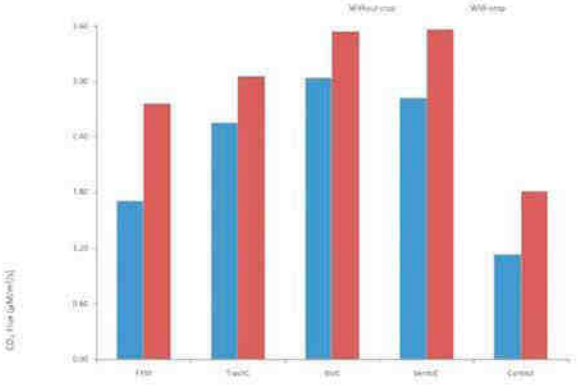


Fig. 57a. Variation in CO_2 flux (µM/m^2/s) in the organic manure treated micro-plots (45 DAP)

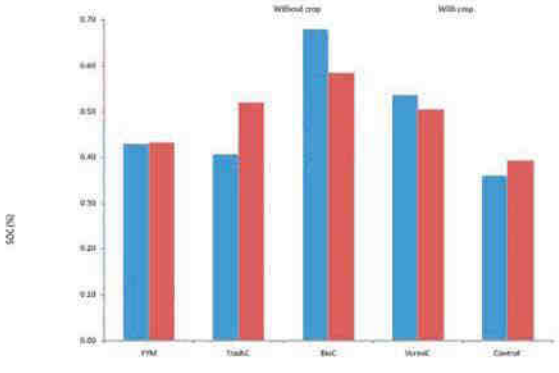


Fig. 57b. Variation in SOC (%) in the organic manure treated micro-plots (45 DAP)

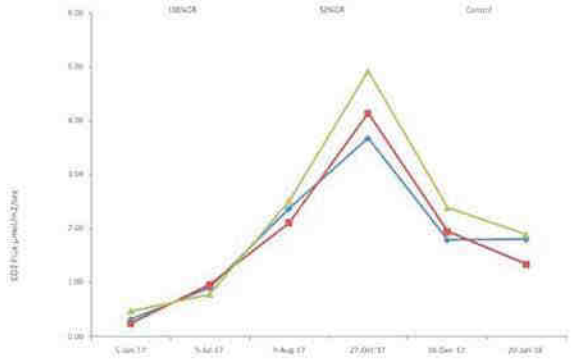


Fig. 58. Variation in CO_2 flux (µmol/m²/sec) in the gypsum treated micro-plots during 2017-2018

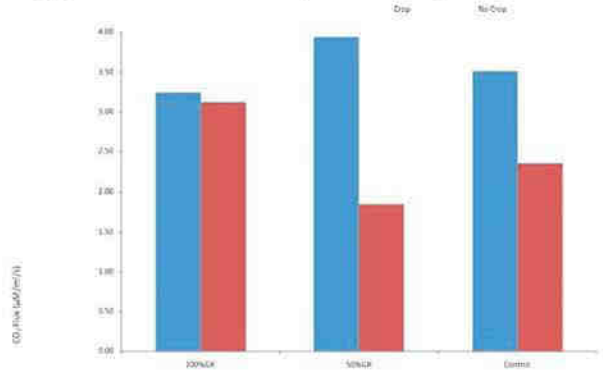


Fig. 59a. Variation in CO_2 Flux (µmol/m²/sec) in the gypsum treated micro-plots (45 DAP)

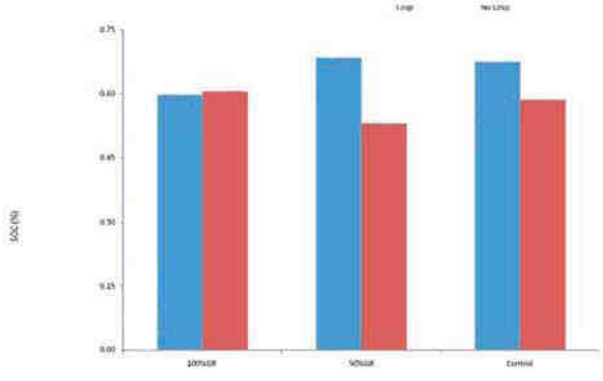


Fig. 59b. Variation in SOC (%) in the gypsum treated micro-plots on (45 DAP)

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

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

Six soil profiles were characterised in Bhavani, Anthiyur and Gobichettipalayam Taluk of Erode District (Fig. 60). Layer-wise samples were collected from each soil profile. The profile in Chinnapallam showed four horizons and parent material was not found at 1.2 m depth. The depth of profile in Vairamangalam was 0.94 m with five horizons and below that parent material was observed. The profile in Sankara goundanpalayam showed four layers and the parent material was reached at 0.75 m. In Brammadesam and Nathipalayam, the soil profiles were very shallow. The profile in Brammadesam showed two layers and the parent material was found at 0.56 m, while in Nathipalayam, three horizons could be observed and the parent material was found at 0.62 m. A deep soil profile was found in Chinnakaliyur with four layers and the parent material was observed below 0.16m. Alkaline reaction was observed in all the layers of soil profiles in Sankara goundanpalayam, Brammadesam, Nathipalayam and Chinnakaliyur. While, pH of all the layers of the soil profiles in Chinnapallam and Vairamangalam was below 8.5 except the layer between 0.22 and 0.36 m in Vairamangalam. All the soils were non-saline. Gravels were absent in the soil layers below 0.4 m depth in Chinnakaliyur profile. Low organic carbon content was observed in all the layers of profiles in Chinnapallam and Brammadesam. High organic carbon was observed in Layer 2 in Vairamangalam, Layers 1 and 2 in Sankara Goundanpalayam, Layer 1 in Nathipalayam. The organic carbon content of Layer 1 and 3 was high, and that of Layer 2 was medium in the profile in Chinnakaliyur. Comparison of penetration resistance with soil depth showed hardening below 10 cm in Brammadesam, below 25 cm in Nathipalayam and below 35 cm in Chinnakaliyur and Vairamangalam with the penetration resistance of around 2 Mpa implying restriction to root growth. Subsurface soil hardening was not found in Sankara goundanpalayam and Chinnapallam. Calcareousness rating of weak to moderate was the observed profiles of Chinnapallam and Vairamangalam, whereas other profiles showed moderate to very strong calcareousness.

A model was developed to predict dry bulk density of soil along the depth of the soil profile using Artificial Neural Network with five input parameters namely, per cent soil organic carbon, clay, sand, silt and soil depth (Fig. 61). The model developed showed Training MSE of 0.126 and Validation MSE of 0.066 (Fig. 62a and b). Analysis of profile samples collected from Perundurai and Sathyamangalam Taluk for available nutrients showed higher available N, P and K in surface horizon than that of other layers in all the profiles except profile no. 3, which showed high available K in the deeper horizons. Cation exchange capacity of soil in different horizons of the four profiles of Sathyamangalam ranged from 7.75 to 19.38 with a mean of 12.40 cmol (p+) kg^{-1}.

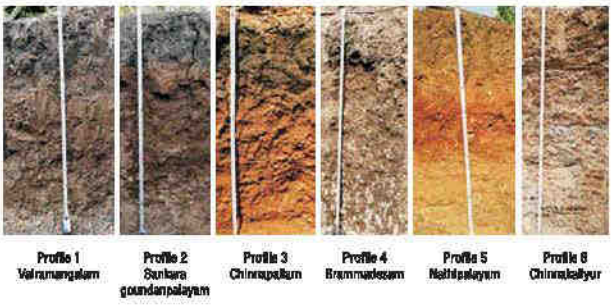


Fig. 60. View of soil profiles excavated in Bhavani, Anthiyur and Gobichettipalayam Taluk of Erode District

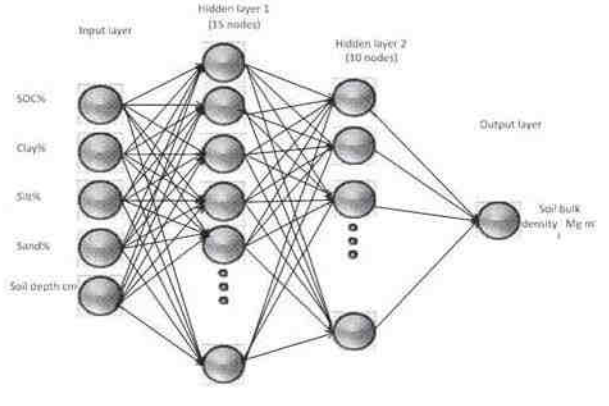


Fig. 61. Neural network with 5 input layers with 2 hidden layers (5 and 10 nodes in Hidden layer 1 and Hidden layer 2, respectively) for soil bulk density prediction

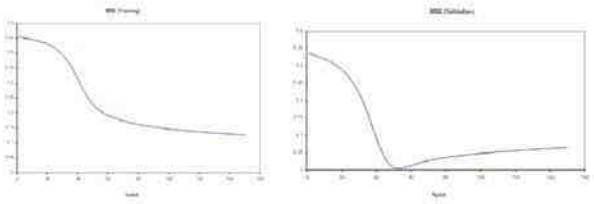


Fig. 62a and b. Validation of ANN model with Mean Square Error comparison

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

Sub-cellular targeting of invertase inhibitory proteins: a novel approach to enhance sucrose yield in sugarcane

In order to study the transient expression of sugarcane invertase inhibitor gene *(ShINH2)*, we developed a gene construct containing *ShINH2* fused with green fluorescent protein (GFP) under the control of maize Ubiquitin promoter. GFP construct of *ShINH2* was bombarded in sugarcane callus cells and examined under fluorescence microscope. Transient expression analysis of GFP fused *ShINH2* revealed that *ShINH2* is vacuolar located protein which is corresponded with the *insilico* analysis where *ShINH2* is having N- terminal signal peptide and predicted to localize in the vacuole (Predisi and SignalP) (Fig. 63a and b). This is the first evidence of cellular location of sugarcane invertase inhibitor *(ShINH2)* protein and provided much scope to regulate vacuolar invertase enzyme to enhance sucrose yield in sugarcane.

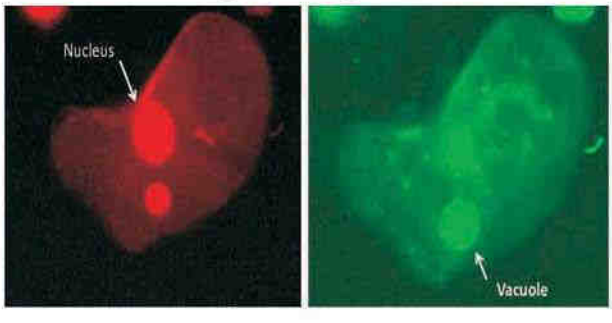


Fig. 63a and b. Transient expression analysis of GFP fused ShINH2

(G.S. Suresha)

5.3. CROP PROTECTION

5.3.1 Plant Pathology

Host resistance, interactomics, pathogen variability, diagnosis and disease management in sugarcane

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: A total of 3075 clones from crop improvement projects and Kannur comprising clonal trials, PZVT, parental clones, GUK/ WL clones, GU clones, germplasm, climate resilient clones and high biomass hybrids were tested for red rot resistance under controlled conditions against CF06 (Cf671) pathotype. About 1598 clones were identified as resistant and moderately resistant to red rot.

Field tolerance to red rot: Impact of debris - borne inoculum of 11 *Colletotrichum falcatum* isolates on germination and further disease development was assessed on 11 varieties under field conditions. The germination data revealed that presence of inoculum near the bud has reduced bud sprouting and caused significant pre-germination death. Untreated control recorded ~73.18% germination whereas in the treated ones, the germination per cent ranged from 34.77 to 55.45 with a mean of 42.54 in different sugarcane varieties. The isolates exhibited a clear cut variation on germination in different varieties. In the presence of inocula, all the varieties recorded significantly less germination. Sett germination was compared with respect to different pathogenic isolates, the isolates *Cf*86032-Srikandapuram and *Cf*06022-Kuthalam caused maximum loss in germination of ~52.17%, whereas the isolate *Cf*0323 - Tirunelveli caused loss of only 24.23% and the other isolates caused loss in germination within this range. The reduction in germination was found to be in the range of 16.57 to 64.90 due to the pathogen inoculum. Among the 11 varieties, Co 0403 and Co 0238 remained free from infection, probably resistant to all the 11 isolates. Co 86032 and Co 0212 had traces of the disease to *Cf*86027 inoculum and similarly Co 11015 had traces of infection from *Cf*06022 and *Cf*86032. The susceptible varieties Co 94012 and CoC 671 had disease infections from many isolates. Similarly, the new varieties Co 06022, Co 06027 and Co 06030 picked the disease for different pathogenic isolates. Overall, Co 06030, Co 94012, CoV 09356 and CoC 671 picked up disease more frequently. The isolates *Cf*86032-Srikandapuram, *Cf*86027-Nathakadu, *Cf*06022-Kuthalam, *Cf*671, *Cf*V09356-Ellanganur, *Cf*0323-Pettavaithalai, Cf99006-Mundiampakkam, *Cf*0323-Tirunelveli, Cf94012-O and Cf671-Tuhuli caused disease on different varieties in descending order. Although the isolate *Cf*2001-13-Perampakkam did not cause any disease during the season, presence of the inoculum has reduced sett germination.

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

Yellow leaf disease (YLD)

Epidemiology: YLD expression in different parental clones and germplasm at Agali and Coimbatore was monitored. Of the 189 entries in DUS reference genotypes, 174 entries were found apparently free from YLD and three entries *viz.*, Co 740, 7R383, and CoSnk 03754 had shown YLD severity grades of 3-4 during the season. All the species clone entries *viz.*, *S. barberi, S. sinense,* and *S. robustum* were found apparently free from YLD, whereas *S. officinarum* clones recorded 5-6% disease incidence. The entries *viz.*, Lakhapur, 51NG 156, 51NG 159 and 57NG77 had shown YLD severity grades of 2-3. At NHG, out of 607 entries, 44 had recorded YLD with severity grades in the range of 1-3 and only four had shown severity grade >3 *viz.*, LG 641, CoJ 82, CoS 01268, and CoPb 1181. The remaining entries did not express severe symptoms of the disease during the season. Poor disease expression in the parental clones might be due to climatic conditions prevailed during the season that needs to be studied in detail.

Impact of YLD on cane growth and yield: Impact of YLD on cane growth and yield was assessed by comparing the crops planted with virus-infected and virus-free planting materials of three varieties in the field. Phenotypic variation was found between the healthy and virus-infected plants from germination onwards. Plant growth / yield parameters such as number of stalks, cane diameter, cane length, number of internodes, cane weight, juice yield etc. recorded at the time of harvest revealed significant reductions for all the parameters due to the virus infection. It was found that due to virus infection, cane and juice yield were reduced by 18.5 to 40.7% and 42.1 to 50.0% respectively in the varieties.

Dynamics in aphid population: Aphid population in different sugarcane varieties was monitored for six months from April to September 2017. Maximum number of aphids per plant was observed during June-July. Maximum number of aphids per plant was observed in CoPant 84211 (90.4) followed by CoC 671 (63.5) and Co 86032 (58) in the diseased YLD plants, whereas, the same healthy plant had 43.5, 21.0 and 26.0 respectively during the starting stage of aphid colonization in April. During the peak season of June, aphid population was high in all the varieties of both healthy and diseased with minimum 31.25 (CoBln 9609) to maximum 280.25 (Co 419) per plant. Population was slowly declined by July end and August in the range of 8 to 143.75 and 7 to 90.4 per plant, respectively. In September, population was completely declined, only one or two highly susceptible varieties were inhabited by least population per plant, 12.5 (B38192) and 22.5 (CoC 671).

(R. Viswanathan and K. Nithya)

Characterization of red rot pathotypes

About 35 *C. falcatum* isolates were tested on 31 sugarcane varieties by plug method and assessed for their pathogenic variation. Overall, the isolates exhibited enormous variation for their virulence and comparatively more isolates showed lesser virulence compared to the previous years. The isolate *Cf*PI1401-Kadaganur was found to be the most virulent this season and was followed by Cf86032-Srikandapuram, *Cf*671-Gujarat, *Cf*06027-Sethiathoppe, *Cf*06022-Madugarai, *Cf*C24-Radhapuram, *Cf*0323-Tveli, *Cf*86027-Nathakadu, *Cf*V09356-Elanganur, *Cf*06022-Kuttalam, *Cf*PI1110-Kallur, *Cf*PI1110-Kothangudi and CfV09356-Paripalli. The isolates such as *Cf*94012-G, *Cf*7805-AP, *Cf*86032-Bari, *Cf*2001-13-Perampakkam, *Cf*Si-8, *Cf*62175-AP and *Cf*94012-O exhibited less virulence especially the first three could not cause susceptible reaction on CoC 671. None of the highly susceptible varieties such as Co 94012, Co 95020 and CoC 671 were completely susceptible to the isolates. Further, the susceptible varieties like Co 419, Co 658, Co 997 and Co 6304 exhibited a differential reaction. There was a deviation from disease reaction / pathogenic virulence than the previous season. The varieties BO 91, CoS 8436 and CoSe 95422 remained resistant to all the isolates and Co 94008, Co 99004 and CoV 09356 behaved as resistant except for few MS reactions; the varieties Co 2001-13 and CoV 92102 although behaved as resistant, they succumbed to few isolates.

(R. Viswanathan and R. Selvakumar)

Mapping pathogenic and molecular variability of sugarcane smut in India

Pathogen Variability / Biology: Genetic relatedness existing amongst distinct pathotypes of *Sporisorium scitaminuem* was studied using established mating types of the representative cultures of the sugarcane smut pathogen. Distinct mating type cultures (+ and -) of phenotyped smut pathogen isolates (isolates varying in virulence pattern) were established for representative isolates to utilise them for understanding variability using molecular markers. Primers were designed targeting mating type specific genes, so as to discriminate between opposite mating types (+ and -). PCR amplification could be successfully optimized to isolate distinct mating type specific genes, which could be used to

establish life cycle transition of the smut pathogen (Fig. 64).

Fig. 64. PCR conditions were optimized to discriminate MAT-1 and MAT-2 strains.

Proteins were isolated from opposite mating type haploids from Ss97009 teliospores and dikaryotic mycelium developed from smut infected meristem (Co97009 X Ss97009). Then the proteins were resolved in 2DE and the differentially abundant protein spots were picked and MS/MS analysis is in progress.

Defense transcriptomics to understand compatible interaction: Protocol optimization was completed for transcript analysis of smut pathogen challenge responsiveness in genotypes (Co 97009 – Susceptible, Co 86032 – Intermediate and Co 6806 – Resistant) with varying reaction to smut inoculation. Genes coding for phenyl-propanoid pathway and salicylic acid pathway intermediaries in sugarcane are targeted in the study.

Orthologous effectors of S. scitamineum: In planta temporal expression analysis of five putative Candidates Secreted Effector Proteins (CSEPs) coding genes (PEP1, PIT1, TIN2, CMU1 and bE1) were analyzed in Co 97009 sugarcane challenge inoculated using high *(Ss97009)* and least virulent *(Ss81V48)* isolates, revealed that expression of the transcript was increased at 72 hpi in high virulent isolate compared to least virulent isolate. The overall expression dynamics of the transcript level of PEP1 (effector gene) was significantly higher, when compared to the other CSEPs (Fig. 65).

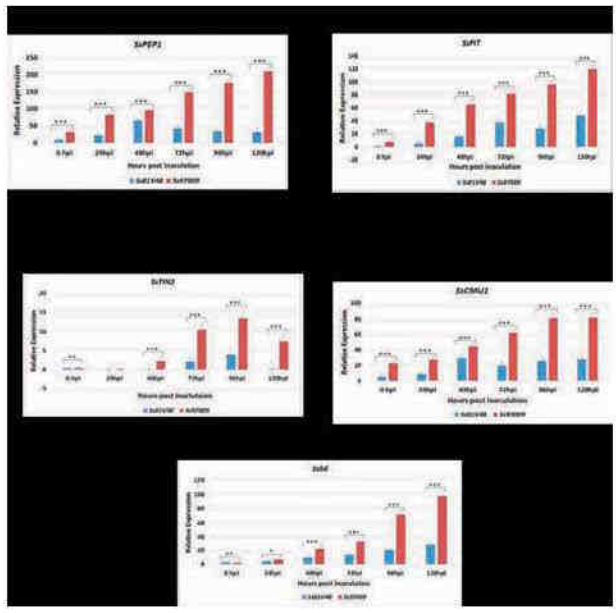


Fig. 65. Expression pattern of pathogenicity-related genes in high (Ss97009) and least virulent (Ss81V48) isolates after inoculation into sugarcane susceptible variety (Co 97009) at six different time points using quantitative reverse transcriptase PCR. (Bars indicate the ± values and * indicate the level of significance of expression of particular gene performed with Student's 't' test between two groups. '*'- P<0.05, '**'- P<0.01, '' – P< 0.001.)***

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

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

Pathogenicity related genes/ proteins of C. falcatum*:* By analyzing phylogenetically differentiated virulent and least virulent isolates in *in vitro* and during host pathogen interaction on susceptible cultivar, about 28 transcripts from genomic (SSH) analysis including six from host pathogen interaction and 22 from *in vitro* cultures were identified as pathogenicity related genes. Besides, 34 differentially expressed unique proteins from proteomic (2-DGE) analysis of mycelial (11) and secretome (8) of two isolates under *in vitro* conditions and during host pathogen interaction (15) were identified as pathogenicity related proteins. The identified genes/ proteins were

validated by qRT-PCR in response to pathogen virulence and host resistance. Primers were designed for all the selected transcripts and proteins and validated during host pathogen interaction by qRt-PCR. The results suggested that the expression of proteins varied at different time intervals. It was found the there was a gradual increase in their expression upon increasing the time interval and the maximum expression was observed at 240hpi. Also the highly susceptible and susceptible sugarcane cultivars showed maximum level of expression of the proteins in all the time intervals taken for the study.

Identification of candidate genes for fungicidal management: From the proteomic analysis of host pathogen interaction, cytochrome P450 has been selected as it has been reported to be potential target site for azole fungicides for red rot management. The charge to mass ratio obtained as a result of MALDI-TOF analysed in Mascot Search, resulted in Top Score for cytochrome p450 has been obtained. Hence, the protein sequence of cytochrome p450 has been compared with transcriptome data of *C. falcatum* and the presence of 285 gene sequences of various sizes from 198bp to 3486bp was found. About 10 cytochrome P450 genes were selected randomly and specific primers were designed, of which, 4 genes including *cyt 3* were amplified in culture. However, among four sequences, only *cyt3* gene, which is the characterized protein differentially expressed during host pathogen interaction in relation to pathogen virulence. The partial sequence size of *cyt3* gene was 200bp from 1563kb of total gene size amplified for validation by expression studies. To test the efficacy of azole fungicide on cytochrome p450, 7 months old CoC 671 canes were drenched with the azole fungicide Nativo® (combination of tebuconazole and strobilurin), proved to be effective against red rot. The drenched canes were inoculated on 5th and 10th day after drenching and made expression analysis in the tissue obtained one node above inoculated node. Results on qRT-PCR studies indicated that there was no *cyt3* gene expression as against well expression of gene with prominent symptom production in untreated canes (Fig. 66a and b). However it has to be confirmed with pure azole compound under *in vitro* and *in vivo* conditions. Furthermore, it is interesting to note that the same protein was found to be suppressed during a tritrophic interaction of *C. falcatum*, and *T. harzianum* in sugarcane.

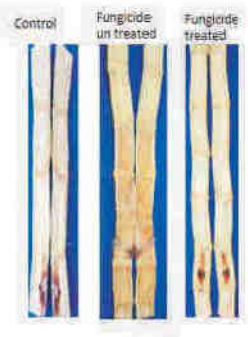


Fig. 66a. Efficacy of azole-strobin fungicide on red rot infection in-planta in CoC 671

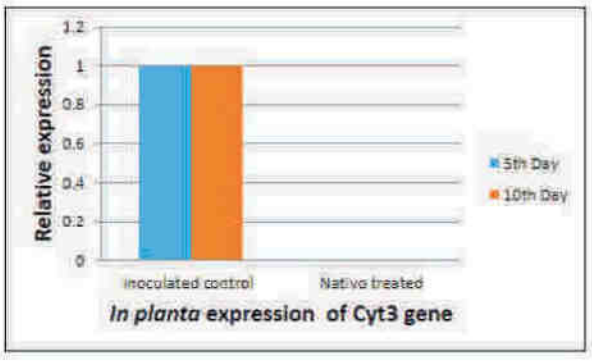


Fig. 66b. Differential expression of cyt3 gene of C. falcatum in sugarcane stalks treated with azole

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

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

Red rot resistance mechanism

The study to explore the role of microRNAs in sugarcane defense mechanism against *C. falcatum* was conducted using NGS platform with resistant (Co 93009) and susceptible (CoC 671) cultivars at different time intervals after pathogen inoculation. Known miRNAs in each library *viz.*, RC-304, R6-536, R24-585, SC-519, S6-456 and S24-417 were identified; similarly the novel miRNAs among each

library *viz.*, RC-799, R6-827, R24-1,288, SC-960, S6-682, and S24-456 were identified. Detailed bioinformatic analyses identified differential expression of up-regulated miRNAs *viz.*, osa-MIR444b, osa-miR444a, sbi-MIR5568b, zma-MIR169b, osa-MIR166d, osa-MIR818f, osa-miR5083, sbi-MIR167e, sbi-MIR167f and sbi-MIR166b and down-regulated miRNAs *viz.*, sbi-miR164c, zma-miR164h-3p, sbi-MIR6227, osa-miR162b, osa-miR166g-3p, osa-MIR444e, sbi-MIR166b, osa-miR167b, osa-MIR395p and osa-MIR395n. Further target analyses of different miRNAs revealed several target genes involved in various stress responses such as hormone signaling pathways, hypersensitive responses, calcium signaling, other signaling cascades, disease resistance and transcription factors.

Characterization of antifungal proteins and metabolites from bacterial antagonist

Proteomic analysis on two-way interaction of *C. falcatum* and *Pseudomonas alvei* indicated inhibition of *C. falcatum* growth and its proteins, in addition to expression of unique proteins of *P. alvei* origin (Fig. 67). The identified proteins were functionally categorized into energy/transport (ATP synthase subunit, ABC transporter substrate binding protein), stress/defence (superoxide dismutase, poly isoprenoid-binding protein YceI), signaling (sensor histidine kinase), metabolism (butanediol dehydrogenase, malate dehydrogenase) and antagonistic traits (porin, flagellin).

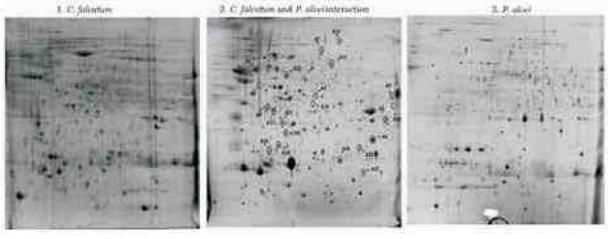


Fig. 67. Representative 2DE profile of proteins from C. falcatum, P. alvei and their interaction in vitro

GC-MS analysis revealed that during *C. falcatum* and *P. alvei* interaction, 11 new volatile compounds in addition to 12 compounds of *P. alvei* and one compound of *C. falcatum* were produced. It indicates that remaining 29 compounds of *C. falcatum* metabolites were suppressed with simultaneous induction of new compounds by the antagonist. The only compound, Oxacyclododecon-2 of *C. falcatum* detected in metabolites of *C. falcatum* and during interaction with *P. alvei* / *T. harzianum* indicates its specificity to *C. falcatum* and probably it may have possible role in pathogenicity or virulence of the pathogen. Volatile compounds of *P. alvei* (Phenol; Eicosane; Dibutyl phthalate; Pyrrolo etc.,) play a major role during interaction with *C. falcatum* and were reported to be antifungal nature. Among them, the volatile compound Eicosane was expressed by both fungal and bacterial antagonists during interaction with the pathogen. The crude metabolites obtained during interaction of *C. falcatum* with *P. alvei*/*T. harzianum* inhibited the *C. falcatum* growth in plates. Further, there was no symptom production by these metabolites on detached leaves as compared to well-developed symptom by *C. falcatum* metabolites. These results also confirm the suppression on production of *C. falcatum* metabolites.

Molecular analysis on suppression of C. falcatum pathogenicity related genes: Expression analysis on transcripts of identified proteins related to sugarcane defence mechanism confirmed that the defence and stress related proteins were upregulated by the induction of *T. harzianum* in sugarcane either alone or along with pathogen. Interestingly, the pathogenicity / virulence related proteins *viz.*, cytochrome p450 and Hsp20-like proteins of *C. falcatum* were down regulated during interaction with *T. harzianum* in sugarcane.

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

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

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

In vitro release properties of chitosan coated SAR inducer nanoparticles: The *in vitro* release pattern of chitosan

coated SAR inducer nanoparticles generally indicated the potential of synthesized material for field application. The release of benzothiadiazole (BTH) and salicylic acid (SA) from chitosan (CS) coated nanoparticles was assessed under *in vitro* condition in citrate buffer at 3 different pH levels. The BTH release was measured using high performance liquid chromatography (HPLC) and SA release was quantified with UV spectrophotometry at 525 nm. The results showed that at pH 3.2 the BTH released was initiated at 41h and continued till 72h, at pH 4.2 the BTH release was initiated at 74h and at pH 5.2 also the release was noticed at 74h (Fig. 68). The SA was also released from chitosan coat in similar pattern as noticed for BTH.

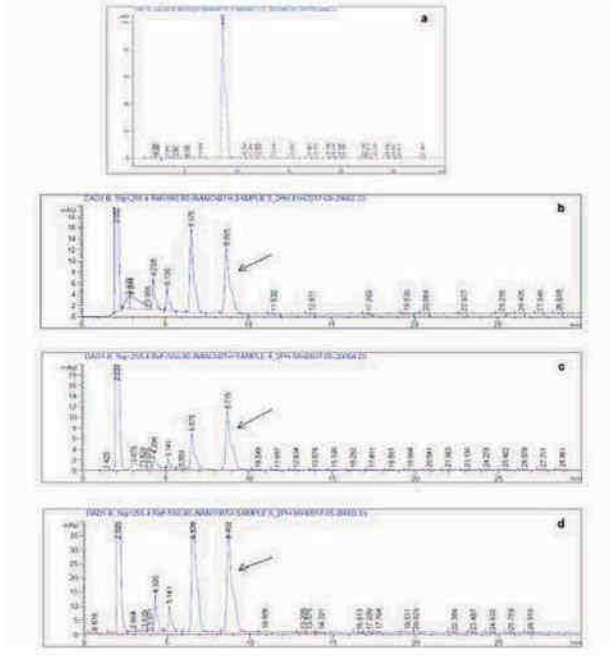


Fig. 68. In vitro release of BTH from chitosan coated BTH nanoparticles at various pH in citrate buffer
a: BTH standard peak at Rt 8.7
b: BTH released at 41h at pH 3.2
c: BTH released at 74h at pH 4.2
d: BTH released at pH 5.2

Controlled condition testing of CS coated SAR inducer NPs against fungal diseases of sugarcane: The systemically acquired resistance (SAR) inducer property of CS coated BTH and SA in sugarcane against red rot, smut and wilt diseases was tested in glass house under artificially pathogen inoculated conditions. The synthesized nanoparticles of CS coated BTH and SA were used for priming of single bud setts of sugarcane cv Co 86002 using sett treatment device. Four treatments were taken for glass house experiments, i.e., T1- setts treated with CS-BTH NPs + pathogen, T2- setts treated with CS-SA NPs + pathogen, T3- setts treated with water + pathogen (pathogen inoculated control) and T4- setts treated with water (healthy control). In red rot and wilt experiments, grain inoculum of *C. falcatum* and *Fusarium sacchari* were inoculated on NPs primed sugarcane buds while planting, whereas for smut experiment primed setts were soaked in mixed inoculum of smut spores and then planted. The results of all the three experiments showed that germination in CS- BTH nanoparticles treated setts were on par with healthy control, whereas germination in CS- SA nanoparticles treated setts were reduced by 7.0 to 26.0%, while in the pathogen inoculated control the germination was reduced by 14.0-27.0%. These results indicated that SA released inside the setts may be ineffective in controlling pathogens at early germination stage. In red rot experiment, drying of seedlings (33.3%) due to disease incidence was noticed in pathogen inoculated control, whereas no red rot was recorded in any of the CS-SAR inducer nanoparticles treated plants till 90 days after planting. In smut and wilt experiments, other than germination loss, no disease incidence was noticed in seedlings of pathogen inoculated control or any other treatments till 120 days after planting.

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

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

Sugarcane rust – a climate dependent foliar disease: During the season, rust incidence and severity were monitored on a set of sugarcane clones. Although

there was no rust infection in the initial months due to dry spell, the maximum temperature below 33°C and the minimum temperature above 20°C that prevailed during July to December 2017 favoured brown rust infection. In general, rust severity was higher than the previous crop season (Fig. 69). During the season, the minimum temperature was slightly warmer (20.8 - 23.4°C) as compared to the previous season (17.3 - 22.8°C) whereas, the maximum temperature was slightly lower (30.43 - 32.5°C) as compared to 2016-17 (30.9 - 33.75°C).

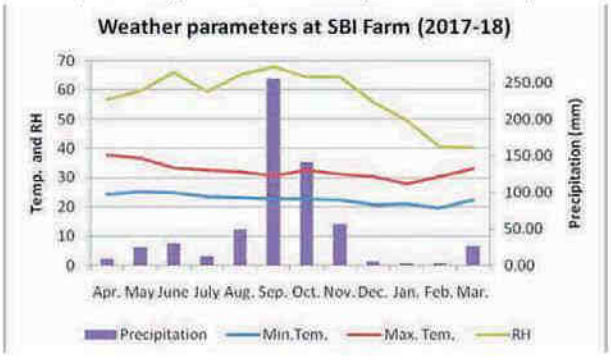


Fig. 69. Impact of weather parameters on rust infection in sugarcane

Evaluation of adult plant rust resistance: During 2017-18 crop season, sugarcane clones in the arrowing plot at SBI, Coimbatore were screened for their adult plant resistance in field conditions. The host response to infection in the field was scored and categorized as resistant (R), moderately resistant (MR), moderately susceptible (MS) and susceptible (S) (Fig. 70). The clones identified under each category are listed below:

S group: Co 740, Co 1287, Co 62198, Co 86002, Co 86011, Co 0218, Co 0238, Co 0403, Co 0409, Co 05009, Co 06002, Co 10005, Co 11004, Co 11007, Co 11015, CoJ 83, CoM 9220 and ISH 100.

MS group: Co 419, Co 658, Co 85019, Co 87011, Co 87044, Co 93005, Co 94008, Co 96002, Co 97009, CoM 88121, C 79218, 2016-0018, 87A 380, Co 0118, Co 0120, Co 0213, Co 0214, Co 0239, Co 0303, Co 0310, Co 0314, Co 0331, Co 1148, Co 12006, Co 13015, Co 15002, Co 15003, Co 15007, CoBln 0417, CoC 671, CoH 110, CoV 09356, ISH 2, 2016-0038 and Co 6806.

MR group: Co 775, Co 8341, Co 8371, Co 87269, Co 89003, Co 92005, Co 92008, Co 93009, Co 93020, Co 94012, Co 95012, Co 95021, Co 96007, Co 97015, Co 98010, Co 99012, Co 98014, Co 86032, CoV 09356, 69 A 591, Co 0116, Co 0209, Co 0212, Co 0320, Co 0327, Co 0402, Co 05001, Co 05008, Co 05011, Co 06022, Co 06030, Co 06032, Co 08016, Co 10015, Co 10026, Co 11001, Co 12009, Co 12014, Co 12016, Co 12025, Co 13020, Co 14016, Co 14019, Co 14020, Co 14028, Co 14032, Co 15018, Co 15021, Co 16002, Co 16018, Co 2000-01, Co 2000-02, CoA 7602, CoM 0265 , CoSnk 05103 and CoT 8201.

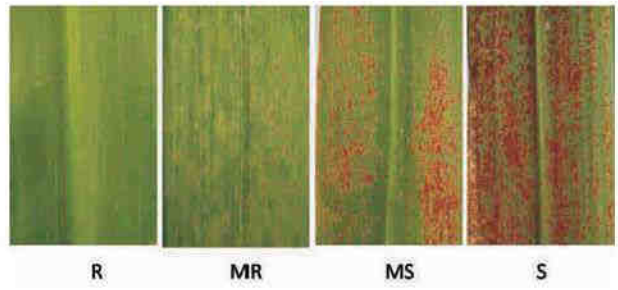


Fig. 70. Rust resistance categories in sugarcane

Rust free group: 05-0234 , 1148-13-11-2-237 , 1148-13-11-2-251 , 1148-13-11-2-255 , 1148-S4-242-13, 1148-S5-242-7, 2007-172, 2007-231, 2011-100, 2011-35, 2013-149, 2013-169, 2013-216, 2013-70, 2016-0020, 81V48, 85 R 186 , 98-270, BO 91, Co 62175, Co 6304, Co 7201 , Co 8338, Co 8347 , Co 84211, Co 85002, Co 86010, Co 86249, Co 87023, Co 89010, Co 91002, Co 91010, Co 92002, Co 92020, Co 94005, Co 94008 , Co 94019, Co 95005, Co 95020, Co 97008, Co 98017, Co 99004, Co 99006 , Co 99008, Co 2000-10, Co 2000-12, Co 2001-09, Co 0124, Co 0217, Co 0230, Co 0232, Co 0233, Co 0235, Co 0237, Co 0240, Co 0304, Co 0312, Co 0424, Co 05002, Co 05003, Co 05005, Co 05007, Co 06012, Co 06015, Co 06034, Co 07004, Co 09007, Co 09010, Co 10004, Co 10017, Co 10026, Co 10031, Co 10033, Co 11005, Co 11012, Co 13001, Co 13006, Co 13007, Co 13014, Co 13018, Co 14002, Co 14007, Co 14014, Co 14024, Co 14026, Co 15013, Co 15015, Co 16001, CoA 06321, CoBln 9609, CoC 85061, CoH 119, CoH 92, CoJ 64, CoLk 8102, CoLk 94184, CoN 10071, CoN 10571, CoP 06436, CoP 9301, CoPant 84211, CoPant 97222, CoS 510, CoS 767, CoS 8436, CoSe

92423, CoSe 96436, CoSnk 03044, CoSnk 03754, CoSnk 14103, CoT 8201, CoTl 1153, CoV 92102, CoV 92103, CP 61-23, CP 78-1628, CP 80-1743, CP 81-1384, CP 84-1198, CP 89-1762, CP 92-1641, CP 94-100, CP 94-1340, CP 96-1252, CP 96-1662, CYM 09-1369, CYM 04-388, CYM 06-212, CYM 07-649, CYM 07-678, CYM 07-971, CYM 07-981, CYM 08-314, CYM 08-922, CYM 09-167, CYM 09-521, CYM 09-565, CYM 10-172, CYM 10-603, CYM 6924, GU04(28) EO-2, IG91-100, ISH 12, ISH 175, ISH 176, ISH 22, ISH 43, ISH 69, M555-160, MS 901, PR 1013, PR 1028, PR 1062, Q 69, Q 73, Q63, SBIEC 11001, SBIEC 11002, SBIEC 11004, SCGS 00402, SP 80-1842 , SP 80-185, U 09069 and U 09196. However, the rust free group clones need to be screened under artificial inoculated condition to ascertain their resistance towards rust infection.

(R. Selvakumar and T. Lakshmipathy)

Molecular characterization of phytoplasma associated with sugarcane

Sugarcane showing YLD symptoms with severity grades of 3 - 4 collected from VPT farm, Agali Centre and NHG were subjected to phytoplasma diagnosis with the primers R16F2n/R2 and YLD FP1/ RP1 targeting 1200 bp and 900 bp, respectively. Of the 64 samples tested, 26 were positive to SCGS-phytoplasma to both the primer sets. The primer YLD FP1/ RP1 designed from 16S-23S ribosomal RNA regions was found better than R16F2n/R2. Amplicons from the affected cvs 57NG56, CoPant 84211, Co 86010, Co 10031, CoC 671, CoS 8436, Co 86032, Co 6304, CoC 99061, CoV 92102, Co 87269, Co 449, and CoV 94101 were confirmed as SCGS phytoplasma (16SrXI) and the sequences have shown 97-99% similarity with the other SCGS isolates in the genbank database. Also, multiple sequence alignment revealed variation in the 16s-23s ribosomal RNA regions in some GSD isolates belonging to both sub-tropical and tropical regions. Based on that, seven isolates *viz.*, Co 87023, Co 0118, Co 0238, Co 0240, Co 06022, CoS 88230 and 2015-92 were chosen for the sub group level identification through *in silico* RFLP using iphyclassifier.

The virtual RFLP pattern derived from the query 16S rDNA F2nR2 fragment of Co 0240, Co 0238 and Co 06022 were identical to the reference pattern of 16Sr group XI, subgroup B (GenBank accession: X76432) with similarity coefficient 1.00, 0.94, 1.0 respectively. Whereas, RFLP pattern of the isolates Co 0118, Co 87023, 2015-92 and CoS 88230 were different from the reference patterns of all the previously established 16Sr groups/subgroups. The reference pattern of the 16Sr group XI, subgroup B (GenBank accession: X76432) exhibited a similarity coefficient of 0.59, 0.53, 0.53, and 0.20 respectively with these isolates, which is less than 0.85. Similarity coefficient (F) was calculated for each pair of phytoplasma strains according to the formula F=2Nxy/ (Nx+Ny). Among the four, the isolate CoS 88230 had shown distinct RFLP pattern to the key restriction enzymes, Bfa I, Hinf I and Mse I in comparison with the so far reported SCGS phytoplasma strains *viz.*, 16Sr XI-A, B, C, D, E and F (Fig. 71). Also, it had distinct nucleotide sequences at nine different positions in the 16s-23s ribosomal RNA regions in place of gaps in the reported SCGS phytoplasma strains. Further wet lab confirmation work is in progress to characterize CoS 88230 isolate as a new SCGS phytoplasma strain.

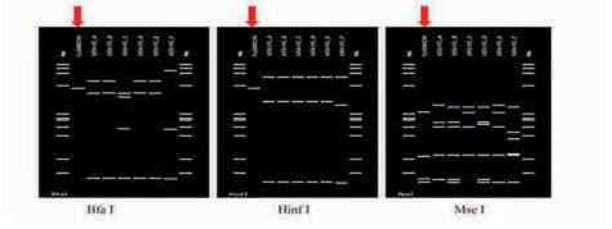


Fig. 71. In silico virtual RFLP pattern of the isolate CoS 88230 for the key restriction enzymes, Bfa I, Hinf I and Mse I

(K. Nithya and R. Viswanathan)

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

Efficacy of azole fungicide by mechanized sett treatment against red rot: Field trials have been laid out to evaluate the efficacy of mechanized sett treatment

with thiophanate methyl at 1000 ppm and azole fungicide (trifloxystrobin-25%+ tebuconazole-50%) at 500 ppm and their combination at 50% of their individual treatments. Results on germination and plant survival indicated that the combination was found to be better than individual treatments. Also, these treatments resulted in significant yield under inoculated conditions. There was minimum level of disease incidence in the field trial including inoculated control.

Efficacy of mechanized sett treatment for the delivery of nutrients and microbes: To study the efficacy of sett treatment with nutrients, five sugarcane cultivars *viz.*, Co 86032, Co 0212, Co 0238, Co 6806 and Co 94008 were treated with combination of urea, $ZnSO_4$ and $FeSO_4$ and evaluated for growth promotion and yield under field conditions. It was observed that the combination with 0.1% concentration each was found to be better as compared to increased concentration of $FeSO_4$ to 0.25% in all the five test varieties. Among them, significant yield was recorded in Co 86032 by treating two budded setts and planting directly in the main field. However, the differences in responsiveness have to be studied using single budded setts at uniform age for all the varieties. Validation has also been carried out in various institute fields instead of pots. Treating setts in STD with urea, $ZnSO_4$ and $FeSO_4$ at 0.1% concentration and propiconazole at 100 ppm to manage nutrient deficiency in early stage with improved plant growth indicated that the treatment had positive effect in various genotypes in NHG and 17 varieties in museum plot. Further, treating single bud setts of Co 11015 for demo plot gave significant improvement in healthiness of settlings and crop stand in the field. Besides, microbial load of fungal and bacterial antagonists for treating single bud setts in sett treatment device was standardized.

Applicability of hot water treatment through Sett Treatment Device: The mechanized system of sett treatment has been validated with hot water along with fungicide and nutrients. *Saccharum officinarum* (IJ-76-419) and prominent cultivar Co 86032 were evaluated with various treatments including hot water alone and its combination with fungicide and nutrients. Observations up to 90 DAP showed that the treatments were not inhibitory to germination, instead their growth and tillering were improved as in normal water with other ingredients (Fig. 72).

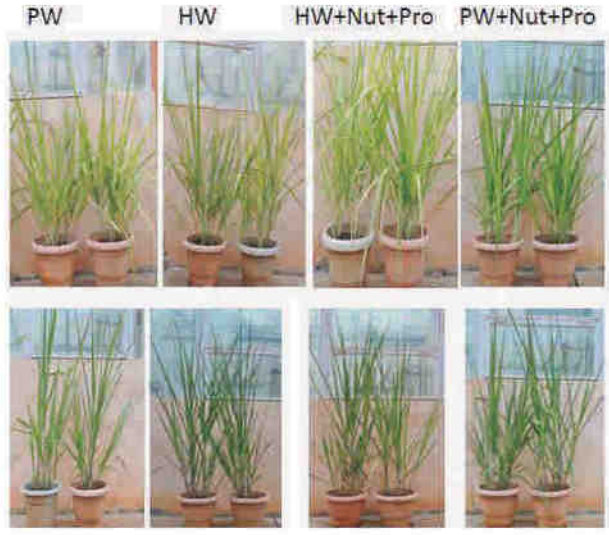


Fig. 72. Efficacy of mechanized sett treatment with various agro-inputs on plant growth: PW – Plain water, HW – Hot water, Nut – Nutrients, Pro - Propiconazole

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

Epidemiology and management of *Fusarium diseases* in sugarcane

Simulation of wilt: Sett and soil borne inoculum sources of *F. sacchari* were compared for disease expression in different sets of varieties. Healthy and infected seed canes of 13 varieties were planted to assess disease development from germination phase onwards. Sett borne inoculum caused 25.0-40.0% loss in germination in different varieties. However, in some varieties like CoPant 97222, it caused more than 50% loss in germination. The plots planted with diseased setts exhibited disease from 30 days onwards and continued till harvest. Although the healthy plots also exhibited disease during the later

crop stages, diseased plots recorded very severe wilt. The varieties Co 86010, MS 68/47, C 79218, 69 A 591 etc. exhibited very severe disease due to sett borne pathogen infections. Pokkah boeng was also recorded in many of the 13 varieties; however, the disease development was random, no relation could be made on sett infection and disease development. Two kinds of soil inoculum *viz.*, chopped infected canes and fungal inoculum multiplied on *Sorghum* grains (isolates FsMS901 and FsSi2000-02) were applied at the time of planting in the soil and disease development was monitored. As in the previous trial, presence of inoculum in the soil reduced the germination in almost all the 10 varieties. Among the two types of soil inoculum, debris borne inoculum had exhibited more disease than the *Sorghum* grain multiplied one. Both the isolates had almost similar pathogenic behaviour on the varieties.

Nine *F. sacchari* isolates were inoculated on seven varieties by plug method of inoculation and assessed for disease development and pathogenic variation. Among the isolates, Fs86010, FsMS901, FsEB09004 and Fs419 were more pathogenic on the varieties and among the varieties, MS 901 and Co 98010 was found to be susceptible to different isolates. All the nine isolates caused susceptible reaction on these two varieties; additionally the isolates Fs419 and FsISH100 caused similar susceptible reaction on Co 86010. Overall, pathogenicity of the varieties for different isolates revealed a clear differential interaction between the host varieties and the pathogenic isolates. Except the isolate Cf86010, no other isolate caused disease reaction on all the test varieties.

Monitoring of wilt and PB in sugarcane

Coimbatore: Monitoring for the diseases was performed in the varietal collections and parental clones in NHG revealed that the climatic conditions prevailed during the season did not favour PB development and spread. A clear seed cane borne infection of *F. sacchari* and further wilt development was observed in the clone 2016-21. A 100% disease incidence with death of canes was recorded in September. Survey for the disease in East Godavari district in December revealed epidemic occurrences of wilt in popular varieties Co 86032, CoV 09356 and 87A380.

Karnal: Progress of PB symptoms was monitored in the varieties under trials from first week of June onwards. The disease started to appear on plants with curling and twisting of leaves with chlorotic /yellow lamina. Among the 56 test entries, mild to 3.4% incidence was expressed in 10 varieties *viz.*, Co 12026, Co 13035, Co 0238, CoPb 13181, CoS 14261, CoS 14232, CoJ 64, Co 89003, CoS 8436 and CoPant 97222; however, after July the symptoms recovered. None of the clone showed advanced or top rot stage. Similarly, observations recorded at farmer fields revealed that disease was prevalent in most of the varieties cultivated under Haryana, UP and Bihar, but overall PB incidence was less as compared to the previous years. The maximum incidence (up to 40%) was found in the variety CoH 160 at village Barsalu, Karnal.

Kannur: A total of 10 clones comprising two *S. officinarum* clones IJ 76 322 and IK 76-70, seven foreign hybrids clones Q 56, Q 68, C 4772, CP 61-84, PR 1065, PT 48-44 and M 1900 and one Indian hybrid clone Co 1002 exhibited pokkah boeng. The incidence started as chlorosis in June and knife-cut symptom was observed in the clone Co 1002 in August (Fig. 73). The clones IK 76-70 and Co 1002 exhibited top rot and the clones IJ 76 322 and IK 76-70 exhibited wilting in January 2018. The incidence of pokkah boeng in IJ 76 322 and IK 76-70 was 25.0% with severity of 16.0% and 25.0%, respectively. The clone Q56 (foreign hybrid) recorded disease incidence of 71.42 whereas the severity was 14.28%. In case of Q 68, incidence was 60.0% and severity was 12.17%. In Co 1002, incidence was 47.36% and severity was 14.73%. In other clones, incidence and severity was very less. PB was not observed in *S. robustum, S. barberi, S. sinense* and *S. spontaneum* and other allied genera during the season.

Fig. 73. Knife cut symptom of pokkah boeng observed at Kannur on the genotype Co 1002

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

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

Putative transgenics with virus suppressor genes: A new set of transgenic events with candidate genes of RNAi constructs were performed and subsequently the putative T_0 events sugarcane cvs Co 86032 and CoC 671 were kept for shooting and rooting. About five positive events were confirmed by PCR. The transformed plants were hardened and SCYLV inoculum was multiplied on *Melanaphis sacchari* for challenge inoculum of putative transgenic lines. Similarly, putative transgenics for SCSMV are being maintained under glasshouse conditions and are challenged with the virus through mechanical inoculation.

Transcriptome of virus-infected sugarcane: To study the transcriptomic changes in sugarcane during virus infection, de novo transcriptome assembly was constructed for virus infected sugarcane cultivars using Illumina-Hiseq 2500 NGS platform. The cultivars Co 86032, CoC 671 and Co 11015 infected with different viruses *viz., Sugarcane yellow leaf virus (SCYLV), Sugarcane mosaic virus* (SCMV) and *Sugarcane streak mosaic virus* (SCSMV) were used. Total of five samples in which two healthy and three disease samples were processed for library construction. After the quality check, trimming and rRNA removal ~14,424,777 raw reads were obtained with GC content >50.0%. The transcript assemblies were built using Trinity software (2.5.1) with length distribution of assembled transcripts >= 200bp. A total of 140,635 unigenes with average contig length of 673bp along with isoforms of 364,883 with average contig length of 896bp were obtained. Further gene ontology annotation for 140,635 unigenes using Blast2go results in 57.03% sequences without significant hits and about 26.83% sequences with significant alignments having no link to any GO entries and 3.17% of GO mapping with no annotation as only 12.97% with functional labelling. The top GO distribution in biological processes were metabolic process, cellular process and single-organism process, while in molecular function, binding, catalytic and transporter activity are in top list similarly cell, membrane and organelle were listed top in cellular component. The initial results showed that basic metabolism plays a critical role in sugarcane during disease development. Further, differential expression analysis and functional characterization of the identified targets would give more insight into complex factors associated with resistance development and also the factors associated with susceptibility during virus infection in sugarcane.

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

ICAR-CRP on Development and application of diagnostics to viruses infecting sugarcane

RT-LAMP assay for SCMV: Detailed studies were conducted to standardize reverse-transcription loop-mediated isothermal amplification (RT-LAMP) assay for the diagnosis of Sugarcane mosaic virus (SCMV). Total RNA was extracted using TRI reagent from sugarcane varieties exhibiting mosaic symptoms *viz.,* Co 92005, CoBln 03174, CoC 671, CoC 99061, CoG 93076, CoJaw 70, CoJaw 270, CoS 94270, CoSi 776 and CoSnk 03754and RT-PCR assay was performed using the standard diagnostic primers of SCMV, SCMV-F381 (5´-GGTNTGGTGYATBGARAATGGTTGCTCACC-

3´) and SCMV-R381 (5´-GGTNTGGTGYATBGARAATGGTTGCTCACC-3´). All the tested samples had shown positive amplification of the expected size of ~381 bp. Along with the conventional RT-PCR and qRT-PCR assay was also carried out. For the qRT-PCR assay, standard curves were established using the already available pTZ57R/T plasmid vectors, ligated with the coat protein (CP) gene fragments of SCMV. Plasmid copy numbers were calculated using the online dsDNA copy number tools of URI Genomics and Sequencing Center. The most conserved CP nucleotide regions identified through multiple sequence alignment tools were selected designing for LAMP primers targeting six different regions of SCMV-CP gene. After optimization of LAMP primers amplification conditions, RT-LAMP assay was carried out for the same set of samples using RT-LAMP inner primers (SCMV-F2 and SCMV-B2) targeting SCMV-CP gene. All the tested samples had shown positive to the expected size of 210bp. Sensitivity analysis of RT-LAMP was carried out using inner primers, F2 and B2 for the samples CoSi 776 and CoSnk 03754 based on the qRT-PCR results. It was found that RT-LAMP assay has the same sensitivity as that of RT-PCR assays in case of the cultivar with high virus titre CoSi 776, whereas in case of low virus titre (CoSnk 03754) RT-LAMP was 10 fold more sensitive than the latter one in diagnosing SCMV.

To produce recombinant antisera to the three major RNA viruses infecting sugarcane SCMV, SCSMV and SCYLV, studies have been initiated to express the CP genes with restriction sites EcoRI, HindIII and ZhoI at both 5' and 3' ends. The specificity of the primers was established and full length CP genes of the three viruses were cloned separately in the vector pET28. Further work is in progress to express recombinant CP purification under prokaryotic expression system for the recombinant antiserum production.

Gold Nanoparticles synthesis: To develop lateral flow assay (LFA) kit for sugarcane viruses, uniformly sized gold nanoparticle (AuNPs) was synthesized by following the wet chemistry boiling method using citrate as a reducing agent. Visual observation of wine red colour indicated the formation of GNPs in the solution (Fig. 74). Further, a gradual intensity variation in the reaction solution colour indicated the formation of gold nanoparticles in the colloidal solution. UV-Vis maximum absorbance spectra of synthesized nanoparticles were 520nm which universally corresponds to the gold nanoparticles. Also, variation in absorbance peak had shown concentration-dependent size variation in the nanoparticles. It was found that 6ml of 50mM citrate solution in 50ml $HAuCl_4$ was sufficient to synthesize gold nanoparticles in the size ranges from 30-40nm and 7ml of 100mM citrate solution in 50ml $HAuCl_4$ was sufficient to synthesize gold nanoparticles in the size ranges from 20-30nm.

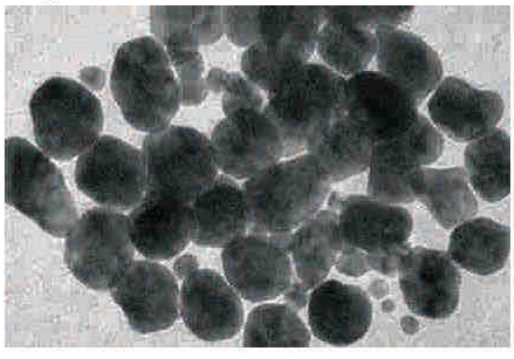


Fig. 74. TEM image of gold nanoparticles

(R. Viswanathan, B. Parameswari, D. Neelamathi and K. Nithya)

Virus indexing service

About 843 tissue culture raised plants from different tissue culture production units *viz.*, M/s EID Parry, Pugalur and M/s RSCL, Theni (Tamil Nadu), KIAAR, Sameervadi, (Karnataka), Sree Sarvaraya sugars, Celluru and Nava Bharat Ventures Ltd., Samalkot (Andhra Pradesh) and ICAR-SBI tissue culture lab were indexed for SCYLV, SCMV, SCSMV and grassy shoot phytoplasmas by following SOPs. Test reports were prepared and sent to the respective labs. A revenue of Rs 2.74 lakhs were generated under virus indexing charges from private tissue culture labs.

(R. Viswanathan)

Sugarcane quarantine

The following clones BO 156, CoP 16436, CoP 16437, CoP 16438, CoP 16440 (Pusa), CoH 10262 (Uchani), CoS 767, CoS 8436, CoS 03251, CoSe 03234 (Shahjahanpur), CoT 8201 (Tirupati), LG 08443, LG 09487, LG 11001 (Lucknow), 2009 R 74, 2010 R 854 (Nizamabad), CoC 08336 and CoC 13339 (Cuddalore) were handed over to NHG after quarantine. Similarly, the following clones Co 09004 (Coimbatore), CoA 11321 [2005A128], CoA 12322 [2006A102] (Anakapalle), CoBln 04174 (Buralikson), CoH 10262 (Uchani) and CoN 09072 (Navasari) were handed over to NAG after quarantine.

The following clones CoP 11437, CoP 14436, CoP 14437, CoP 15436, CoP 15440, CoP 15441, CoP 15437, CoP 17436, CoP 17437, CoP 17438, CoP 9301, BO 128 (Pusa), LG 09475, LG 09487 (Lucknow), CoV 12356, CoV 12357, CoV 13356, CoV 14356, CoV 15356, CoV 16356 and CoV 16357 (Vuyyuru) were received for NHG are in quarantine. The following clones CoP 11437, CoP 11438, CoP 15437, CoP 15438, CoP 15439, CoP 16437 (Pusa), CoV 12356, CoV 12357, CoV 13356, CoV 14356, CoV 15356, CoV 16356, CoV 16357 (Vuyyuru), CoPb 16181, CoPb 16211, CoPb 16212, CoPb 17211, CoPb 17212, CoPb 17213, CoPb 17214 (Faridkot), CoN 13073 (Navsari), CoA 11323, CoA 11326, CoA 12321, CoA 12322, CoA 12323, CoA 12324 (Anakapalle), CoG 6, SNK 09293, CoSnk 14102, CoSnk 15101, CoSnk 15102, CoSnk 15104 (Sankeshwar), CoLk 11203, CoLk 11206 (Lucknow) and UP 09453 (Gorakhpur) were received for NAG are in quarantine.

(R. Viswanathan)

ENTOMOLOGY

Studies on sugarcane pests and their management

Host plant factors influencing genotypic reaction to shoot borer, *Chilo infuscatellus*

Assessment of shoot borer incidence on sugarcane varieties and Erianthus arundinaceus*:* During 2017-18 cropping season, 39 'Co' hybrids were screened under field conditions for their relative degree of resistance against *Chilo infuscatellus* and the incidence ranged from 0.23 to 12.89%. Of the 39 entries evaluated, 35 genotypes were graded as least susceptible (LS) and 4 genotypes as moderately susceptible (MS), based on their cumulative percent incidence of ESB upto 90 days after planting. Among them, Co 97015, CoJ 83, CoJ 65, Cosnk 0361 and Co 99016 recorded <1.0% shoot borer infestation. Similarly, out of 17 exotic clones screened, 2 clones US 497 and M16/39 were not attacked by shoot borer. Shoot borer incidence was absolutely nil in 11 entries of *E. arundinaceous* genotypes (IJ 76 364, IK 76-166, IJ 76-384, IJ 76 370, IS 76-188, IK 76-48, IK 76-99, IJ 76-400, IK 76-81, IK 76-88 and IJ 76-332). In the *Saccharum* entries, nil or very low shoot borer incidence was recorded in Dhaurgalig, Rekha, Pathri and Lalri.

Biochemical profiling of shoot borer promising E. arundinaceus *genotypes:* Biochemical constituents *viz.*, total chlorophyll, total phenols, total proteins and total sugars were analyzed in the shoot borer promising *E. arundinaceous* genotypes (IK 76 78, IJ 76 400, IK 76 84, IK 76 88, IJ 76 370, ERI 2798, Fiji 55, IJ 76 364 and a check Co 86032). There was a significant difference in the total chlorophyll content among *E. arundinaceous* genotypes which ranged from 34.11 ± 0.91 to 42.51 ± 1.35 mg/g. The total chlorophyll content was highest in the genotype IK 76 84 and lowest in the genotype IJ 76 364. Similarly, the total phenolic content was significantly higher in the genotypes IJ 76 370 (2.70 ± 0.33mg/g), IJ 76 364 (2.60 ± 0.17 mg/g) and IJ 76 400 (2.02 ± 0.12 mg/g). Among the genotypes tested, the total protein content varied from 9.22 ± 0.52 to 16.74 ± 1.57 mg/g. The genotypes IK 76 78, IJ 76 400, IJ 76 370, Fiji 55 and IJ 76 364 had highest protein content resulting 16.74, 15.92, 15.75, 15.19 and 15.04 mg/g, respectively. The protein content was the lowest in the genotype IK 76 84 (9.22 ± 0.52mg/g). Also, total sugars content differed significantly among the selected *E. arundinaceous*. It was the highest in the genotypes Co 86032(12.39 mg/g) followed by Fiji 55 (8.97 mg/g) and IK 76 88 (8.41 mg/g) and low in the genotypes IJ 76 364 (5.92 mg/g) followed by IJ 76370 (6.20 mg/g) and IJ 76 84 (6.39 mg/g), respectively. Results also showed that the poly phenol oxidase (PPO) activity differed

significantly among genotypes. It was higher in IJ 76 370, IJ 76 364 and IK 76 88 and lower in Co 86032 and HRI 2798. Among the genotypes assayed, IK 76 84 had absolutely meager activity of PPO as compared to other genotypes.

Laboratory screening of sugarcane hybrids against shoot borer: Sugarcane varieties such as CoSnk 0361, Co 98013, 84A146, Co 7805, Co 94012, 91A37 and Co 775 were identified as least susceptible (LS) to shoot borer in field screening. To confirm the resistance, the identified sugarcane varieties were further screened under lab screening techniques. Developmental characteristics of shoot borer were studied on these least susceptible sugarcane varieties. The results revealed that shoot borer larval duration not differed significantly among varieties which ranged from 23.86 ± 0.59 to 25.71 ± 1.15 days. The longer and shorter larval duration was recorded in the genotypes Co 7805 and Co 98013, respectively. Similarly, pupal period varied from 5 to 7 days. The total egg laying capacity of shoot borer female ranged from 281 ± 20 to 415 ± 23 eggs / female on selected sugarcane varieties. The genotype Co 94012 recorded minimum fecundity of 281 ± 20 eggs / female. In the adults, male longevity was always shorter than female. There was significant difference in the larval and pupal survivability of shoot borer which respectively ranged from 46.0 to 68.0% and 40.0 to 66.0% among the selected genotypes (Fig. 75). Lower larval and pupal survival was recorded in the genotypes 84A146 and Co 7805 with 46 and 40.0% and 49.0 and 41.0% respectively.

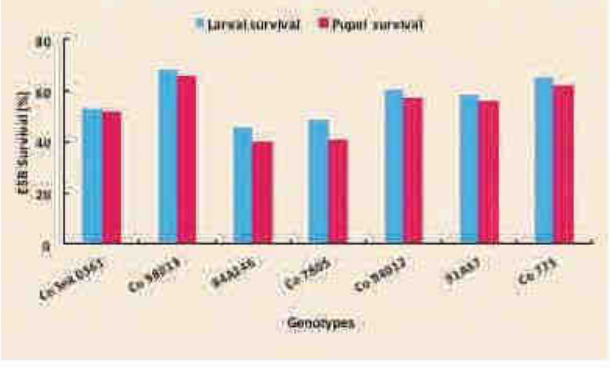


Fig.75. Survivability of early shoot borer on sugarcane varieties

(M. Punithavalli and K.P. Salin)

Prospective determinants of virulence and rhizosphere competency in Metarhizium anisopliae

Metarhizium anisopliae strains MCC 1130 and MCC 1189 were found to be on par with Ma local 2 and Ma new 3 in virulence when tested against III and IV instar larvae of *G. mellonella*. MCC 1189 was as persistent as SBMa upto nine months of inoculation. Among the new three local isolates collected, Ma new 3 was found to be significantly better than others in terms of colony growth, sporulation, virulence and persistence. In continuation with earlier studies, strains ITCC 5489, ITCC 6322, MTCC 6060, MTCC 3943, MCC 1130, MCC 1189, SBMa NAIMCC-F-01295, NAIMCC-F-01296 and NAIMCC F- 02108 were retested against first instar grub of H. serrata. All of them confirmed mortality over 90.0% at 106/ml. The mortality at increased dose of 107/ml was 60.0-85.0% on the second instar. However, ITCC 5489, SB Ma and MTCC 6060 alone showed mortality up to 40% against III instar. Pot culture studies indicated differential mortality efficacies when the grubs (I instar) were inoculated one week after fungus inoculation but recovered after different incubation times. A field trial was laid out at Sathyamangalam area of M/s Bannari Amman Sugars to assess the efficacy of *M. anisopliae* with *B. brongniartii* as microbial check and phorate as insecticidal check. But the results were inconclusive due to low pest incidence.

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

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

One hundred soil samples were collected from central Western Ghats in Karnataka for isolation of indigenous *Bacillus thuringiensis* isolates. Two Bt isolates from the Western Ghats area was were isolated from 30 soil samples. The screening of the remaining sample is in progress. Bioassay studies with Bt isolate SBI-KK 27 which contains six cry

genes belonging to *cry1A, cry1C, cry1D, cry1E, cry1I, cry2A* and *vip3B* families revealed it was toxic to early shoot borer and internode borer.

The full coding sequence of the *cry1D* gene from SBI-KK 27 was deduced and its amino acid sequence similarity when compared to four other *cry1D* holotype genes revealed that the *cry1D* in SBI-KK27 is a new holotype *cry1D* gene as the maximum hit for homology was only 90.0% *cry1Da* gene. This is the first report of *cry 1D* holotype gene from India. The partial sequence of *cry1E* from SBI-KK 27 also revealed that it could be a new holotype gene. Hence, whole genome sequencing of SBI-KK 27 was undertaken along with another 5 Bt isolates to understand the toxin gene composition of the indigenous Bt isolate. Analysis for the toxin gene content of these isolates is in progress. Cloning and expression of cry8Sa1 in acrystalliferous Bt isolate HD73 was attempted using Bt shuttle vector. Putative Bt transformed when bioassayed against white grub did not show mortality. The electron micrography studies of the putative Bt transformants revealed that there was only spore production but no toxins by the acrystalliferous Bt isolate. The transformation experiment will be repeated again to develop new transformants to conduct bioassay studies and to study their protein expression levels.

(B. Singaravelu, J. Srikanth, C. Sankaranarayanan, P. Mahesh, C. Appunu and G.S.Suresha)

Pesticide dynamics in sugarcane and its ecosystem

Dissipation kinetics of thiamethoxam in the soil of tropical sugarcane ecosystem: Thiamethoxam 75 SG has label claim for managing termites and early shoot borer of sugarcane. Since it has got registered for managing the pests of sugarcane only recently, its dissipation kinetics has not yet been studied in detail in the tropical sugarcane belt of the country. Hence, the dissipation kinetics of thiamethoxam 75 SG was studied in the soil of tropical sugarcane ecosystem at two different doses *viz.*, recommended dose (120 g a.i./ha) and double the recommended dose (240 g a.i./ha). The insecticide was applied at the time of planting as soil drench. Soil samples were collected at periodical intervals from zero day (within two hours after application) till the residues reach below the detectable level of 0.01 mg/kg of soil. The residues were extracted by adopting a sensitive analytical method that involves no dispersive-solid phase extraction (d-SPE) clean-up. The residues were detected and quantified in high performance liquid chromatography (Model: LC 8A, Make: Shimadzu) equipped with diode array detector (SPD-M 10A). The reversed-phase C18 column (Gemini – 250 × 4.6 mm × 5 µm, Phenomenex, USA) was used to determine the residues of thiamethoxam with the mixture of acetonitrile and water (30:70) as mobile phase. The retention time of thiamethoxam at these operating conditions was in the range of 4.77-4.79 min. At the recommended dose, the initial deposit was 0.178 mg/kg. The residues were detected up to 75 days after treatment (DAT) with the half-life of 9.12 days. The initial deposit of thiamethoxam at double the recommended dose was 0.376 mg/kg and the residues were quantified up to 75 DAT. More than 93.0% of the initial deposits got dissipated after 75 days of application and the residues reached below the detectable level of 0.01 mg/kg after 90 days of application in the soil irrespective of the doses. Since thiamethoxam has the soil persistence of more than 75 days, it may protect the sugarcane crop from termites and early shoot borer.

Persistence and metabolism of fipronil in the soil of tropical sugarcane ecosystem: Fipronil 0.3 GR has label claim for managing early shoot borer and root borer of sugarcane. It is one of the widely used insecticides for managing early shoot borer in the tropical cane belt. Its persistence and metabolism were studied in tropical sugarcane ecosystem at its recommended and double the recommended doses. The sample preparation method involves no clean-up with d-SPE sorbents. The residues were detected and

quantified in gas chromatography (Model: GC 2010, Make: Shimadzu) equipped with mass spectrometry (Model: QP 2010 Plus, Make: Shimadzu) using fused silica capillary column (30 m × 0.25 mm × 0.25 µm; Agilent Technologies, USA). The retention times of fipronil, fipronil-sulphide, fipronil-desulfinyl, fipronil-sulfone and fipronil-carboxamide were 12.72, 15.82, 9.03, 12.24 and 18.41 min, respectively. The residues of parent compound and four metabolites *viz.*, fipronil-sulphide, fipronil-desulfinyl, fipronil-sulfone and fipronil-carboxamide were detected and quantified from zero day (two hours after application) onwards. The initial deposits of fipronil and total residues comprising the parent compound and its metabolites were 0.195 and 0.327 mg/kg, respectively. The fipronil residues were detected up to 30 DAT and they reached below the detectable level of 0.005 mg/kg on 45th DAT. Fipronil-sulphide was observed to be the major metabolite in the soil and was quantified up to 45 DAT. The residues of fipronil-sulphide were found to be higher than that of the residues of parent compound from 14 DAT to 45 DAT. Fipronil-carboxamide was detected for a brief period of up to five DAT. The total residues reached below the detectable level on 60 DAT. The half-lives of fipronil and the total residues were 2.33 and 3.38 days respectively. At double the recommended dose, the initial deposits of fipronil and total residues were 0.434 and 0.739 mg/kg, respectively. Fipronil-sulphide was the major metabolite with the initial deposit of 0.162 mg/kg. The residues of fipronil were quantified up to 30 DAT and the residues of fipronil-sulphide were detected up to 60 DAT. The residues of later were observed to be higher than that of the residues of former from 14 DAT till 60 DAT. The total residues comprising the parent compound and its four metabolites were quantified up to 60 DAT and they reached below the detectable level on 75 DAT.

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

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

DNA barcodes were developed for *Saccharicoccus sacchari, Antonina graminis, Holotrichia serrata, Icerya pilosa, Schizotetranychus andropogoni, Chilo partellus and Dysmicoccus carens.* Insects/mites involved in this study were collected from sugarcane fields in Tamil Nadu. Genomic DNA was isolated by adopting the conventional CTAB method with necessary modifications. LCO1490 (5'-GGTCAACAAATCATAAAGATATTGG-3') and HCO2198 (5'-TAAACTTCAGGGTGACCAAAAAATCA-3') were the forward and reverse primers used to amplify the target fragment from the mitochondrial cytochrome c oxidase-I (COI) gene. The PCR programme used to amplify the target fragment is as follows: Initial denaturation at 94°C for 4 min.; 38 cycles of 94°C for 30 sec., 47°C for 45 sec and 72°C for 45 sec.; Final extension at 72°C for 20 min. Sequencing of target fragment was performed in both the directions to identify mismatches, if any, in the sequences. The DNA barcodes thus, developed would serve as ideal species-diagnostic kits for the respective species.

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

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

Seasonal pattern of Telenomus sp. *in internode borer:* The activity of internode borer (INB) egg parasitoids was monitored by collecting borer egg masses from sugarcane crop system at fortnightly intervals. The parasitoid *Telenomus dignus* was active throughout the year, except during the summer months, i.e. March-April. Parasitism rates ranged 33.3-100.0% on egg mass basis, the lower values being in May 2017 and the highest in June and August 2017. Within the egg masses, parasitism rates were 100.0% in almost all observations. Adult emergence from individual egg masses ranged 33.3-100.0% (Fig. 76).

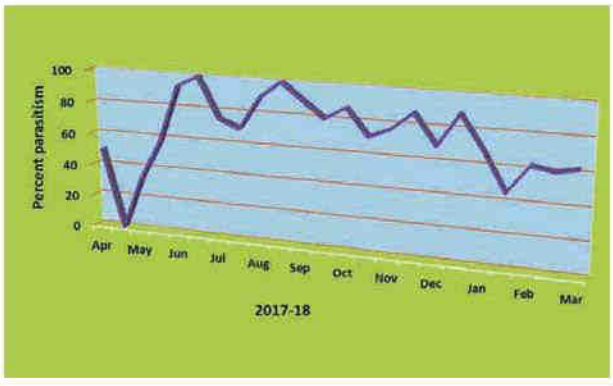


Fig. 76.* Telenomus *activity in internode borer eggs during 2017-18

Survey for egg parasitoids in other cane areas: Egg parasitoid activity in internode borer was surveyed in the farm of ICAR-SBI-RC, Agali, as a part of a preliminary experiment on field colonization of *Telenomus* sp. In a sample of egg masses (n=8), six egg masses (75.0%) were parasitized by *Telenomus* sp., one egg mass (12.5%) was parasitized by *Trichogramma* sp. and one egg mass was not parasitized (12.5%). Mean *Telenomus* adult emergence was 83.3% from parasitized egg masses.

Laboratory parasitization and multiplication studies: In laboratory studies, *Telenomus* adults were exposed to variable number of freshly laid lab-reared egg masses of internode borer to give different host egg: parasitoid ratios. When exposed in glass tubes in small numbers, parasitism was 100% within egg masses with high adult emergence. Parasitization tests were also conducted in glass chimneys to develop as a mass multiplication method. When different ratios of host: parasitoid were maintained, parasitization within egg masses was almost 100% with moderate to high adult emergence. These were comparable to the results obtained in glass tube trials (Table 38).

Effect of host egg age on parasitization

Telenomus generally prefers freshly laid INB eggs. To determine whether old eggs are also accepted for oviposition, one-day old host eggs were exposed to freshly emerged adults of the parasitoid. Results of different batches indicated that parasitization and adult emergence rates within egg masses were comparable to those in fresh eggs but with an occasional lower value (Table 39).

***Table 38.* Laboratory parasitization of internode borer eggs by *Telenomus* sp. at variable host-parasitoid ratio**

Batch no.	No. of INB eggs exposed	No. of parasitoids released	Host: parasitoid ratio	No. of parasitoids emerged	% parasitization	% parasitoid emergence
a. Glass tubes						
1	19	1	19:1	17	100	89.5
2	23	1	23:1	12	100	52.2
3	15	1	15:1	9	100	60.0
4	28	1	28:1	27	100	96.4
5	17	1	17:1	15	100	88.2
6	18	1	18:1	18	100	100
7	20	1	20:1	20	100	100
b. Glass chimneys						
1	110	11	10:1	46	90.9	41.8
2	57	7	8.1:1	39	100	68.4
3	41	8	5.1:1	29	100	70.7

Table 39. **Laboratory parasitization of one-day old internode borer eggs by *Telenomus sp.***

Batch no.	No. of INB eggs exposed	No. of parasitoids released	% parasitization	% parasitoid emergence
1	18	18	100	100
2	29	8	27.6	100
3	30	28	100	93.3
4	21	8	100	38.1
5	34	29	88.2	96.7

Age of parasitoid vs. ovipostion: The oviposition pattern of *Telenomus* adults of varying age was examined by exposing them to INB egg masses. When 20 d old parasitoids were exposed to the host, 100% parsitization and high adult emergence were observed. It appeared that the parasitoid may not oviposit beyond 20 days age, as was observed in two batches. However, in another batch of 22 d old adults, 100% parasitization and high adult emergence were observed which indicated that the parasitoid is likely to oviposit beyond 22 days when provided with honey.

UV sterilization of internode borer eggs: Egg masses of INB were exposed to UV irradiation in a laminar flow for a constant duration of 15 min placing the eggs at two different distances, i.e. 30 and 60 cm from the source of UV light. In both tests, exposed eggs showed hatching and when inoculated in artificial diet, the larvae developed normally, pupated and adults emerged. Further, these adults oviposited in cages.

Improvisation of diet for internode borer: Internode borer diet was modified by substituting sorghum leaf powder with sugarcane shoot powder and maintaining five or 10 larvae in 20 ml diet dispensed in 45 ml vials. Larval/pupal recovery was more or less uniform in different combinations. Pupal weight of males and females, in general, was lower in vials with the higher density (10 larvae) in both leaf powder and shoot powder enriched diet. Between leaf powder and shoot powder, the differences were not very apparent.

Egg laying behaviour of INB: Egg laying behaviour of internode borer in the field was examined (n= 100 leaves) by taking in to account different variables. When position of leaf on the plant (from +1 to + 11) was considered, maximum oviposition was observed on +4 (22%) and +5 (24%) leaves. Slightly higher percentage of eggs was observed on the adaxial surface (56%) of leaves than abaxial surface (44%). When vertical stratification of the leaf was considered, highest percentage of eggs was laid in the middle part (58%) of the lamina. On the surface of leaf, highest percentage of eggs was observed on the lamina (45%) followed by margin (30%) and midrib (25%). The number of eggs per mass ranged 8-25 and among these, a higher percentage (61%) had even number of eggs.

(J. Srikanth, P. Mahesh, K.P. Salin and L. Saravanan)

Bio intensive management of white grub in sugarcane

Efficacy of various microbials in the laboratory against target hosts: Bioassays have been taken up with the insecticides (chlorantraniliprole, chlorpyriphos, imidacloprid, phorate, carbofuran and fipronil), three fungi and the EPN, *H. indica* and *S. glaseri* against IV instar *G. mellonella* at different doses and combinations of each other through three methods of treatments *viz.*, dipping, walk-over and granule exposure. Comparisons of H. indica and insecticides combinations showed that mortality ranged between 0.0 to 100.0% across the treatments, the most effective treatments being *H. indica* + carbofuran (granular exposure method), *H. indica* +

fipronil (Direct dipping), carbofuran (granular exposure), fipronil (direct dipping) causing more than 90% mortality while phorate alone in all three methods and carbofuran alone or imidacloprid alone in walk-over method caused nil mortality. *H. indica* in combination of chlorantraniliprole, carbofuran caused less than 20.0% mortality. *H. indica* caused 23.3% mortality.

Several assays were conducted to assess the efficacy of combined treatments of B. bassiana and insecticides. The results of three sets showed varied efficacies of 0-80.0% mortalities. Since cannibalism, atypical of *G. mellonella* was observed in these treatments; accurate mortalities due to fungi alone or in combination of insecticides could not be ascertained.

Efficacy of various microbials in the pot culture: Pot culture experiments with various combinations of *B. brongniartii, B. bassiana, M.anispliae, H. indica, S. glaseri* and the 6 selected insecticides have been imposed at field recommended dose. First instar grubs of *H. serrata* were inoculated 5 /pot and recovered for observations on mortality after a month through upturning the pots. Three replications and control were maintained. Effect of residual effect was observed by reinoculation of grubs and recovered one month later.

Mortality in treatments involving *B. bassiana* alone or with either chlorantraniliprole or chlorpyriphos or fipronil or carbofuran or imidacloprid or phorate resulted in 100.0% mortality of the whitegrub while the combinations with *B. brongniartii* (93.3%) or *M. anisopliae* (80.0%) or *H. indica* (93.3%) or *S. glaseri* (66.67%) resulted in varied levels of mortality. When the experiments were repeated with fresh second set of inoculation of the grubs, the residual mortality was observed at higher level of 77.0-100.0% in some combinations but to a lower degree in combinations involving fipronil, carbofuran and chlorantraniliprole. Variable levels of efficacy were observed with *B. brongniartii* either alone or in combination of insecticides or other EPF (13.3-100.0%) and residual mortality rates ranged from 11.1-100%. *B. brongniartii* with H. indica or fipronil or chlorantraniliprole was more effective than other treatments while the combination with *M. anisopliae* was the least effective.

M. anisopliae caused 80.0-100.0% mortality in several combinations with the least being 80.0% in the combination with carbofuran. The residual mortality too was high in treatments involving either *M. anisopliae* alone or with chlorantraniliprole, chlorpyriphos, carbofuran and imidacloprid. The EPN *H. indica* performed best with 100% mortality when combined with chlorantraniliprole, fipronil, imidacloprid when compared to the *H. indica* alone (80%). *S. glaseri* alone caused 53.3% mortality while it resulted in higher range of mortality (73.3-100%) when combined with any of the insecticides tested. The insecticides when tested alone caused a mortality range of 20.0% (carbofuran) to 100.0% (chlorantraniliprole) immediately after treatment while the residual mortality was better in case of carbofuran (77.73%), imidacloprid (88.66%), chlorpyriphos (88.86%) and phorate (88.86%).

Persistence of the microbials applied in pot culture: Two sets of experiments were conducted to assess the survival of the spores of the fungi in ambient temperature and in pot culture. In the first set, at saturated moisture levels, the EPF survival in sterile soil without the plants was monitored at 15°C constant through *G. mellonella* baiting at 10 days interval. The experiment is set to include temperatures ranging from 15°C to 35°C to be compared with the fungi survival in pots maintained at ambient temperature, simulating natural conditions. At 10 days after inoculation, the mortalities reached 100% in all the three EPF while the mortality due to EPN *S. glaseri* was 93.33%. Spore harvest /larva from the dead cadavers ranged between 3.2 x x107 to 2.52 x108.

In the second set, the microbials were inoculated in pot culture with the plants and repeated observations are made at 45 days initially and further at monthly intervals on residual efficacy through *G. mellonella* bioassays. At 45 days,

B. bassiana in combinations of any of the insecticides caused more than 80% mortality in *G. mellonella* trap studies and was most compatible with *M. anisopliae* resulting in 100% mortality of larvae. With *H. indica*, the mortality rates were 90% and *S. glaseri*, the mortality rates were 93.33%. At 135th day, while in the combination treatments with insecticides and with *B. brongniartii* and *M. anisopliae* synergistic residual mortalities reached up to 100, the combinations with *H. indica* and *S. glaseri* caused 70% and 80% mortalities respectively. At 9.5 months after inoculation of the microbials, the mortality rates were combinations with chlorantraniliprole and fipronil were more than 90% whereas the mortalities in other microbial combinations were 73.33% *(B. brongniartii)*, 83.3% *(M. anisopliae)*, 80.0% (*H. indica*) and 66.67% (*S. glaseri*). Similar trend was observed with B. brongniartii in combination with other microbials and insecticides.

In *M. anisopliae*, initially combinations with insecticides were antagonistic in nature causing lower mortalities but at six months the interaction flipped over to be synergistic causing resurgence in larval mortalities. By 9th month, 75.0-96.7% efficacy was observed due to treatments involving *M. anisopliae* and insecticides. While mortality due to *M. anisopliae* alone was observed to the tune of 90.0% at 9.5 months, combinations with *H. indica* or *S. glaseri* resulted in 86.6% and 83.3% respectively. The harvest of *M. anisopliae* spores / cadaver ranged from 1x 107 to 1.54 x 108 among the several combinations while it was 4.06 x 107 in treatment involving *M. anisopliae* alone in the observations at 9.5 months.

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

Standardization of mass production of scarabaeid specific Bacillus thuringiensis using agro-industrial by-products for white grub management

Four different media material, namely molasses, sugarcane trash, groundnut cake and neem cake at two concentrations each, along with T3 media, were evaluated for production of Bt-62 strain. In the first experiment, bacterial production differed among the treatments. The highest spore count of 214.34 × 1010 CFU/ml was observed in molasses 6% followed by sugarcane trash 6% (160.60 × 10^{10} CFU/ml) (Fig. 77). Groundnut cake 6% (118.79 × 10^{10} CFU/ml) and molasses 3% (117.74 × 1010 CFU/ml) produced similar output. Similarly, sugarcane trash 3% (106.12 × 10^{10} CFU/ml) and groundnut cake 3% (92.58 × 10^{10} CFU/ml) gave more or less similar output. Neem cake produced the lowest bacterial output among all treatments at both lower (3%) (10.11 × 1010 CFU/ml) and higher (6%) (2.35 × 1010 CFU/ml) concentrations with a dosage dependent effect. T3 medium used as control produced the highest bacterial output (480.95 × 10^{10} CFU/ml).

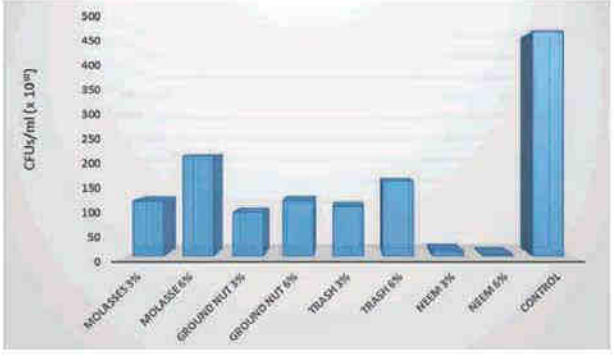


Fig. 77. Bacillus thuringiensis output in different media materials

(P. Mahesh, B. Singaravelu, J. Srikanth and K. Hari)

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

Evaluation of proteinase inhibitors (PIs) of Erianthus arundinaceous against gut proteinases of sugarcane ESB and INB: Proteinase inhibitors (PIs) were extracted from meristem region and stalk tissues of six selected *E. arundinaceous* genotypes *viz.*, IK 76 84, IJ 76 400, IJ 76 364, ERI 2798, Fiji 55 and IJ 76 370. The apical meristem and stalk tissues PIs were assayed against midgut protease enzymes of early shoot

borer (ESB) and internode borer (INB) (Fig. 78 and 79). It is evident from the results that *E. arundinaceous* apical meristem PIs significantly inhibited the midgut proteinases of ESB and INB to the extent of >70.0% and >60.0% respectively. In the genotypes, IJ 76 370, Fiji 55 and IJ 76 364 apical meristem PIs were found to be causing significant reduction of proteinase enzyme of ESB and INB. However, IK 76 84 apical meristem recorded meagre or nil midgut protease inhibition of ESB (0.46%) and INB (0.02%). Similarly, stalk tissues PIs when assayed against midgut protease enzyme of ESB and INB, ESB proteinase inhibition differed significantly and varied from 36.44 to 66.34%. However, it was not significant in midgut proteinase inhibition of INB. The highest ESB protease inhibition of 66.34 and 64.11% was observed in the stalk tissues of IJ 76 370 and IJ 76 364, respectively. Moreover, none of the stalk tissues PIs of *E. arundinaceous* were effective against midgut protease of INB.

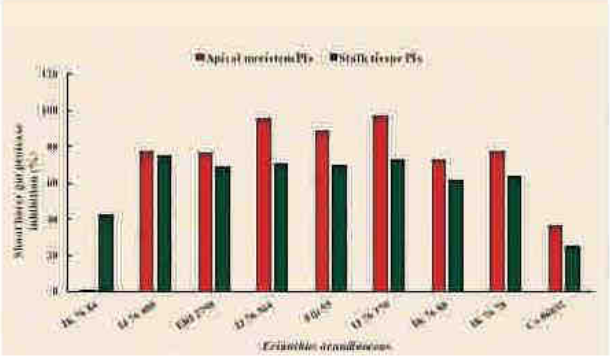


Fig. 78. Evaluation of* E. arundinaceus *PIs against gut proteinases of early shoot borer

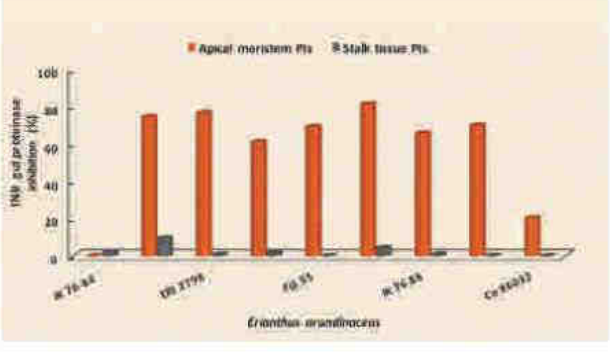


Fig. 79. Evaluation of* E. arundinaceus *PIs against gut proteinases of internode borer

Relationship between E. arundinaceus *apical meristem PIs vs developmental characteristics of sugarcane shoot borer:* A correlation analysis was done to determine the relationship between developmental characteristics of shoot borer with apical meristem PIs of selected *E. arundinaceus* genotypes. Shoot borer larval and pupal survival was negatively correlated with apical meristem PIs of *E. arundinaceus* with coefficient values $P<0.05$, $r= -0.14$ and $P<0.05$, $r=-0.56$ for larval and pupal survival, respectively. Similarly, significant positive correlations were found between the shoot borer developmental period and apical meristem PIs of *E. arundinaceus* with the values $P<0.05$, $r= 0.52$, $P<0.05$, $r= 0.24$ and $P<0.05$, $r=0.56$ for larval, pupal and total developmental period of sugarcane shoot borer, respectively.

Profiling of proteinase inhibitors (PIs) of exotic clones and their evaluation against gut proteinases of ESB and INB: Profiling of proteinase inhibitors (PIs) on leaf sheath, apical meristem and stalk tissues of 6 selected exotic clones *viz.*, F49-11, CP 48-103, US 497, P3332, LF 63 16/17 and H44-2772 were studied. The trypsin inhibition differed significantly among exotic clones which varied from 4.62 to 14.43%, 21.20 to 29.19% and 17.17 to 25.33% in leaf sheath, apical meristem followed by stalk tissues and leaf sheath of selected genotypes. To ascertain the efficacy of PIs of exotic clones, apical meristem and stalk tissue PIs were assayed against midgut proteinase enzymes of ESB. The apical meristem PIs showed considerable inhibition of gut proteinases of shoot borer which varied from 0.00 to 17.76%. A similar trend was followed by the stalk tissue PIs against gut proteinases inhibition of ESB. A simple correlation analysis showed that apical apical meristem PIs were negatively correlated with field incidence of ESB.

Standardization of protocol for purification of proteinase inhibitors: Proteinase inhibitors were partially purified from Co 86032 and *E. arundinaceous* genotype IJ 76 364. The meristem region was powdered with liquid nitrogen. The tissue powder

was further extracted with 20 mMTris-Hcl (pH 7.4) and kept in incubator cum shaker at 4°C for 2 hr. The crude homogenate was centrifuged at 5000 rpm for 30 minutes at 4°C. The soluble proteins in the supernatant were precipitated by adding ammonium sulphate up to 30.0% saturation at 4°C. Then, the precipitated proteins (0-30% fraction) were separated by centrifugation. The remaining proteins in the supernatant were precipitated by adding ammonium sulphate up to 60% saturation at 4°C and pelleted out (30-60% fraction) by centrifugation. The final soluble proteins in the supernatant were precipitated by adding ammonium sulphate up to 90% saturation at 4°C and pelleted out (60-90% fraction) by centrifugation. The three fraction protein samples were taken in a pretreated dialysis bag (0.0025 µm pore size) and dialyzed 48 hours with the same extraction buffer at 40°C. At each concentration, the proteinase inhibitory activity was estimated against commercial trypsin and midgut proteinases of sugarcane borers. The F60-90%, which corresponds to a 60-90% saturation range, showed a high level of inhibitory activity against trypsin. The fractionated proteins (30-60% and 60-90%) of IJ 76 364 significantly inhibited the midgut proteinases of ESB and INB. Similar results also observed in Co 86032, however, gut proteinase inhibitory activity was considerably lower than *E. arundinaceous* genotype IJ 76 364.

Electrophoresis of proteinase inhibitors was carried out by sodium dodecyl sulphate-poly acrylamide gel electrophoresis (SDS-PAGE) method (4% stacking gel and 12% resolving gel) (Fig. 80). The supernatants of IJ 76 364 and Co 86032 crude extract and fractionated protein samples (0-30%, 30-60%, 60-90%) were loaded on the gel and electrophoresis was carried out at room temperature. The gel was stained for 4h. It was then destained till the background was colourless and the bands became clearly visible. The SDS-PAGE was given two wide intact band around 18-25 kDA range in both crude extract and ammonium sulfate 30-60 and 60-90 fraction of IJ 76 364 and Co 86032`.

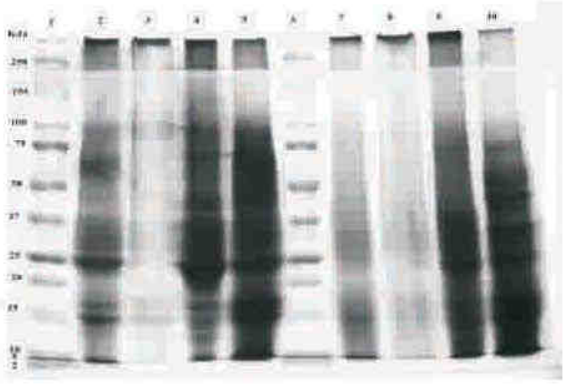


Fig. 80. SDS-PAGE analysis of proteinase inhibitors of* E. arundinacceus *and Co 86032 Lane 1- marker, lane 2- IJ 76 364 crude extract, lane 3 – 5 IJ 76 364 (0-30%, 30-60%, 60-90%) fractions, lane 6 –marker, lane 7- Co 86032 crude extract, lane 8-10 Co 860 32 (0-30%, 30-60%, 60-90%) fractions

(M. Punithavalli)

NEMATOLOGY

Studies on insecticidal molecules of symbiotic bacteria associated with entomopathogenic nematodes

Isolation and molecular characterization of Photorhabdus *and* Xenorhabdus *spp:* Fourteen *Photorhabdus* (SBIPLAH2, SBIPLAH5, SBIPLAH6, SBIPLLP1, SBIPLAP5, SBIPLAP6, SBIPLAP7, SBIPLPA8, SBIPLAP9, SBIPLAP10, SBIPLAP11, SBIPLAP12, SBIP AUP60 and SBIPLAUP113) symbiotic bacteria were isolated from larvae of *Galleria mellonella* infested with EPN *Heterorhabditis* spp. Molecular characterization of five *Photorhabdus* bacterial isolates was done by amplification of the 16S rDNA gene and it was observed that one *Photorhabdus* strain SBIPLLP1 has maximum similarity with *P. luminescens* sub sp. *laumondii.* and all other *Photorhabdus* strains have maximum similarity with *P. luminescens* sub sp. *akhurstii.* Nine *Xenorhabdus* spp. bacteria (SBIXSP3, SBIXSP13, SBIXSUP83, SBIXSUP96, SBIXSUP166, SBIXIH1, SBIXSH3, SBIXIUP81, SBIXHUP8,) were isolated from EPN *Steinernema* spp. Molecular characterization of seven *Xenorhabdus* bacterial isolates was done by amplification of the 16S rDNA gene and it was observed that six *Xenorhabdus*

(SBIXSP3, SBIXSP13, SBIXSUP83, SBIXSUP96, SBIXSUP166 and SBIXSH3) have maximum similarity with *X. stockiae* and two *Xenorhabdus* strains (SBIXIH1, SBIXIUP81) have maximum similarity with *X. indica*; one *Xenorhabdus* (SBIXHUP8) have maximum similarity with *X. hominicki*.

NCBI Submission 16S rDNA sequences of symbiotic bacteria Photorhabdus and Xenorhabdus: Twenty two 16S rDNA sequences of *Photorhabdus* and *Xenorhabdus* have been submitted to NCBI Database with following accession numbers MF872627, MF872628, MF872629, MF872630, MF872631, MF872632, MF872633, MF872634, MF872635, MF872636, MF872637, MF950907, MF950908 *(Photorhabdus)*, MF872619, MF872620, MF872621, MF872622, MF872623, MF872624, MF872625, MF872626, MF950906 (*Xenorhabdus*).

Insecticidal activity of Xenorhabdus against 2nd instar Galleria mellonella: Insecticidal activity of cell and cell free culture of two *X. stockiae* strains (SBIXSUP96 and SBIXSUP166) was studied on *G. mellonella*. *Xenorhabdus* sp.(SBIUP96) as cell free culture and cell culture filtrate recorded maximum mortality of 78.6% and 73.3% of *G. mellonella* larvae respectively.

Insecticidal activity of Xenorhabdus metabolites: Purification of insecticidal metabolites from *X. stockiae* strains *(SBIXSP4)* was done and the fraction was tested against *G. mellonella*. Purified fraction of symbiotic bacteria caused 60-80% mortality of *G. mellonella* larvae.

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

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

Identification of EPN from subtropical sugarcane ecosystem: Twenty-nine EPN were isolated from the subtropical region. Among the 29 EPN, *Heterorhabditis* was isolated from 16 samples and remaining 13 samples were *Steinernema* spp. The EPNs were processed for pure culture, Koch postulate was confirmed and the EPN cultures are being maintained for further studies. Molecular identification of all the EPN isolates was done by analysis of genomic DNA sequences with internal transcribed spacer (ITS) specific primers. The sequences were compared with NCBI database. Among the 16 *Heterorhabditis* isolates, six having maximum similarity with *H. indica* and one isolate having maximum similarity with *H. bacteriaphora* and remaining nine isolates were *Hererorhabditis* spp.

Among 13 *Steinernema* isolates, one has maximum similarity with *S. thermophilum*; five isolates having maximum similarity with *S. surkhetense*; one isolate having maximum similarity with *S. carpocapsae* and remaining isolates were *Steinernema* spp.

NCBI submission of ITS sequences of EPN: ITS sequences of 13 EPN (*Heterorhabditis* and *Steinernema* spp.) isolated from sub-tropical sugarcane ecosystem have been submitted to NCBI Database with the following accession numbers MF919610 to MF919618 (*Steinernema* spp) and MF919619 to MF919622 (*Heterorhabditis* spp).

Bioefficacy of subtropical isolates against Galleria mellonella*:* Bio efficacy of 16 *Heterorhabditis* and 13 *Steinernema* isolates were tested against larvae of *G. mellonella*. All the EPN caused 40 to 100 % mortality of the *Galleria* larvae. Among the *Heterorhabditis*, isolate SBIUP caused 100% mortality followed by three isolates which caused 90% mortality. Among *Steinernema* isolates SBIUP8 and SBIUP96 caused 90% mortality.

Pathogenicity of Heterorhabditis *isolates against H. serrata 1st instar:* Pathogenicity of 15 subtropical *Heterorhabditis* spp. against first instar white grub of *H. serrata* revealed the mortality of white grubs by EPN. The mortality of grubs ranged between 20 and 100%. Lowest LD_{50} (22 IJs/grub) was recorded for three EPN isolates *viz, H. indica* (SBIP1834) *H. indica* (SBIP1835) and *Heterorhabditis* sp. (SBIUP76).

Pathogenicity of Steinernema *isolates against* H. serrata *1st instar:* Pathogenicity of 11 subtropical *Steinernema* spp. against first instar white grub of *H.*

serrata revealed that *S. surkhetense* (SBIUP171) recorded the lowest LD_{50} (22 IJs/grub) against white grub.

Mass production of EPN by monoxenic liquid culturing: Mass production of EPN, *S. abbasi* SBIP4 was attempted by Monoxenic liquid culture method. Nine different media compositions were tried with or without carbon and lipid source. Successful multiplication of EPN was observed in liquid media and the yield of EPN was 8700IJs/ml of media which was 43 fold. The *in vitro* produced IJs were bioassayed against *G. mellonella.*

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

5.4 STATISTICS AND ECONOMICS SECTION

Management and Maintenance of Database Resources/facilities

Agricultural Knowledge Management Unit has redesigned and upgraded the Institute's website http://sugarcane.icar.gov.in hosted at ICAR-Data centre. Added the link to online payment vide State Bank of India. The information on scientists' profiles, employee details, tenders and quotations, vacancy annoncements, recent news and events at ICAR-SBI were updated.

The On-line database on Personnel Management Information System Network (PERMISNET-II) for ICAR was updated at regular monthly basis. Other details of scientists' particulars were updated as and when required by the Nodal Officer, PIMSNET and HYPM.

Capacity development programmes were conducted to staff with respect to HRMS which includes employee self service module related to leave application, APAR, etc. and pay roll module. In addition, module related to supply chain management (SCM) and finance are in the process of integration in the day to day work.

Capacity development programmes conducted to the staff are listed:

Date	Module	Topics
21.04.2017	Finance	Bill-creation (contigents,TA,medical, LTC, advance and etc)
22.04.2017	Finance	Bill validation, payment, voucher report, receipt creation
24.04.2017	Grants and Budget	Budget upload and funding, cash based report, fund inquiry report
25.04.2017	Payroll	Payroll data updation, Payroll run, assignment creation, single payroll run, payroll roll backup, payslip download, reports taken after payroll run
26.04.2017	Project	Project-creation (RPPI,RPPII,RPPIII), externally funded project creation, enter budget, status of budget for external funded project, report for project
27.04.2017	Core-HRMS	Leave management, Leave monitoring, Leave pending status, apply leaves, joining report, service book updation, personal file updation, promotion, Retirement, reports - Leave order, promotion, relieving and etc.,
28.04.2017	Store Management	Indent creation, vendor creation, RFQ creation, Quotation creation.
01.05.2017	Store Management	PO creation, PR-PO hierarchy, inspection, material issue, receipt creation, on hand quanity, stationery items stock updation etc.,
02.05.2017	Finance and Grants Budget	Payroll run and following the process in payroll run in Audit and Account section, import the journal, journal post, BE and RE uploading etc.,

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

The following technologies *viz.*, Soil moisture indicator, Sett treatment device, Production of farm yard manure and jaggery production enterprise were finalized for study of the entrepreneurship potential. On the basis of the analysis of the various economic activities involved in the technology development process, commercial production and marketing of the technologies, the cost factors involved in promoting an enterprise will be worked out. Other factors like demand/market estimates, production potential and break even points for the profitable operation of the four enterprises will be delineated. The entrepreneurial value / commercial potential of the technologies will be worked out based on the following analysis/ techniques which were finalized for the study after screening/ reviewed about 21 different techniques: Based on the output and outcome of the study Capacity Development Module and Benefit-Cost Analysis (Net income/Internal rate of return/Present minimum investment value/ average annual margin of profit), Break Even Point, Man power assessment, Energy Auditing and TEM, Total quality management, Good engineering and manufacturing Practices, Material and inventory management and JIT, Market analysis.

(V. Venkatasubramanian, P. Murali, D.PuthiraPrathap and T. Arumuganathan)

An economic analysis on sugar recovery in different states in India

The study aimed to estimate the improvement in sugar recovery *vis-a-vis* with varieties in Tamil Nadu. Time series data on area under the variety CoC 671 during 1980 to 2000 was collected along with sugar recovery and yield in six different sugar mills area namely, Dharmapuri Cooperative Sugar Mill at Palacode, Ponni sugars at Pallipalayam, Aruna alias Ambika Sugars at Pennadam, Sakthi Sugars at Appakudal, and Amaravathi Cooperative sugar mills at Krishnapuram which had considerable area under CoC 671. The variety was adopted in the range of 30 to 70% in different agro climatic zones of Tamil Nadu during 1981-2000.

The cultivated area of variety CoC 671 and sugar recovery in Dharmapuri sugar mill during 1981-2000 is shown in Fig. 81.

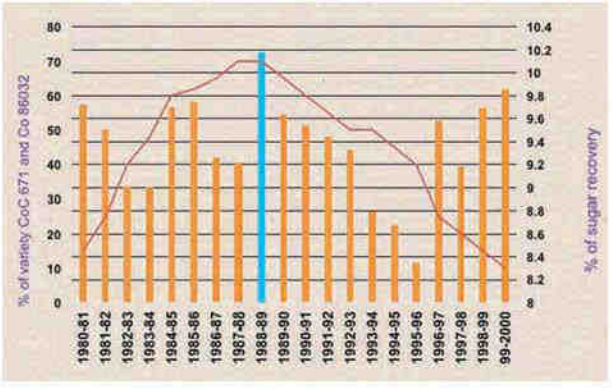


Fig. 81. Correlation of sugar recovery with % of area of CoC 671 at Dharmapuri Sugar mill zone

Sugar recovery was significantly improved in correlation with adoption of the variety. The peak sugar recovery was recorded (10.2%) during 1988-89 and it was more than 1.5% when it was compared with 1980-81, where the variety was adopted in a meagre 10% in the study area. Nevertheless, sugar recovery was significantly reduced after 1992-93 due to red rot disease and consequently cultivation of the variety in the sugar mill zone was reduced less than 10% for containment of the disease.

The varietal percentage and sugar recovery of Ponni sugars Erode is depicted in Fig. 82. The sugar mill was started during 1983-84 and sugar recovery was improved corresponding with adoption of variety CoC 671. The peak sugar recovery was recorded during 1988-89, nevertheless the varietal adoption was 25% of total cane area in mill zone and its concluded that improvement in sugar recovery was not primely governed by the variety CoC 671. The other varieties such as Co 6304 and Co 8021 also immensely contributed for the betterment of the sugar recovery in the particular region. The variety was slowly withdrawn from cultivation anticipating the disease outbreak. Consequently, Co 86032 was adopted and predominantly cultivated in the sugar mill zone.

Fig. 82. Sugar recovery and % area of variety CoC 671 at Ponni sugars, Erode

Pennadam in Villupuram district is a traditionally sugarcane growing zone in Tamil Nadu. Aruna sugars which was established in 1965 has about 20,000 acres of registered cane area. The variety CoC 671 was adopted during 1980's was 70% of the total cane area cultivated in the sugar mill zone (Fig. 83). Sugar recovery was 10% during 1988-89 and peak sugar recovery was recorded (10.4%) in 1992-93. The variety CoC 671 has set a tone for high sugar recovery in the zone; however, peak sugar recovery was recorded when the varietal area was about 50% of the total cultivated cane area in the sugar mill zone.

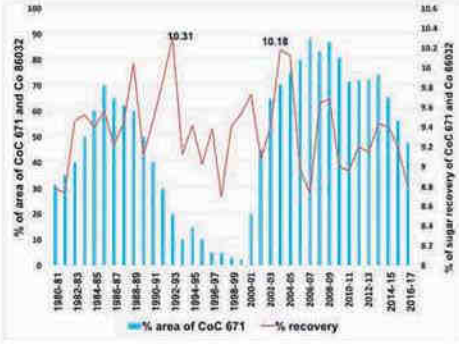


Fig. 83. Sugar recovery in relation with varieties at Aruna alias Ambika sugars, Pennadam

Sakthi sugars at Appakudal has adopted the variety CoC 671 since 1982-83 with 25% of the cane area in the sugar mill zone (Fig. 84); the area of the variety had been increased to 42% in 1984-85. Due to its susceptibility to red rot, the area of the variety was restricted to 25% of the total cane area in the sugar mill zone. The sugar mill has four prominent varieties such as CoC 671, Co 6304, Co 7704 and Co 8021 with 25% each has achieved peak sugar recovery of 10.6% during 1988-89. The analysis has revealed that mixture of varieties with right proportion had achieved peak sugar recovery than a prominent variety alone.

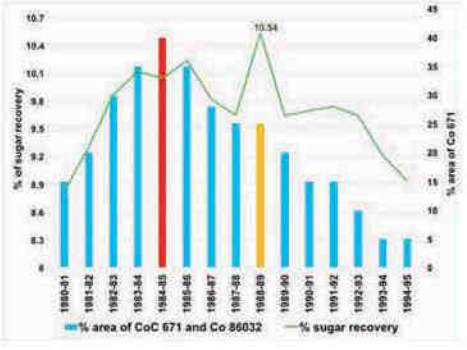


Fig. 84. Sugar recovery in relation with variety CoC 671 at Sakthi sugars, Appakudal

The Amaravathy sugar mill is located in North Western Zone of Tamil Nadu. The sugar mill had adopted CoC 671 since 1981 and the variety has reached 70% of the cane area in the sugar mill zone in 1988-89. The peak sugar recovery was recorded (10.1%) during 1988-89 with 70% of cane area was cultivated by CoC 671 in the sugar mill zone. The variety has significantly improved recovery percentage. Though the variety was susceptible to red rot, it was not severe in the sugar mill zone (Fig. 85).

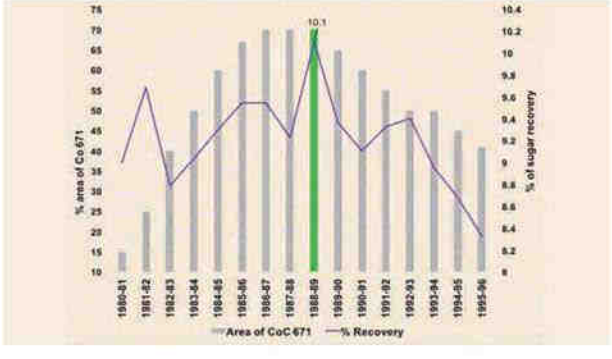


Fig. 85. Sugar recovery in correlation with variety CoC 671 at Amaravathy Sugars- North Western Zone of Tamil Nadu

The study has estimated that sugar recovery was significantly increased due to cultivation of variety CoC 671 in different agro climatic zones of Tamil Nadu. The variety has performed well in the canal command area and tropical climate, nevertheless, the performance was comparatively lesser in the coastal climate coupled with high relative humidity. The variety was gradually withdrawn by many sugar mills due to red rot disease, finally the variety was banned in the coastal areas to avoid the disease spread and the sugar recovery was recorded lowest in 1995-96.

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

Socio-economic impact of ICAR-SBI varieties and production technologies in different agro-climatic zones of India

The project was initiated with the aim of consolidating the research efforts of ICAR – SBI since 1912. The scenario of sugarcane and sugar production since beginning of the 20th century and during the release of first hybrid variety Co 205 was compiled and analyzed. The data and information from various reports and journals during the study period were collected and used for the study. Since the sugar production of British India was for the first time incorporated into the world's statistics, the world's sugar production (beet and cane combined) has been depicted in the table1 and expressed in long of 2,240 lb (Table 39).

The United States had produced amounting to 9,90,710 long tonnes during 1920-21 which is the largest crop yet produced in that country. About 50% of the total world sugar production was shared by the USA with beet sugar. The United States of America had 3,37,710 long tonnes more homegrown sugar and being a large importer, this reduction in requirements of foreign sugar had some influence on the prices of sugar commodity in the world's markets.

From these figures, it was concluded that in the first decade of the past century, sugar production of the world oscillated around 14,000,000 tonnes and since during long a period, no considerable stocks had accumulated. The average consumption amounted to a corresponding figure. In 1910-11, there was large increase in production, which was only temporarily interrupted by the disastrous drought in central Europe of 1911 and it brought the total sugar production up to the astounding figure of 18,498,498 tonnes in 1914-15.

For numerous reasons, the European sugar production had decreased wholesale and the deficit was only partially made good by an extension of the cane sugar production in some countries, among which Cuba was the most conspicuous. The world's total diminished each year, till it attained its lowest point in 1919-20 with 15,22,684 tonnes. The general feeling was one of sugar scarcity and shortage, and it

***Table. 39.* World sugar production (beet and cane)**

Year	Sugar production (Long tonnes)	Sugar production (million long tonnes)
1904-05	12,022,000	1.20
1905-06	14,007,000	1.40
1906-07	14,799,000	1.49
1907-08	13,861,000	1.38
1908-09	14,582,165	1.46
1909-10	14,891,187	1.49
1910-11	17,001,529	1.70
1911-12	16,064,391	1.61
1912-13	18,243,235	1.82
1913-14	18,430,873	1.84
1914-15	18,498,498	1.85
1915-16	16,968,003	1.69
1916-17	17,096,828	1.71
1917-18	17,422,589	1.74
1918-19	15,858,265	1.59
1919-20	15,222,684	1.52
1920-21	17,302,510	1.73

led to be phenomenally high prices recorded in the second quarter of 1920.

German had production in excess of early estimates. According to these reports, the country had produced 1,20,000 tonnes which was not only provide an increased ration for household consumption but permited of distribution to all industries. It was even possible that at a satisfactory price a small export was possible, after provision has been made for domestic needs. The Government had announced that it intended to increase the internal tax on sugar to 100 marks per 100 kilograms. The present tax was 7 pfenning per pound. However, Germany's present production was nowhere near her internal consumption, there was little probability of much export anywhere.

It was estimated that production of sugar in France during 1920-21 was 3,26,238 long tonnes of raw sugar against 1,69,560 tonnes for the last campaign. These figures had indicated that the French production was 2,93,600 tonnes of refined sugar. It was recorded that the pre-war annual consumption of sugar in France was 6,50,000 tonnes, and in spite of this 92 per cent increase in production. If no rationing was resorted to, France still had to import sugar from other countries.

This fact had inclined to suggest that the production of 1920-21 was equal to the figures of 1910-11 (only ten years ago), that production was more than sufficient to cover the demand under the prevalent circumstances.

During 1921, the net cost price of white Java sugar ready for direct consumption at 10.67 guilders per picul or £14-9-0 per long tonnes, (all included, interest on capital and renewals). The cost of refining crystals was about one pound lower per long tonnes. The excess profits tax, which was levied on the difference between the selling price and 10 guliders per picul, is not incorporated in this price. It is estimated for 1920 at 5 guliders per picul, thus bringing the total net cost price, inclusive of all taxes, but excluding interest on capital and renewals, to 15.67 guliders per picul, or £ 21-4-5 per tonne of white sugar. Taking interest and renewals into account, the cost in Java would come £ 23 tonnes which was equal to 17 Rs. per maund (80 lb).

Taking percent exchange as 1s. 4d. to the rupee, Rs.14 as the cost price per maund, all included, at warehouse in Java. Adding to this ocean freight and other charges incidental to shipping and landing, nearly Rs.16 per maund was the landed cost at Calcutta. India had levied a 15 per cent as ad valorem duty, thus adding Rs. 3-8 in the second. This had raised the price to Rs. 19-8-0 per maund in the case of white sugar for direct consumption and to a little less than Rs. 19 in the case of low grade sugar.

We thus get a basis of Rs.20 per maund before Java sugar came into Indian sugar at sugar consumption centers up-country. Now at a basis of Rs.20 per maund, the worked-out value was 11 annas per maund for cane which was a fair efficiency to demand. It will thus be seen that the future for Indian sugar was very favourable and it was to be hoped that full advantage had been taken of present conditions.

In the years immediately preceding the war, the civilized world was enjoying an unknown preceding. Consumption of articles, which may to some extent, be considered as a kind luxury and among which sugar occupies a prominent place, increased considerably, a fact which had deduced from the enormous increase in the per capita sugar consumption in many a European and American country. Therefore, in the years before the war, the increased sugar production was correspondingly absorbed by consumption. So generally, the case that in the calculations made by the sugar statisticians, the question of the consumption was treated as a secondary matter and as a rule, the sugar produced had find a destination without trouble.

In the war years, consumption remained high; the wants of armies and navies had necessitated the supply of huge amounts of sugar, both in the shape of sugar for food and beverages as in that for confections, while some sugar also was used in the manufacture of explosives. After the armistice, a

spirit of lavishness ensured all over the world, which delivered from the prolonged oppression of war, indulged in every from of extravagance. The high wages were accorded immediately after being claimed allowed wide sections of the populations to spend money on extras, and it was remarkable to witness the extent to which grown-up people fed on chocolates, sweets, acid drops and the like. The price of the article was not regarded as a hindrance to its being purchased up to the amount allowed by the Government rationing, which in many countries was far above the average per capita consumption of the years immediately after the war.

Further, people who during the years of war had witnessed periods of sugar scarcity, it was not possible to obtain the quantities which they might desire to purchase, now profited by temporary abundance to lay in stocks which at once disappeared from view. It looked as though there could not be produced enough to supply the ever-growing desire for sugar, and notwithstanding the fact that immense quantities of sugar, which owing to the blockades and general scarcity of merchant of shipping had been held up in foreign countries, now became available, the visible stocks of sugar was remained short. It was accorded that statisticians neglected the study of consumption and only fixed their attention on the production, the increase of which was the aim and end of everybody concerned.

But during the last half of 1920, the free purchase of sugar by the general public came to an abrupt stop. Sugar was no longer snapped up in the market as soon as it made its appearance; it was even offered in vain; prices had showed an inclination to drop, and that precipitated the trouble. The public who, in many cases possessed appreciable quantities of sugar hidden in their store cupboards, stopped buying and lived on their supplies. The grocers stopped their orders and the wholesale dealers, who had already contracted large purchases, became overstocked in consequence. Thus, all at once, instead of a sugar scarcity, there ensured an abundance of sugar (Coming from every part of the world) with very restricted purchase and consequently a heavy drop in the price.

By now the invisible supplies had been consumed and the public had to buy it if wants sugar; but, in the meantime, the general aspect of matters has greatly changed. Instead of high wages and good earnings, unemployment had become the chief factor that rules the budget of the average household. Sugar was one of the articles the consumption of which was greatly dependent on the earnings of large proportion of the populations. So long as the wages were high, sugar was brought and used in great quantities, but as soon as more economy had to be practiced, it was the first article had been sacrificed.

The same or analogous reports has reported from every part of Europe and shown that a general decrease in sugar consumption was the rule everywhere including Russia. The sugar production of 1920-21 was attained to about as high a figure as that of 1910-11, which in the last-mentioned year consumed about 2,000,000 tonnes, had fallen out almost completely, while the consumption of many others was greatly handicapped. The conclusion to be drawn from all these data was that the day had surely passed to for the time being when any amount of sugar produced was sure to find an outlet; and the question of the probable world's consumption was once more have to be taken into earnest consideration.

(P. Murali, V. Venkatasubramanian, Ravinder Kumar and K. Elayaraja)

Application of indents and purchase orders are done through ERP system. Payroll is run successfully in the Institute including the Regional Centres. Payment is also done through ERP and PFMS system.

AEBAS: Seven wall mount Biometric Systems in Main institute, Coimbatore and one wall mount Biometric system in Karnal and five numbers of desktop biometric systems was installed. AEBAS application for desktop and wall mount are updated with the latest version.

5.5 EXTENSION SECTION

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

Sugarcane Research and Development workers meetings Tamil Nadu & Puducherry: The 48th meeting of Tamil Nadu and Puducherry was held at Hotel Radisson, Salem during 1-2 November 2017 and hosted by Kallakurichi - II Co-op. Sugar Mills Ltd. (Gomuki), Kallakurichi. Shri M. Senthamil Selvan, Additional Director of Sugar, Govt. of Tamil Nadu inaugurated the meeting and released the 'Compendium of Research Articles and Status Papers' (Fig. 86).

Fig. 86. Release of Compendium during R&D meeting (1-2 November 2017)

Dr. Bakshi Ram Director, ICAR-SBI delivered the Theme Address. About 450 delegates from ICAR-Sugarcane Breeding Institute, Coimbatore and Tamil Nadu Agricultural University, Coimbatore, Cane Development personnel from various sugar factories, officers from the Department of Agriculture, Directorate of Sugar and other Cane Development organizations in Tamil Nadu and Puducherry participated in the meeting. The factory had organized a varietal display of recent and popular varieties at the venue. The major topics discussed were, soil fertility based fertigation for sugarcane, review of sugarcane mechanization initiatives including mechanical harvesting, current varietal position and performance of new sugarcane varieties etc.

National level programs organized: Five two-days National Level Training programmes on 'Scientific Sugarcane Cultivation' sponsored by the Directorate of Extension, Ministry of Agriculture, Government of India under National Food Security Mission were organized (Fig. 87-91) as detailed below:

- I training: 27 participants from Andhra Pradesh (2), Karnataka (5), Tamil Nadu (9), Odisha (2), Uttar Pradesh (5), Goa (1) and Uttarkahand (3) during 26-27 September 2017.
- II training: 28 participants from Andhra Pradesh (2), Karnataka (6), Tamil Nadu (15), Odisha (2) and Uttar Pradesh (3) during 3-4 October 2017.
- III training: 25 participants from Andhra Pradesh (2), Karnataka (6), Tamil Nadu (12), Odisha (2) and Uttar Pradesh (3) during 6-7 October 2017.
- IV training: 25 participants from Andhra Pradesh (2), Karnataka (6), Tamil Nadu (13), Odisha (2) and Uttar Pradesh (2) during 9-10 October 2017.
- V training: 25 participants from Andhra Pradesh (3), Karnataka (4), Tamil Nadu (13), Odisha (3) and Uttar Pradesh (2) during 12-13 October 2017.

Knowledge evaluation studies conducted at pre and post training indicated that the average pre-evaluation score was 69.99, the range being 65.95 to 73.90; the average post-evaluation score was 90.08, the range being 86.58 to 92.05; the average of difference in knowledge level was 20.09% with a range of 14.94 to 26.13.

Fig. 87. Participants of the training programme (26-27 September 2017)

Fig. 88. Participants of the training program (3-4 October 2017)

Fig. 89. Participants of the training program (6-7 October 2017)

Fig. 90. Participants of the training program (9-10 October 2017)

Fig. 91. Participants of the training program (12-13 October 2017)

Model Training Course: A Model Training Course on 'Best management practices for sustained sugarcane productivity' sponsored by Department of Agriculture and Cooperation, Ministry of Agriculture and Farmers Welfare, Government of India was conducted during 4-11 January 2018 (Fig. 92-94). Eighteen officers from the state department of agriculture from the states of Chattisgarh, Haryana, Himachal Pradesh, Kerala, Maharashtra, Odisha, Tamil Nadu, Telengana and Uttarkhand attended the programme. The programme comprised theory classes, practical sessions, visits to experimental fields, laboratory visits, visit to bud chip settling unit and visit to farmers fields.

Fig. 92. Participants of the Model Training Course

Fig. 93. Participants visiting Bud chip settling unit in Erode district

Fig. 94. MTC participants visiting farmers fields

State level training program

A state level training program was organized for 18 senior cane officials from Uttar Pradesh during 17-22 April 2017 (Fig. 95 and 96). The training was sponsored by Lal Bahadur Shastri Ganna Kisan Sansthan, Lucknow. As a part of the training, visits were made to Indian Institute of Soil and Water Conservation Research Centre, Udhagamandalam, Central Marine Fisheries Research Institute Research Centre, Mandapam and Agricultural College and Research Institute, Madurai.

Fig. 95. Participants of the training program (17-22 April 2017)

Fig. 96. Participants at CMFRI - RC, Mandapam

A state level one-day training program on 'Recent advances in sugarcane cultivation' sponsored by Directorate of Sugarcane Development, Lucknow was conducted for 90 farmers from Coimbatore, Erode and Tirupur districts on 31 January 2018 (Fig. 97 and 98).

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

- For 22 cane staff from Dharmapuri District Cooperative Sugar Mills Ltd., Palacode on 23 August 2017.

Fig. 97. Participant farmers of the one-day training (30 January 2018)

Fig. 98. Demonstration of Bud chip settling planter

- For 52 farmers from Namakkal district on 26 September 2017.
- A one-day training program on 'Liquid jaggery production' was organized in collaboration with MYRADA KVK, Erode district for 14 sugarcane growers from Erode district on 26 October 2017 (Fig. 99 and 100).
- A one-day training program on 'Scientific sugarcane cultivation' was organized for 50 sugarcane growers from Yekandur, Chamrajnagar, Karnataka state on 14 November 2017 (Fig.101).
- For 15 sugarcane growers from Hosangabad, Madhya Pradesh on 14 February 2018.

Fig. 99. Visit to Institute museum

Fig. 100. Practical session in progress

Fig. 101. Farmers from Chamrajnagar, Karnataka visiting sugarcane fields (14 November 2017)

Exposure Visits: Conducted 'Exposure Visits' for 78 students of class 11 from Sethubhaskara Higher Secondary School, Chennai on 30 May 2017 (Fig. 102); 30 Students from Govt. Higher Secondary School, Vallankumaranvilai, Kanyakumari district on 5 August 2017. 42 students of class VII from Corporation Higher Secondary School, Coimbatore district on 2 November 2017. 30 delegates from 16 countries organized by Kothari Management Research Centre, Coonoor on 12 January 2018 (Fig. 103).

Fig. 102. Students being explained in the Institute museum

Fig. 103. Delegates visiting Technology Park on 12 January 2018

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 three batches:

- 18 IV semester students during 3-7 May 2017
- 26 II semester students during 11-20 June 2017
- 21 II semester students during 27 October - 5 November 2017.

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

- Agri-Intex 2017 organized at CODISSIA Trade Fair Complex during 14-17 July 2017 (Fig. 104).

Fig. 104. A view of ICAR-SBI stall in Agri-Intex 2017

- 'Velaan thiruvizha 2018' organized by Shri Sakthi Institute of Engineering and Technology, Coimbatore during 6-7 January 2018.

- State level Farmers Day organized at TNAU, Coimbatore during 9-10 February 2018 (Fig. 105).

Fig. 105. Dr. Alagusundaram, DDG (Engg), ICAR & Dr K. Ramasamy, VC, TNAU visiting ICAR-SBI stall (9 February 2018)

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

Visitors programme: We had entertained 5289 visitors during the period comprising students (4427), farmers (613), cane development officers and university staff (259). They were shown the Institute Museum, Technology Park and the laboratories.

Scientists-Extension Workers-Farmers Interface Meet: Conducted a District level Scientists-Extension Workers-Farmers Interface Meet in collaboration with Avinashilingam KVK on 29 March 2018 with the participation of 22 farmers and district level officials from the Departments of Agriculture, Horticulture, Animal husbandry and Sericulture (Fig. 106).

Fig. 106. Interface Meet in progress (29 March 2018)

Frontline demonstration: The following demonstrations were planted:

- A frontline demonstration plot with four sugarcane varieties *viz.*, Co 0212, Co 92005, Co 06030, Co 86032 was planted in a jaggery farmers' field in Periyamangalam village, Vellore district on 8 February 2017. Performance of FLD plots were: Co 0212-112.50 t/ha, Co 92005-105 t/ha and Co 06030-95 t/ha.
- Five FLDs on the variety Co 0212 with Co 86032 as control were planted in Kumarasamypuram, Ganeshapuram, Periyasadayampalayam, Vellode and Koorampalayam.
- The Varietal Demonstration in Avinashilingam KVK, Karamadai with six sugarcane varieties namely Co 86032, Co 0212, Co 0238, Co 06022, Co 06030 and Co 99006 was maintained.

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 tissue culture plants were planted in the Institute covering 150 rows.

National Science Day: National Science Day was celebrated as an 'open day' on 28 February 2018 (Fig. 107). Students of schools and colleges were invited for inculcating scientific awareness for nation building. Nearly 850 students visited the Institute. The students were taken around the Institute's museum and the exhibits with live specimens were explained by Scientists and Technicians apart from video shows.

Fig. 107. Students looking at the exhibits

Institute publications:

- SBI Annual Report 2015-16. pp.154 in Hindi
- SBI Annual Report 2016-17. Pp 184
- SBI News Vol. 37 (2), (3), (4)
- Training Manual – 2

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 programs.

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

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

This project identified the ICT resources used by sugarcane growers and cane development personnel in the disadvantaged districts of Tamil Nadu, ascertained the demographics of cane development personnel and cane growers in these districts and ascertained their problems/ barriers/ limiting factors in accessing and using ICTs.

A total of 240 farmers and 60 cane development personnel selected at random from all the disadvantaged districts of Tamil Nadu, *viz.*, Tiruvannamalai, Cuddalore, Villupuram and Nagapattinam, as identified by the Planning Commission of India formed the sample for the study.

Initially, a standardized interview schedule was prepared in consultation with the stakeholders and review of existing literature. Following this, a pilot survey was conducted in EID Parry (I) Ltd., Sugar factory, Pugalur area among cane growers and cane development personnel belonging to the factory divisions of Muthur, Karur, Kodumudi, Molapalayam, Velayudhampalayam (W) and Vaangal. After refining the interview schedule based on the findings of the pilot survey, the main survey was conducted in Nagapattinam district, a disadvantageous region in Tamil Nadu. Sixty farmers and 15 cane development personnel belonging to Kuthalam and 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.

Subsequent to the main survey conducted in Nagapattinam district, survey was conducted in Bannari Amman Sugars Ltd., Sugar factory, Thandarampattu area and Tirupattur Co-op Sugar Mills Ltd., area in Tiruvannamalai district, a disadvantageous region of Tamil Nadu. Sixty farmers and fifteen cane development personnel belonging to Chengam, Pudhupalayam, Mangalam, Kanji, Tiruvannamalai and Thandarampattu Cane divisions of Bannari Amman Sugars Ltd., (BAS) Thandarampattu and Chengam Cane division of Tirupattur Co-op Sugar mills Ltd., formed the sample for the survey.

In Villupuram district, 60 farmers and 15 cane development personnel belonging to Villupuram, Koliyanoor, Valavanoor, Mundiyampakkam and Soorappattu divisions of Rajshree Sugars and Chemicals Ltd., Mundiyampakkam formed the sample for the main survey.

Finally, in Cuddalore district, 60 farmers and 15 cane development personnel belonging to millsite, Pennadam, Murungukudi and Kariveppilankurichi divisions of Sri Ambiga Sugars Ltd., Pennadam and mill site, Vriddhachalam West, Veppur/ Sirupakkam, Nagalur, Kottai and Athur divisions of Thiru Arooran Sugars Ltd., A. Chittur formed the sample. Data pertaining to ICT resources used by the cane growers, perception on ICT availability and use, barriers in access and use and their information needs and content priorities for CaneInfo website were collected from them. The results of the study would be relevant to the extension agents, researchers and students of agriculture. From a policy perspective, the findings of the study could help policy makers, ICT providers, sugar factories, NeGP-related initiatives and information providers, to develop strategies in implementing ICT programmes and in addressing the challenges faced by the cane growers and the change agents.

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

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

Surveys were carried out in Tiruvannamalai, Cuddalore and Villupuram districts of Tamil Nadu for assessing the extent of adoption of cane technologies. Earlier, districts namely Namakkal, Dharmapuri, Tirunelveli, Vellore, Nagapattinam and Karur were covered.

- A field demonstration was held in Irugur village to demonstrate Co 0212 variety. This variety yielded about 90 t/ha at nine months of age as against 75 t/ha of Co 86032.
- An On-Farm Trial was laid out in the field of Shri Ambigapathy of Pallapalayam (Oddarpalayam) village with varieties Co 09004, a pre-release clone of ICAR-SBI and Co 86032 on 8.2.2016. In the OFT plot of Co 09004, this variety had yielded about 79 t/ha at nine months of age as against 75 t/ha of Co 86032
- *On-Farm Trial:* An On-Farm Trial was laid out in Varappallam (Perumugai) village, Erode district with varieties Co 09004, a pre-release clone of ICAR-SBI and Co 86032 on 1 March 2017. Results showed that Co 09004 variety had yielded 145 t/ha as against Co 86032 which had yielded 167.5 t/ha.
- At nine months, Brix % of Co 09004 was 18.84 as against 17.43 for Co 86032. Brix % at 12 months was 20.20 in Co 09004 as against 20.06 in Co 86032 with CCS % of 10.86 and 10.76 respectively.

(D. Puthira Prathap, T. Ramasubramanian, T. Rajula Shanthy, P. Murali, V. Venkatasubramanian and K. Mohan Raj)

Farmer support program for sustainable sugarcane production in India

This project was sponsored by Solidaridad through Prakruthi with the objective to train lead farmers representing eight sugar mills of Tamil Nadu on sustainable agricultural practices to improve their knowledge base and thereby cane productivity and profitability of cane farming. The trained lead farmers would serve as change agents to enable fellow farmers take up sustainable farming at village levels.

A total of 16 training programs with the participation of 755 cane growers and 58 cane development personnel from eight sugar mills of Tamil Nadu state were conducted and were trained as Sugarcane Lead Farmers. During every training programme, a Scientists-Farmers Interface Meet was conducted and 111 frequently asked questions were compiled and categorized into queries related to varieties (35), production technologies (17), pest management (24) and disease management (35) and is being printed as a booklet in English and Tamil.

Conducted a one-day training program on 'Organic sugarcane cultivation' followed by an Interface Meet for 93 farmers from Coimbatore and Erode districts on 17 March 2018 (Fig. 108).

Fig. 108. Farmers-Scientists Interface Meet on 17 March 2018

(T. Rajula Shanthy)

Digital inclusion of rural youth for sustainable development: A comparative assessment

This project, funded by Rajiv Gandhi National Institute of Youth Development, had been formulated in line with UN's Sustainable Development Goals (SDGs) that came into effect on January 1, 2016. Two main surveys were conducted among the rural youth in Tirunelveli, a non-backward district of Tamil Nadu and Sivaganga, a backward district of Tamil Nadu.

Altogether, 42 young sugarcane farmers belonging to Devipattinam, Sivagiri, Ramanathapuram, Puliyangudi and Tirunelveli divisions of Dharani Sugars and Chemicals Ltd., factory formed the sample. Data pertaining to dynamics of ICT uptake, perception on use and availability of ICTs, enablers and barriers in accessing and using ICTs among rural youth were collected. The preliminary observations are:

- Majority of the rural youth were found to be using smartphones. They access agriculture-related information through their mobile phones.
- Television was the most commonly used one-way source of sugarcane information while sugar factory personnel was the most commonly used two-way source of sugarcane information. The factory publication, Dharanimalar magazine is also being read.
- As for the average hours per day spent through various communication outlets, the time spent through social media was around 30 minutes per day. Farmers were using the WhatsApp discussion groups related to agriculture / sugarcane production.
- Majority of the young farmers had used social media for sharing agriculture / sugarcane related information. The most commonly used social networking tools were Facebook (Agriculture related pages), WhatsApp and YouTube. As for the information needs, most of the farmers need varietal information, machinery and training information, 'fairly often'. Over 220 CSCs (Common Service Centres) are functioning in the district. Only a few were aware of their utilities. Those functioning under the aegis of PACCS (Primary Agricultural Co-op Credit Society) are more popular among the respondents.

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

5.6. ICAR-SBI REGIONAL CENTRE, KARNAL

Breeding elite clones suitable for North West Zone

Hybridization, progeny evaluation and selection

Sugarcane variety notified for commercial cultivation

Co 09022, a midlate clone was notified for commercial cultivation in Haryana, Punjab, Rajasthan, Uttarakhand, Central and Western Uttar Pradesh by CVRC (Gazette notification No. 2458, New Delhi, dt. 29 August 2017).

Fluff sowing in mist chamber: During the crossing season 2017-18, 45 bi parental crosses, 19 general crosses and 5 poly crosses were attempted. The fluff was received and sown in mist chamber for raising the seedlings.

Seedling ground nursery ratoon 2016-17: The ground nursery ratoon 2016-17 season was evaluated for cane yield contributing traits, juice quality and morphological parameters during October 2017. A total of 685 better performing progenies based on the general appearance were selected and assigned selection numbers K15-001 to 685. These progenies were advanced to C1 evaluation stage in ABD layout along with four standards *viz.*, Co 0238, CoJ 64, Co 05011 and CoS 767. The experimental average for HR Brix, cane height (till top visible dewlap), NMC, cane diameter and selection intensity was 18.4%, 247.8 cm, 6.4, 2.6 cm and 20.9% respectively. The performance of top ten high quality cross combinations for yield contributing traits and selection intensity is shown in Fig.109.

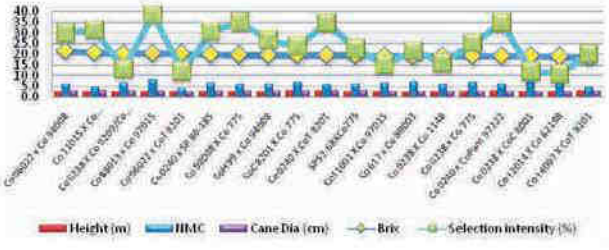


Fig. 109. Performance of high juice quality cross combinations for selection intensity and yield contributing traits

Seedling ground nursery 2017-18: A total of 10,781 seedlings representing 129 crosses were field transplanted in ground nursery in July 2017. The seedlings were winter ratooned during last week of December 2017 at peak winter.

First clonal trial: The experiment consisting of 558 C1 selections of K14 series was periodically evaluated for cane yield and juice quality traits. The experimental average for HR Brix was 17.88 and 83 clones had >20 HR Brix and among them, K14-180 (24.6), K14-212 (24.1), K14-176 (23.2), K14-199 (22.47), K14-488 (22.42), K14-403 (22.23), K14-107 (22.17) and K14-005 (22) were top performing. Based on HR Brix, cane diameter, cane height, NMC and other desirable morphological traits, 200 clones were selected and advanced to preliminary trial (C2 stage).

Preliminary trial: A total of 119 test clones of K13 series selection were evaluated for juice quality and cane yield parameters along with standards Co 0238, CoJ 64, CoS 767 and CoS 8436. The experimental average for sucrose % at 10th month was 16.71 and CoJ 64 was the best standard with 18.18% sucrose. A total of 65 test entries recorded on par with CoJ 64 for sucrose % at 10th month and entries *viz.*, K13-351(19.44%), K13-415 (19.25%), K13-410 (19.13%), K13-163 (18.96%), K13-420 (18.94%), K13-383 (18.55%), K13-346 (18.54%) and K13-165 (18.52%) were the top performer entries. Based on juice quality and cane yield parameters, 28 clones from K13 series were selected and advanced to pre-zonal varietal trial.

Evaluation for red rot: Out of 121 (K-13 series) clones evaluated, 23 were resistant, 43 moderately resistant, 14 moderately susceptible, 29 susceptible and 12 highly susceptible against red rot.

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

Pre-Zonal Varietal Trial

The experiment was evaluated for cane yield and juice quality parameters at 8th, 10th and 12th month. The experimental average for cane yield was 90.08 t/ha and the clones K12-328 (131.98 t/ha), K08-429 (125.54 t/ha), K12-60 (121.14 t/ha), K12-352 (120.81 t/ha), GU07-1841 (120.34 t/ha), K12-183 (118.48 t/ha) were the top performer entries. Combining cane, juice quality, red-rot reaction and other desirable traits clones *viz.*, K12-352 (Co 18019) & GU07-1841 (Co 18020) were awarded 'Co' cane status under early whereas the clones *viz.*, K12-60 (Co 18021) and K08-429 (Co 18022) were awarded 'Co' cane status under midlate category. Their performance in PZVT trial in comparison with standards is presented in Table 6 and 7.

Evaluation for red rot: Thirty-six clones were screened against mixed inocula of CF08 and CF09 isolates, of which, nine exhibited resistant, 16 moderately resistant, seven moderately susceptible, one susceptible and three highly susceptible reactions against red rot.

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

Evaluation of elite clones at different factory locations in Bihar, Uttar Pradesh and Haryana

Evaluation of elite clones at Harinagar: The experimental mean for sucrose % was 16.28 and 18.40 at 10th month and 12th (harvest) month respectively. For pol% in juice, entries Co 15023 (18.54%), Co 12027 (18.32%) Co 0116 (18.2%), Co 15026 (17.7%) and Co 13036 (17.16%) were top performer at 10th month whereas, entries Co 15023 (19.72%), Co 0116 (19.45%) Co 12027 (19.23%), Co 13033 (19.14%) and Co 13034 (18.87%) were top performers at harvest. A total of nine entries *viz.*, Co 12026, Co 12027, Co 13033, Co 13034, Co 13036, Co 14034, Co 15023, Co 15025 and Co 15026 were selected and planted along with two standards *viz.*, Co 0238 and CoP 9301 in RBD layout with three replications. The harvested trial was maintained as ratoon crop. The seed material of eight elite Co canes *viz.*, Co 12029, Co 13034, Co 13035, Co 14034, Co 15023, Co 15024, Co 15026 and Co 15027 was supplied to Balrampur Chini Mills Ltd (three units), DSCL Ajbapur (two units), Dhampur Sugar Mill,

Dhampur and Saraswati Sugar Mill, Yamunanagar under MoU through MTA.

Evaluation for red rot: Sixteen entries were inoculated in the trial at Harinagar Sugar Mills, Harinagar with CF07 and CF08 isolates of red rot. Variety CoP 2061 was found to be susceptible with CF07 and Co 0327 to CF08 isolates by plug method of inoculation, whereas remaining entries expressed resistant to moderately resistant reactions.

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

'Co' cane maintenance and evaluation

A total of 58 'Co' canes were field maintained and evaluated for cane yield and juice quality traits. The experimental average for cane yield was 119.39 t/ha. Co 15027 (210.5 t/ha) was the top performer and Co 16030 (168.9 t/ha), Co 15026 (156.6 t/ha), Co 15023 (155.1 t/ha), Co 14036 (149.1 t/ha) and Co 0238 (147.0 t/ha) were the other top performer entries for cane yield. For juice quality, Co 15023 (21.51% juice sucrose at 10th month and 22.18% sucrose at 12th month) was the top performer. At harvest, Co 0116 (21.6%), Co 12026 (21.59%), Co 07025 (21.57%), Co 0118 (21.45%), Co 0331 (21.31%), Co 0237 (21.25%), Co 06034 (21.16%), Co 0424 (21.09%), Co 09020 (21.04%) and Co 06036 (21.06%) were the other better performer entries which recorded >21% juice sucrose.

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

Evaluation of sugarcane germplasm under sub-tropical conditions

Evaluation of inter-specific and inter-generic hybrid clones

Evaluation of interspecific and inter-generic hybrid clones: The experiment was evaluated for NMC, cane yield and juice quality parameters at harvest. The experimental mean for NMC was 1.18 lakh/ha and Co 0238 (1.46 lakh/ha) was the best standard whereas eight test entries *viz.*, GUK02-91 (2.0 lakh/ha), 81 GUK506 (1.95 lakh/ha), GUK 09-165 (1.8 lakh/ha), GUK 02-89 (1.7 lakh/ha), GUK 02-800 (1.7 lakh/ha), GUK 08-134 (1.6 lakh/ha), Maneria 1552 (1.6 lakh/ha), 84GUK 138 (1.6 lakh/ha) were superior to Co 0238. At 10th month, Co 0238 (19.0%) was the best standard for pol % in juice and three test entries *viz.*, GUK 09-165 (19.47%), WL 04-81 (19.26%) and GUK 08-210 (19.17%) had recorded numerically higher value over Co 0238 and similarly, the test entries *viz.*, G8-GUK 509 (18.57%), GUK 08-329 (18.56%) and 94GUK 2452 (18.48%) had numerically higher value than CoJ 64 (18.38%). At harvest stage, mean value for pol% in juice was 17.19% and Co 0238 (19.85%) was the best standard. One test entry GUK 08-239 (20.68%) was superior and three entries *viz.*, GUK 08-210 (20.29%), 84 GUK 511(20.12%) and GUK09-165 (19.96%) had numerically higher value for pol% in juice than Co 0238 and five other entries were on par. The mean estimated cane yield in trial was 128.8 t/ha and Co 0238 was the best standard with 146 t/ha cane yield and nine entries *viz.*, GUK 09-165 (237.3 t/ha), GUK02-89 (221.2 t/ha), GUK 08-134 (207.9 t/ha), 81 GUK506 (215.2 t/ha), GUK 02-91 (199 t/ha), WL04-81 (187.1 t/ha), WL07-252 (189.3 t/ha), 84 GUK 138 (182.8 t/ha) and GUK 00-560 (175.4 t/ha) were found superior than Co 0238.

SPAD values: Maximum SPAD values were recorded in GUK 01-588 (48.49), 81 GUK-527 (47.48) and 900 GUK 311 (46.49) and minimum in UBA-Naquin (22.38) and 57 NG-161(29.04). Co 0238 (43.04) was the best standard for SPAD values.

Evaluation for red rot: Of the 48 exotic and ISH clones evaluated for red rot reaction, 20 clones were resistant/ moderately resistant, five moderately susceptible, 22 susceptible and one highly susceptible.

Insect pests: A total of 48 sugarcane germplasms/ species clones were evaluated against early shoot borer (ESB), top borer (TB), root borer (RB) and stalk borer (SB). Early shoot borer and top borer incidence was <15.0 and <10.0%, respectively. Hence, all the clones showed least susceptible reaction to early shoot borer and top borer. For root borer 10, 20 and 18 germplasms were found to be least susceptible (<15 %), moderately susceptible (15.1-30%) and

highly susceptible (>30.0%), respectively. For stalk borer, 25 germplasm accessions were least susceptible (infestation index < 2.0), 18 moderately susceptible (infestation index 2.1 to 5.0) and five highly susceptible (infestation index >5.1). However, seven germplasms *viz.* GUK 02-89, 90GUK-311, 98 GUK-466, F 91, GUK 07-252, 84 GUK-138 and Uba Naquin were least susceptible, eight (GUK 09-165, GUK02-800, GUK 05-133, WL 09-965, GUK 01-425, GUK 08-329, GUK 0-560, GUK 01-404 and WL 08-270) were moderately susceptible and three (GUK 01-558, 84 GUK-138 and 90 GUK 311) were highly susceptible to root borer and stalk borer commonly.

(N. Kulshreshtha, M.R. Meena, RavinderKumar, S.K. Pandey, B. Parameswari and Pooja)

Characterization and mining genetic variability in sugarcane germplasm against abiotic stress (salinity/ alkalinity and low temperature) under sub-tropical India (Karnal)

Evaluation under salinity: There was 19.93% reduction in cane yield at 12 EC irrigation water compared to normal irrigation water. At 12 EC, highest reduction for cane yield was observed in Co 0237 (50.52%) followed by Co 06034 (27.5%), Co 15027 (37.64%) and Co 13033 (32.50%). Least reduction for cane yield under salinity was found in GU 07-3774 (1.3%), AS04-635 (6.9%), AS04-2097 (16.0%) and IK 76-48 (10.71%). Similarly, 5.8% reduction in pol% in juice was observed under salinity conditions. Entries *viz.*, GU 07-3774 (3%), AS04-635 (1.8%), AS04-2097 (2.3%) and IK 76-48 (3.8%) recorded least reduction whereas, entries *viz.*, Co 0237 (10.2%), Co 13033 (9.5%), Co 15027 (6.16%) and Co 06034 (12.83%) recorded reduction for pol%.

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

Genotypic behaviour of sugarcane under moisture stress in subtropical India

Evaluation of plant crop of 'Co' clones under moisture stress conditions: An experiment was conducted to study the effect of moisture stress conditions in plant crop of ten 'Co'canes namely Co 0118, Co 0124, Co 0238, Co 05011, Co 98014, Co 07023, Co 11027, Co 12029, Co 15023 and Co 15027. Moisture stress was imposed during formative phase of the crop by withholding irrigation. Data were analyzed with factorial RBD. Maximum numbers of tillers were observed in the entry Co 12029, followed by Co 05011 and Co 0124. Tiller production was significantly reduced (26.45%) under moisture stress conditions, highest reduction was noticed in entry Co 11027 and lowest in Co 15023. Photosynthetic rate (21.32 to 11.60 m μmol CO_2 m^{-2} s^{-1}), transpiration rate (6.20 to 2.95 m mol H_2O m^{-2} s^{-1}), stomatal conductance (0.312 to 0.131 m mol H_2O m^{-2} s^{-1}) and chlorophyll fluorescence (0.632 to 0.480) reduced under moisture stress and maximum reduction was recorded in Co 15027 followed by Co 0118 and Co 0124 while minimum in Co 98014, Co 15023, Co 07023 and Co 0238. Relative water content (RWC %) and SPAD values reduced up to 18.86% and 14.5% respectively under moisture stress conditions. The yield parameters reduced significantly under moisture stress conditions as compared to control. Cane length was reduced up to 20.2% and NMC were reduced up to 24.60% and maximum reduction was recorded in Co 11027 and Co 07023 whereas minimum in Co 0238, Co 98014, Co 15023, Co 05011 and Co 12029. The juice quality parameters (Brix, pol%, purity% and CCS %) were not significantly affected under moisture stress as compared to control. Clones Co 15023 (21.64%), Co 0118 (21.47%) and Co 0238 (21.0%) produced significantly higher sucrose % over the experimental average 19.64%.

(Pooja, Neeraj Kulshreshtha and Ravinder Kumar)

Host resistance, interactomics, pathogen variability, diagnosis and disease management in sugarcane

Assessing the impact of non-fungal diseases in popular sugar varieties in subtropical region and their management

Molecular characterization of GSD infected samples analysed through nested PCR assay revealed that

THE varieties *viz.* CoH 150, CoS 88230, CoS 767 and AVT clones namely CoH 13262 and CoPant 13224 had positive reaction and these samples were sequenced and confirmed with grassy shoot phytoplasma sequences available in NCBI database. Survey carried out in sub-tropical region revealed that leaf fleck disease caused by *sugarcane bacilliform virus* (SCBV) was the most prevalent one followed by grassy shoot disease (GSD) in different varieties grown in Haryana and Uttar Pradesh. Maximum incidence of SCBV was reported in the variety CoH 160 (up to 20%) and Co 89003 (5%) followed by other varieties *viz.*, CoS 8436, CoJ 85, CoJ 88, CoH 152, and Co 0238 (trace to 3%). Similarly, the incidence and severity of leaf fleck disease, YLD and mosaic was recorded periodically for the season at ICAR-SBI Regional Centre, Karnal. *Sugarcane bacilliform virus* (SCBV) symptoms were observed in majority of the entries and highest incidence of 5 to 10% was reported from AICRP ratoon trial. Further, molecular characterization of associated pathogen(s) of GSD, mosaic, leaf fleck disease and YLD is in progress.

(B. Parameswari, M.L. Chhabra and R. Viswanathan)

Epidemiology and management of *Fusarium* diseases in sugarcane

Natural incidence of *Fusarium* diseases of sugarcane i.e. wilt and pokkah boeng was recorded in the varieties planted under trials and farmer fields. The observations are given below.

Wilt: Mild incidence of wilt (*Fusarium sacchari*) was noticed in CoS 12232 (AVT- ML II Plant) and Co 89003 under trials, whereas, up to 40% incidence in ratoon of CoH 160 at village Gagsina (Karnal).

Pokkah boeng (PB): Progression of PB symptoms was monitored in varieties under trials from first week of June onwards. Disease started to appear on plants with curling and twisting of leaves and whitish / chlorotic yellow leaves symptoms. Among the 56 test entries, mild to 3.4% incidence was expressed in 10 varieties *viz.*, Co 12026, Co 0238, CoPb13181, CoH 14261, Co 13035, Co 14232, CoJ 64, Co 89003, CoS 8436 and CoPant 97222, but after rains these clones recovered in July. None of the clone showed advanced or top rot stage. Similarly, observations recorded at farmer fields revealed that disease was prevalent in most of the varieties cultivated in Haryana, Uttar Pradesh and Bihar, but the overall PB incidence was less as compared to previous years. The maximum incidence (up to 40.0%) was found in one field of variety CoH 160 at village Barsalu, Karnal.

(R. Viswanathan, R. Selvakumar, P. Malthi, A. Ramesh Sundar, M.L. Chhabra, B. Parameswari, R. Gopi and R. Arun Kumar)

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

Evaluation of hybrids - Subtropical (Karnal)

Around 500 seedlings of 12 cross combinations involving advance inbred lines were field transplanted during February 2018 for their evaluation under sub-tropical conditions.

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

All India Coordinated Research Project (Sugarcane)

IVT Early: Experiment was evaluated for cane yield and juice quality parameters at 8th and 10th month crop stage. CoJ 64 (104.16) was the best standard for NMC ('000/ha) and none of the test entries could outperform it. However, CoLk 14201(112.96), CoPb 14211 (109.72), CoPb 14181 (103.85) and Co 14034 (103.7) were the best performing entries in the trial. At 8th month, Co 0238 (16.79%) was the best standard for juice sucrose and CoPb 14182 (16.8%), Co 14034 (16.6%) were the best entries. At harvest (10th month), Co 0238 was the best standard for cane yield (125.57 t/ha) and juice quality (19.68% juice sucrose). Co 14034 with 144.85 t/ha cane yield, 20.26 t/ha CCS yield, 19.82% juice sucrose and 15.39% pol in cane was the best performer test entry.

AVT Early I Plant: Co 0238 (17.52%) was the best standard for juice sucrose at 8th month. CoS 13231

(17.61%) and Co 13034 (17.6%) were the best entries. At harvest (10th month), Co 13034 with 129.96 t/ha cane yield, 17.68 t/ha CCS yield, 14.83% pol in cane and 19.28% juice sucrose was the best performer entry which exhibited on par performance with Co 0238 the best standard for cane yield (124.76 t/ha) and juice quality (19.47% juice sucrose). A very high natural incidence of smut was observed in entry CoS 13231, whereas flowering symptoms were observed in CoPb 13181.

AVT Midlate II Plant: The experiment was periodically evaluated for cane yield and juice quality parameters. At 10th month, CoS 8436 was the best standard and none of the entry was found superior. However, entries CoH 12263 (17.39%), CoLk 12205 (17.44%) and Co 12029 (17.02%) were on par with it. At harvest, test entry Co 12029 recorded highest cane yield (151.27 t/ha) followed by CoS 12232 (148.77 t/ha) against experimental average 112.09 t/ha and best standard CoPant 97222 (126.76 t/ha). Similarly, at harvest for juice quality also, Co 12029 (20.11% juice sucrose) was the top performer entry against experimental average (18.74%) and best standard CoS 8436 (19.51%).

AVT Midlate Ratoon: The experimental average for cane yield was 95.22 t/ha and Co 12029 (144.85 t/ha) was the top performer entry whereas CoS 767 (102.21 t/ha) was the top performer standard. The experimental mean for juice sucrose% was 18.81 and CoS 8436 (19.54%) was the best standard. Test entry Co 12029 (19.93%) followed by CoS 12232 (19.42%) and CoLk 12206 (19.38%) were the best performer entries. The excellent ratoon ability, profuse tillering, non-lodging, high cane yield and high juice quality characters of Co 12029 indicates that it can be a future potential sugarcane variety.

Evaluation of climatic resilient ISH/IGH clones against drought (II Plant crop): The experiment consisting of 27 test entries and three standards was evaluated for various cane yield, juice quality and morpho-physiological parameters. In general, there was reduction in the expression of metric traits under drought compared to normal conditions. At harvest under drought, there was reduction of 31.25%, 29.25%, 24.58%, 6.57%, 1.39%,11.99%, 7.19%, 0.97% and 1.60% compared to normal conditions for cane yield, CCS yield, NMC, cane height, cane dia, single cane weight, extraction%, Brix and pol% respectively. Genotypes AS04-1689 (166.56 t/ha), AS04-2097 (141.81 t/ha), GU07-3849 (132.89 t/ha) and SA04-472 (116.25 t/ha) were top performers under normal conditions for cane yield and among them the genotypes AS 04-2097(109.85 t/ha) and AS04-1689 (103.5 t/ha) were good performers under drought conditions as well. Clone GU07-3774 depicted higher cane yield under drought (98.87 t/ha) compared to normal conditions (95.84 t/ha). Highest reduction in cane yield under drought conditions was observed in the clone PG9869-137 (255%), followed by CoJ 88 (98.28%), MA5/37 (89.46%), MA 05/99 (87.0%), BM1022-173 (76.82%) and MA05/22 (73.71%) whereas the least reduction in cane yield was observed in genotypes GU07-3774 (-3.05%), BM 1005-149 (6.69%), SA04-458 (16.16%), SA04-496 (17.24%), AS04-1687 (22.45%) and CYM 07-986 (25.02%). Co 0238 with % juice sucrose of 19.36 under normal and 19.22 under drought was the best performer entry.

Evaluation of climatic resilient ISH/IGH clones against drought (II Plant crop): The ratoon trial depicted very high reduction in the expression of metric and juice quality traits. Highest reduction was observed for cane yield (64.09%) followed by tiller population at 90 days (53.08%), 120 days (48.15%), 180 days (44.75%), 150 days (44.45%), NMC (43.41%), juice extraction (31.96%) and single cane weight (19.13%). There was 6.3% gain in average juice Brix under drought but juice sucrose was 4.5% lesser under drought compared to normal conditions (Fig. 110).

AICRP seed supply and seed multiplication: The seed of 16 (nine early and seven midlate) AICRP(S) VSI, Pune, 2016 biennial workshop accepted entries was received and multiplied. Since the Shahjahanpur Centre sent seed in the form of single bud setts, entry CoS 16231 could not be produced in sufficient quantity and hence the seed of 15 entries (8 early and 7 midlate) was supplied to nine participating centres (Faridkot, Kapurthala, Pantnagar, Shahjahanpur,

Sriganganagar, Kota, Uchani, Lucknow and Muzaffarnagar) during February and March. Similarly, 24 (nine early and 15 midlate) AICRP entries accepted during the group meeting of AICRP(S) held at TNAU, Coimbatore in 2017 were received and multiplied for next year seed supply to the participating centers of NWZ.

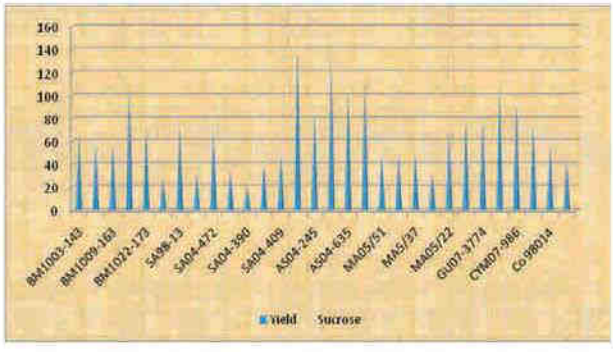


Fig. 110. Overall performance of ISH/IGH clones for cane yield and juice sucrose % (Plant + ratoon)

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

Identification of pathotypes / races of red rot pathogen: A set of 14 *C. falcatum* isolates comprising seven established pathotypes and seven isolates collected from CoS 8436 (3), BO 138 (1), CoSe 95422 (1), CoBln 05521(1) and Co 89903 (1) were inoculated independently on a set of 20 sugarcane differentials by plug method of inoculation. The overall disease reaction indicated that there was a clear pathogenic variation on the host differentials. The pathogenic reaction on differential hosts indicated that among the designated pathotypes, CF11 was found to be the most virulent followed by CF07, CF02, CF01, CF08, CF09 and CF03 (Table 40). Of the three Cf8436 isolates, Cf8436 (Karnal) succumbed only to differential CoS 8436 with intermediate to susceptible reactions on 11 host differentials. Another new isolate Cf89003 collected from variety Co 89003 was also virulent and expressed intermediate to susceptible reactions on 12 host differentials, suggesting the possible emergence of new pathotype in subtropics. Further, three isolates *viz.*, CfBLN 05521, CfBO138 and CfSe 95422 exhibited intermediate reaction to some of the host differentials, whereas differential SES 594 showed complete resistance to all the test isolates.

Supply of seed: Supplied the seed of 20 sugarcane differentials and 27 ISH clones to AICRP(S) participating centres i.e. Uchani, Seorahi, Shahjahanpur and Pusa for trials.

Survey of sugarcane diseases naturally occurring in the area on important sugarcane varieties: Survey was carried out to observe natural incidence of diseases under reserved area of 13 sugar mills of the zone comprising Haryana (8), Uttar Pradesh (4) and Bihar (1). Red rot incidence was recorded up to 45% in variety CoS 8436 at Harinagar (Bihar) and mild incidence in some fields of variety Co 89003 in Uttar Pradesh and Haryana. Severe incidence of smut was observed in variety CoH 160 at village Gagsina (Karnal) and mild incidence in fields of variety Co 0238 under Karnal, Bhadson, Indri, Nilokheri, Assandh and Yamunangar and also in varieties Co 89003 at Karnal, Sonipat and Gohana (Haryana). Similarly, trace infection of smut was noticed in variety BO 147 at Harinagar (Bihar) and also in the test entries *viz.*, CoLk 14201, CoLk 14203, CoLk 16201, CoLk 15203 and CoPb 16212 under different trials. By and large, Pokkah boeng was prevailing in most of the varieties cultivated in the surveyed sugar mills area; however, maximum incidence (up to 40%) was found in CoH 160 at village Barsalu, Karnal. Further, wilt incidence up to 40% and Sugarcane bacilliform virus (30%) was seen in variety CoH 160 (ratoon) at village Gagsina, Karnal and 20% in varieties CoLk 15203 and CoLk 15204 in the trials. Mild incidence of GSD was noticed in Co 0238 (ratoon) at two fields in Uttar Pradesh.

Evaluation of IET / Zonal varieties for resistance to red rot: Thirty-eight zonal varieties along with six standard varieties were evaluated for red rot resistance against CF08 and CF09 isolates. One IVT (E) clone CoPb 14211 exhibited MS reaction to both CF08 and CF09 isolates by plug method, while two IVT (ML) entries (CoS 14231 and CoS 14233) were susceptible to CF08 isolate by plug and cotton swab methods and also showed MS reaction with CF09

isolate. Two entries *viz.*, CoPb 13181 (AVT E-I plant) and CoPb 12211(AVT ML-II Plant) expressed susceptibility to isolate CF08 by plug method. However, remaining entries were resistant or moderately resistant with both the inocula and methods (Table 41).

Smut: Trace incidence of smut was recorded in entries CoLk 14203 and CoLk 14201.

Assessment of elite ISH clones for resistance to red rot: Out of 27 ISH clones inoculated with CF08 and CF09 isolates by plug method of inoculation for red rot resistance, 15 clones showed R/MR reaction, seven MS and five S/HS reaction with CF08 isolate, while seven clones were R/MR, 12 MS and eight S/HS with CF09 isolate by plug method (Table 40). Trace incidence of wilt and smut was also recorded in the clones AS04-245 and MA5/22, respectively.

Yellow Leaf Disease (YLD): Observation on natural incidence of YLD was recorded in 38 entries under trial. Nineteen entries exhibited resistantand 16 (CoLk 14201, CoLk 14202 (IVT E), Co 12026, Co 12027, CoLk 12203, Co Pant 12221 (AVT-E II), Co 14035, CoH 14261, CoH 14262, CoS 14233 (IVT-ML), Co 13035, CoLK 13204 (AVT- ML-I), CoLK 12205, Co Pant 12226, Co Pb 12211 and CoS 12232, (AVT-ML-II) moderately resistant and three (Co Pb 13181, CoS 13231 (AVT-E I), CoLk 14203 IVT (ML) moderately susceptible reaction to YLD (Table 41). Among the standard varieties, CoS 767, Co Pant 84211 and CoJ 64 showed susceptible, CoS 8436 moderately susceptible, Co 0238 and Co Pant 97222 moderately resistant reactions to YLD.

***Table 40.* Pathogenic behaviour of *C. falcatum* pathotypes on host differentials – SBI-RC, Karnal**

Pathotype / isolate	Source	Reaction on host differentials																			
		Co 419	Co 975	Co 997	Co 1148	Co 7717	Co 7805	Co 89003	Co 62399	Co 86002	Co 86032	CoC 671	CoJ 64	CoS 767	CoS 8436	CoV 92102	CoSe 95422	BO 91	Baragua	Khakai	SES 594
CF01	C0 1148	I	R	S	S	R	R	R	I	I	R	R	S	R	R	R	R	R	R	R	R
CF02	Co 7717	R	I	S	S	S	I	R	R	R	I	S	R	R	R	I	R	R	R	R	R
CF03	CoJ 64	S	R	S	R	R	R	R	R	R	I	I	S	R	R	R	R	R	R	R	R
CF07	CoJ 64	S	S	S	I	R	S	R	I	R	R	S	I	R	R	R	R	R	R	R	R
CF08	CoJ 64	I	R	S	I	R	R	R	R	S	R	R	S	S	R	R	R	R	R	R	R
CF09	CoS 767	R	R	S	R	R	R	R	R	R	R	R	S	S	R	I	R	R	R	S	R
CF11	CoJ 64	I	S	S	S	S	I	R	S	S	S	S	S	S	R	R	R	R	R	S	R
Cf 89003	Co 89003	S	I	S	S	R	I	S	S	R	S	S	I	I	R	S	R	R	R	R	R
Cf8436 (K)	CoS 8436	S	R	S	I	R	I	R	I	R	S	S	S	R	S	R	R	I	R	I	R
Cf8436 (UPCSR)	CoS 8436	I	R	S	R	R	R	I	S	I	S	S	S	I	R	I	R	R	R	R	R
Cf8436 (RI)	CoS 8436	R	R	R	R	R	I	R	R	R	I	S	R	R	R	R	R	R	R	R	R
CfBLN 05521	CoBln 05521	R	R	R	R	R	R	R	I	I	R	R	R	R	R	R	R	R	R	R	R
CfBO138	BO 138	R	R	R	R	R	R	R	R	R	R	R	I	R	R	R	R	R	R	R	R
CfSe 95422	CoSe 95422	I	R	R	R	R	R	I	R	I	I	R	R	R	R	R	I	R	R	I	R

R- Resistant; X- Intermediate; S- Susceptible

Table 41. **Evaluation of zonal varieties for red rot and YLD resistance at SBI-RC, Karnal**

Entry	Cotton swab method				YLD	Other diseases
	Plug Method		Red rot rating			
	CF 08	CF09	CF 08	CF09		
Co 14034	MR	MR	R	R	R	
CoLk 14201	MR	MR	R	R	MR	Smut(T)
CoLk 14202	MR	MR	R	R	MR	
Co Pant 14222	MR	MR	R	R	R	
CoPb 14181	MR	MR	R	R	R	
CoPb 14182	MR	MR	R	R	R	
CoPb 14211	MS	MS	R	R	R	
AVT(E-I)						
Co 13034	R	R	R	R	R	
CoPb 13181	S	MS	R	R	MS	
CoS 13231	MR	MR	R	R	MS	
AVT(E-II)						
Co 12026	MR	MR	R	R	MR	
Co 12027	MR	R	R	R	MR	
CoLk 12203	MS	MR	R	R	MR	
CoPant 12221	MS	MR	R	R	MR	
IVT(ML)						
Co 14035	R	MR	R	R	MR	
CoH 14261	R	MR	R	R	MR	
CoH 14262	R	R	R	R	MR	
CoLk 14203	R	MR	R	R	MS	Smut(T)
CoLk 14204	R	MR	R	R	R	
CoLk 14205	MR	MS	R	R	R	
CoPb 14183	MS	MS	R	R	R	
CoPb 14184	MR	R	R	R	R	
CoPb 14185	MR	R	R	R	R	
CoPb 14212	MR	MR	R	R	R	
CoS 14231	S	MS	S	R	R	
CoS 14232	MR	MR	R	R	R	
CoS 14233	S	MS	S	R	MR	
AVT(ML-I)						
Co 13035	MR	MR	R	R	MR	
CoH 13263	MS	MS	R	R	R	
CoPant 13224	MS	MS	R	R	R	
CoPb 13182	MR	MR	R	R	R	
CoLk 13204	MS	MS	R	R	MR	
AVT(ML-II)						
Co 12029	MR	MR	R	R	R	
CoH 12263	MS	MS	R	R	R	

Entry	Cotton swab method				YLD	Other diseases
	Plug Method		Red rot rating			
	CF 08	CF09	CF 08	CF09		
CoLk 12205	MS	MS	R	R	MR	
CoPant 12226	MR	MR	R	R	MR	
CoPb 12211	S	MS	R	R	MR	
CoS 12232	MR	MR	R	R	MR	Wilt(T)
Standards						
CoJ 64	S	S	S	S	S	
Co 0238	MR	R	R	R	MR	
CoS 767	S	S	S	R	S	
CoS 8436	MR	MR	R	R	MS	
CoPant 97222	MS	MS	R	R	MR	
CoPant 84211	MS	MS	R	R	S	

T= Trace incidence

(M.L. Chhabra and B. Parameswari)

Evaluation of zonal varieties for their reaction against major insect pests

AVT Ratoon: A total of 10 genotypes along with two check varieties were evaluated in RBD with three replications against major insect pests namely; black bug (BB), early shoot borer (ESB), top borer (TB) root borer (RB) and stalk borer (SB). All the 10 genotypes (CoH 11262, CoLk 11201, CoLk 11202, CoLk 11203, CoS 11232, CoH 11263, CoLk 11204, CoLk 11206, CoPb 11214 and Co 11027) showed least susceptible (LS) reaction to BB (<25.0 individual/20 leaves), ESB (<15.0%) and top borer (<10.0%). Two genotypes (CoLk 11201 and CoLk 11204) were least susceptible (<15%); Six genotypes (CoH 11262, CoLk 11202, CoLk 11203, Co 11027, CoH 11263 and CoPb 11214) were moderately susceptible (15.1 to 30 %) and two genotypes (CoLk 11206 and CoS 11232) showed highly susceptible (HS) reaction to root borer (>30%). In case of stalk borer all the 10 genotypes were least susceptible to stalk borer (infestation index < 2.0).

AVT I Plant: A total of eight genotypes along with two check varieties were evaluated in RBD with three replications against early shoot borer (ESB), top borer (TB) root borer (RB) and stalk borer (SB). All the eight genotypes (CoPb 13181, CoS 13231, Co 13034, CoLk 13204, Co 13035, CoH 13263, CoPant 13224 and CoPb 13182) showed least susceptible reaction to early shoot borer (<15.0%) and top borer (<10.0%). In case of root borer, four genotypes (Co 13035, Co 13034, CoLk 13204 and CoPant 13224) were moderately susceptible (15.1-30%) and four genotypes (CoPb 13181, CoS 13231, CoPb 13182 and CoH 13263) showed highly susceptible (HS) reaction (>30%). In case of stalk borer, two genotypes (CoPb 13181 and CoS 13231 were least susceptible (infestation index < 2.0) and six genotypes; (Co 13034, CoLk 13204, CoPb 13182, CoH 13263, CoPant 13224 and Co 13035) showed moderately susceptible reaction (infestation index 2.1 to 5.0).

AVT II Plant: A total of 10 genotypes along with two check varieties were evaluated in RBD with three replications against early shoot borer (ESB), top borer (TB) root borer (RB) and stalk borer (SB). All the 10 genotypes (CoPant 12221, Co 12027, Co 12026, CoLk 12203, CoPb 12211, Co 12029, CoH 12263, CoLk 12205, CoPant 12226 and CoS 12232) were least susceptible to ESB (<15.0%) and top borer (<10.0%). Six genotypes (CoPant 12221, CoS 12232, Co 12029, CoH 12263, CoLk 12205 and CoPb 12211) exhibited

moderately susceptible reaction (15.1-30%) to root borer and four genotypes *viz.*, Co 12027, Co 12026, CoLk 12203 and CoPant 12226 were highly susceptible (>30%). In case of stalk borer, two genotypes (Co CoLk 12205 and CoPb 12211) were least susceptible (infestation index < 2.0) and seven genotypes (CoPant 12221, Co 12027, Co 12026, CoLk 12203, CoS 12232, Co 12029 and CoPant 12226) showed moderately susceptible reaction (infestation index 2.1 to 5.0) and one genotype (CoH 12263) was highly susceptible (infestation index >5.0).

(S.K. Pandey)

Survey and surveillance of sugarcane insect- pests

To identify the key insect pests of sugarcane under North Western Zone, survey was carried out under the reserved areas of seven co-operative sugar mills of Haryana namely Karnal, Shahabad, Panipat, Rohtak, Palwal, Jind and Meham and three sugar mills of Uttar Pradesh *viz.*, Mawana sugar works Mawana, district Meerut, Triveni Engineering Works, Deoband, district Saharanpur and Triveni engineering Works, Khatauli, Muzaffarnagar (Uttar Pradesh). Pink borer, internode borer and blister mite were identified as new pests of sugarcane in Haryana and western Uttar Pradesh. The incidence of these three pests was found increasing severely where pink borer and internode borer incidence was 40.0 and 8.0 and 30.0 and 5.0 per cent, respectively in Haryana and Uttar Pradesh. Blister mite incidence was 78.2 and 62.0 per cent in Uttar Pradesh and Haryana, respectively. White grubs, early shoot borer, pink borer internode borer, top borer, root borer, stalk borer, pyrilla, webbing mites, blister mites, black bug and termites were identified as key pests in Uttar Pradesh while early shoot borer, top borer, root borer, stalk borer, pink borer pyrilla, black bug, blister mites, webbing mites and termites were in listed as key pests of sugarcane in Haryana. However, incidence of army worm, white fly, thrips and grasshopper was recorded as occasional pests of sugarcane under the zone.

(S.K. Pandey)

Monitoring of insect pests and bio agents in sugarcane agro ecosystem

A non replicated experiment with sugarcane variety Co 0238 was carried out and monitored the incidences of major insect pests and their bio agents of sugarcane at regular intervals. Pink borer emerged as a new insect pest of sugarcane. The cumulative incidence of pink borer right from shoot stage to harvest of the crop was 45.0 per cent. The incidence of early shoot borer and top borer was below ETL (<15.0 and <10%, respectively). Root borer and termite incidence was 26.6 and 7.0%, respectively. It was also observed that black bug, an insect pest of sugarcane ratoon infested the planted sugarcane crop also during June to harvest of the crop. The mean population of black bug was 1.7/tiller/canes. Stalk borer incidence, intensity and infestation index were 39.6%, 8.5% and 3.4, respectively. *Pyrilla* population was 2.0 individual / 20 leaf. Among bio agents, *Epiricania melanoleuca* was identified as an effective parasitoid of *Pyrilla* nymphs and adults with 22.3 per cent parasitization. *Tetrasticus pyrillae*, an egg parasitoid of *Pyrilla*, parasitized 28.3 per cent egg masses. *Isotima javensis* and *Stenobracon deesae* parasitization of top borer larvae was 1.2 and 0.6 per cent respectively. *Cotesia flavipes* was identified as a larval cum pre pupal parasitoid of stalk borer which parasitized 9.3 % stalk borer larvae during August to February in cane.

(S.K. Pandey)

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

Maintenance of reference collection of sugarcane varieties: One hundred and twenty six sub-tropical sugarcane reference varieties was maintained in two row plots and under disease free condition at ICAR-SBI-RC, Karnal. Further verification of 27 DUS descriptors was completed in all the reference varieties and has been modified as per the requirement of PPV and FR Authority. The photographs of reference varieties were captured as

part of digitization of sub-tropical DUS reference varieties.

DUS testing of farmer varieties: First year DUS test for one farmer's variety *viz.*, Captan Basti was conducted at ICAR-SBI Regional Centre, Karnal along with four reference varieties (CoS 97270, CoS 96258, CoPant 96219 and BO 130). A total of 160 settlings derived from single bud set of each varieties were transplanted in RBD design with two replications in the DUS testing field in May 2017. The plot size was 4 Rows x 6 m length x 0.9 m row to row spacing. Observations on 27 morphological traits were recorded from the farmer as well as reference varieties. The result of first year trial shows that Captan Basti was distinct from the reference varieties and the population of this variety was uniform.

Farmer's varieties received for DUS testing: Two farmer's varieties *viz., Meitei Chu Angouba and Meitei Chu Angangba* were received for DUS testing at Karnal. Polybags raised settlings of both the varieties were transplanted in field at 0.9m x 6m x 4 rows in two row plots and being maintained at ICAR-SBIRC, Karnal. The DUS testing will be done as soon as reference varieties are decided by the nodal centre.

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

Physiological approaches for winter ratooning management in sugarcane under subtropical conditions: Three 'Co' canes namely Co 0238, Co 05011 and Co 0118 were planted during second fortnight of March to assess winter ratoonability of the clone with application of different concentrations of ethrel, calcium chloride and lime. Soil samples from 75 farmer's field were collected to prepare soil health card.

(Pooja)

Mega seed Project- Seed Production in agricultural crops and fisheries-Sugarcane

On farm seed production and supply: The Breeder seed of important sugarcane varieties *viz.*, Co 0238, Co 0118, Co 05011, Co 0237, Co 0124, Co 98014, Co 06034 and Co 05009 was produced in 6.5 acres of land to supply healthy seed cane to various stakeholders. A total of 2726.07 quintals of Breeder seed with a productivity of 104.85 t/ha worth Rs 8, 91,768/- was supplied. The highest quantity of seed produced (1399.86 quintals) and supplied was of the variety Co 0238, followed by Co 0118 (1048.78 quintals) and Co 05011 (104.17 quintals).

Off farm farmer's participatory seed production and supply: Because of scarcity of land only limited quantity of healthy seed was available for supply and very often the late comer stakeholders were not able to get the seed. To address this issue and increasing the farmers income, Farmers participatory seed production (FPSP) programme was initiated by ICAR-SBIRC, Karnal. Six farmers were selected, they were trained on seed production activities and healthy seed of varieties Co 0238, Co 0118 and Co 05011 was supplied to them. Their seed fields were monitored at regular intervals and advised as and when required to raise the healthy crop. A total of 9339.8 quintals of seed worth Rs 30,82,135 was supplied to Uttrakhand and Uttar Pradesh and @ Rs 20 per quintals a revenue of Rs 1,86,796 was generated. The variety-wise details of FPSP programme is given in Table 42.

Use of micro-propagated tissue culture seedlings as nucleus seed: Keeping in view the increasing demand for healthy seed of important sugarcane varieties, micropropagated tissue culture seedlings of variety Co 0238 and Co 05011 were brought from ICAR-SBI, Coimbatore. Now the entire seed of Co 0238 is replaced by micro propagated tissue culture seedlings. Care was given for effective seed treatment using sett treatment device and the transplanting of seed crop is now mechanised.

Installation of drip irrigation facility in seed crop: A drip irrigation facility was installed in 1.25 acre seed crop field with financing by Rivulis India Limited, a micro-irrigation company.

Table 42. **Variety wise details of seed supply from farmer's participatory seed production programme**

Seed Farmers Name	Varieties supplied (quintals)			Total seed supplied (quintals)	Farmers share (Rs)	Institute's share (Rs)
	Co 0118	Co 0238	Co 05011			
Shri Inam Khan, Jadoli, Karnal	35.6	4545	75.9	4656.7	14,43,577	93,134
Shri Sumer Chand Mohan Verma, Vill-Panjokhra, Karnal	682	288	-	970.4	3,00,824	19,408
Shri Jai Bhagwan, Mahamadpur, Karnal	1204	736.4	-	1940.4	6,01,524	38,808
Shri Puran Chand, village-Dhakwala Gujran, Karnal	375	-	-	375.05	1,16,266	7,501
Shri Sompal S/o Sh Chatter Singh, village- Dhakwala Roran, Karnal	420	-	-	419.6	1,30,076	8,392
Shri Himanshu S/o Sh Akshay Kumar, village-Lalupura, Karnal	978	-	-	977.65	3,03,072	19,553
Total	3694	5570	75.9	9339.8	28,95,339	1,86,796

(Ravinder Kumar)

Evaluation of molecule PII8007 20% SC against early shoot borer, top borer and termite in sugarcane

Field experiment was conducted in Randomized Block Design with three replications. Nine treatments were applied at different intervals and incidence of early shoot borer, top borer and termites was recorded right from germination till harvest. Brix, pol and purity in juice at 12th month and yield parameters; cane height (10-20 canes), cane weight and cane diameter/plot were recorded.

Efficacy of test insecticides on early shoot borer and termite: The natural incidence of early shoot borer and termite ranged from 0.1 to 2.1 and 0.0 to 1.2 per cent in different treatments, respectively. Incidence of both the insects was too low; hence no conclusion on efficacy of test insecticides could be drawn.

Efficacy of test insecticides on top borer: Top borer incidence varied from 3.7 to 15.0% among treatments. All the treatments significantly reduced top borer incidence. The mean top borer incidence in control was 15.0%. Among the test insecticides, Chloranraniliprole @ 100g a.i. /ha gave highest top borer incidence reduction (75.6%) over control followed by Chlorantraniliprole @ 75g a.i. /ha (56.0%), PII 8007 @ 150g a.i. /ha (54.2%) and PII 8007 @ 75 g a.i. /ha (44.7%). Similarly, PII 8007@ 25 g a.i. /ha was found least effective in controlling top borer incidence (14.4%) over control followed by Fipronil 5% SC @ 75g a.i. /ha (20.0%) and Fipronil + Imidacloprid @175+175g a.i. /ha (36.9%).

(S.K. Pandey)

Production of Breeder Seed with farmer's participation under National Food Security Mission (Crop Science) - NFSM

The Breeder seed of popular varieties *viz.*, Co 0238, Co 0118 and Co 05011 was planted at farmer's field in Haryana and Uttar Pradesh in 10 hectares area. A total of 12,000 quintals of Breeder seed was produced and the farmers were referred to the NFSM (CC) seed farms for purchasing the healthy seed. The seed crop was monitored at regular

interval. For seed production during 2018-2019, 614.6 quintal seed was planted in the Institute farm as well as farmers fields in 10 hectare area.

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

Fertility status of SBI-RC farm soils

Soil samples have been collected from all the fields of SBI-RC, Research farm and analysed for pH, EC, macro and micronutrients. The pH of the soils was alkaline in nature and ranged from 7.74 to 8.54. EC of the soil was below 2 dsm^{-1} and non-saline in nature. Nitrogen status of the soils was low, phosphorus status was medium to high and potassium status was medium. Sulphur content was low and among micronutrients, boron and organic carbon status of the soils was low.

(K. Rajasekar, Pooja and Neeraj Kulshrestha)

5.7 SUGARCANE BREEDING INSTITUTE-RESEARCH CENTRE, KANNUR

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

Breeding varieties resistant to waterlogging

A final clonal evaluation was conducted with seven test clones and three check varieties in three replications to select the best performing clone based on yield and quality traits. Germination count of the test clone ranged from 37-76, tillering at 90 days from 74-145 and NMC from 36-80 the performance was better than control. Cane thickness of the test clones varied from 2.1-2.7 cm, which was lesser than the best check Co 62175 with 2.8 cm thickness. The cane length of the test clones showed poor performance in comparison to the check varieties. Similar trend was observed for single cane weight. HR Brix at 7th month ranged from 19-24 for the test clones and the highest Brix was recorded in the clone WL-12-101 with moderate resistance to red rot. The check varieties recorded 18-21 HR Brix at 7th month. Sucrose % of the test clones at 10th month ranged from 17- 23 whereas check varieties had 16-19. Cane yield per plot for the test clones ranged from 32-57 kg, whereas the check varieties recorded 48-82 kg (Co 62175). Hence, none of the test clones outperformed Co 62175 for CCS/plot. However, the test clones WL-12-101, WL-12-509 and WL-12-314 had higher CCS yield/plot compared to the check varieties Co 99006 and Co 86032. All the three selected clones had medium resistance to red rot and therefore can be effectively utilized in the breeding program as source of high Brix and sucrose.

In the second clonal trial, 24 test clones and three check varieties were evaluated. The test clones performed better than the check varieties for cane thickness, HR Brix at 7th month and 10th month, sucrose % and CCS yield/plot. NMC of the test clones were on par with the check varieties whereas check varieties performed better for single cane weight and subsequently for yield/plot. Three clones WL-13-456, WL -13-175 and WL-13-815 outperformed the best check Co 62175 for CCS yield/plot. Sixteen clones that recorded higher CCS per plot compared to the check varieties were selected and further planted in a larger replicated trial.

A pre-clonal trial of 55 clones and three check varieties was planted, wherein NMC of the clones ranged from 4-45. Cane thickness of the clone WL-15-1022 (3.2 cm) was the highest among the clones and the lowest value of 1.8 cm for the clone WL-15-1083. HR Brix at 7th month ranged from 18-23.7. About 60% of the clones recorded higher Brix compared to the best check variety Co 99006. Based on the better performance for NMC, cane thickness and HR Brix at 7th month, 28 clones were advanced to clonal trial.

Four hundred and ninety-eight progenies from six intraspecific crosses were evaluated for NMC, cane thickness and HR Brix at 7th month. NMC ranged from 1-31, thickness from 1.1-3.2 cm and Brix from 11-24%. Most of the clones from the cross Co 99006 X WL-10-40 recorded Brix more than 21. Thirteen intraspecific crosses were made to develop clones resistant to waterlogging. The parents used were foreign hybrids, 'Co' canes and WL clones. 2587

seedlings from 12 crosses were planted in the field for evaluation and 105 waterlogging clones maintained over the years were characterized for 27 traits listed in the DUS guidelines.

Physiological evaluation of 20 waterlogging tolerant clones and 20 *Saccharum* species clones were carried out in a trial planted in well drained as well as waterlogged field with three replications. Among the traits recorded at 180 DAP, leaf area, NMC, cane weight, cane height, cane girth, internode number and total biomass of above-ground as well as roots was significantly higher under control as compared to waterlogging stress. Similar trend was observed in observations recorded at 280 DAP. In concurrence, juice analysis revealed higher Brix, sucrose % and purity % in control as compared to stress. Significant genotypic variation was observed for all the traits grown under control and waterlogging stress. Irrespective of stress, the total above-ground biomass was significantly high in Co 62175, Co 62178, SEL 74/1, Co 86032, Co 62181 at 180 (Fig. 111) as well as 280 DAP. Root weight and volume were the highest in the control Co 62175 (180 DAP) and Co 62202 (280 DAP). Biomass partitioning efficiency to cane under waterlogging stress varied from 57 to 87% in Saccharum species clones, whereas all the waterlogging tolerant clones except SEL 76/17 partitioned 80% or more biomass to the cane (Fig. 112). Juice quality traits in waterlogging tolerant clones were on par with that observed under control condition (Fig. 113).

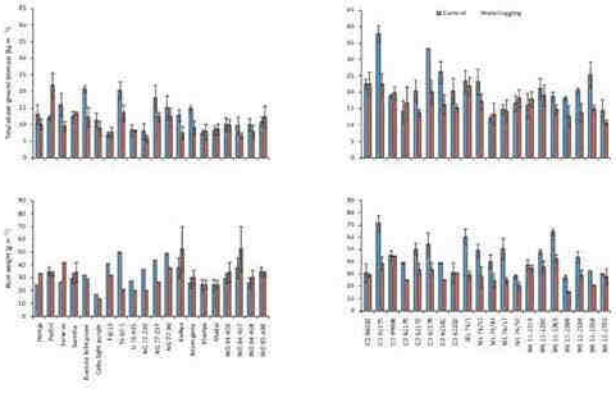


Fig. 111. Total above-ground biomass and root weight at 180 DAP in* Saccharum *species and waterlogging tolerant clones

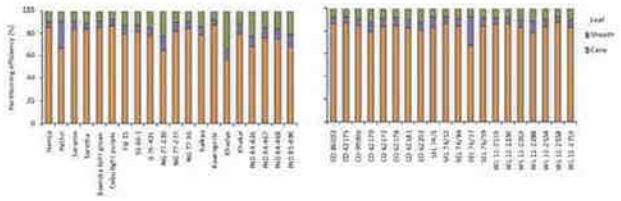


Fig. 112. Biomass partitioning efficiency to cane, sheath and leaves at 180 DAP in* Saccharum *species and waterlogging tolerant clones under waterlogging stress

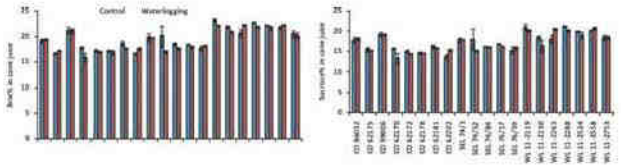


Fig. 113. Brix and sucrose% in cane juice in waterlogging tolerant clones

(K. Chandran, M. Nisha and V. Krishnapriya)

Enhancement of sugarcane germplasm and development of pre-breeding material

Utilisation of germplasm resources for developing new genetic stocks

A clonal evaluation trial was conducted with eight clones and two check varieties. GUK 13-1360 and GUK 13-1313 (F 49-11 x WL 05-499) were numerically superior to the check varieties for CCS yield. These clones were having 22.1 and 19.11 sucrose% at harvest and 23 and 22 HR Brix at 7th month respectively and both were resistant to red rot. In a second clonal trial with eight clones, a back cross progeny (GUK 14-1092) of the cross involving IK 76-10 (*S. spontaneum*) was found promising with sucrose 19% and MR to red rot. Another clone GUK 14-140 with *Erianthus arundinaceus* (IK 76-92) background was on par with Co 99006 for yield with 19.7% sucrose at harvest and resistant to red rot.

In another clonal trial, 77 progenies of polycross on red fleshed *S. robustum* clones were evaluated along with Co 86032 and the two female parents as check varieties. The clones were evaluated for yield and quality traits, flesh colour, internode length and for aerial rooting. None of the clones out yielded the

check variety Co 86032 for CCS yield but 48 clones were superior to female parent NG 77-76 and 46 clones over NG 77-84. The biomass yield was superior in 20 progenies, single cane weight in 10 progenies and NMC in 39 progenies over the check varieties. The traits that need to be improved in the progenies are juice content, Brix and sucrose% to reach commercial status. Leaf length, cane length and number of aerial roots were significantly high in most of the test clones indicating the potential of the progenies under waterlogged conditions. Among the 77 progenies, 27 were analysed for chromosome numbers along with parental clones under light microscopy. The results showed that the progenies showed variation in chromosome number from 2n =60 to 86 (Fig. 114) and more variation with respect to chromosome numbers was observed in the progenies of NG 77-84.

There was no direct correlation of flesh colour with chromosome numbers. However, the full expression of red flesh colour was observed only in the clones having 2n=60 (Fig. 115). It is also inferred this progeny might have developed as a result of un-intentional selfing.

Fig. 114. 2n = 60 to 86 (NG 77-84)

Fig. 115. 2n = 60 (GUK 14-7)

Natural incidence of INB in field condition was studied to determine the level of INB resistance in progenies of red fleshed *S. robustum*. Very low level natural incidence (3.22 to 14.28%) with an average infestation of 6.52% was recorded. Due to very low level of natural incidence, more than 50 clones were found to be free from INB incidence. Highest percent incidence (14.28%) and intensity (19.35%) was noticed in GUK 14-880 and GUK 14-41 respectively.

Ninety-six progenies of various interspecific crosses were evaluated in pre-clonal trial and 18 clones were selected for first clonal trial based on NMC, cane thickness and HR Brix. Another 670 seedlings from 10 crosses / backcrosses were evaluated and 35 clones were selected for pre-clonal evaluation. Eleven backcrosses involving F1 of interspecific progenies were attempted and 390 seedlings were planted in ground nursery.

(K. Chandran, M. Nisha and B. Mahendran)

Maintenance of world collection of sugarcane germplasm

Maintenance and evaluation of germplasm : A total of 3373 germplasm clones were maintained and monitored for germination, flowering, pests and diseases. All clones were re-planted during February-March 2018. Morphological descriptors including auricle shape and colour, dewlap shape and colour, leaf sheath colour, leaf length and width, internode length and thickness, growth ring length, thickness and colour, and number of root eyes were recorded in 79 *S. spontaneum* clones. One hundred and thirty IA clones and 152 *Erianthus* clones were characterized for 30 morphological traits as per the descriptor list.

(K. Chandran, M. Nisha and V. Krishnapriya)

Monitoring of diseases and quarantine

A total of 614 clones of foreign hybrids (Argentina 1 to CPCL-4111) were subjected to hot water (52°C) cum fungicide (Carbendazim- 0.1%) treatment for 30 min and then planted in polybags. Monitoring for diseases was done at regular intervals. Leaf spot and Pokkah boeng diseases were noticed in June. Smut was found in Co 844 in November. Smut infected inflorescence was removed and destroyed to avoid further spread. Rust was noticed in Co 658, 698 and Co 699 in October. Maximum incidence of leaf spot was noticed in 28 NG 260, 18, 20, Kham, Awela green sport, Azul de Caza of *S. officinarum*, Q42, PR 1039, POJ 2753 clones of foreign hybrids and Co 386, Co 713, Co 863 of Indian hybrids. In *S. spontaneum*, rust was noticed in the clones IND 81-20, IND 81-74, IND 81-80, IND 81-82, IND 81-83 and IND 81-101. Viral diseases were noticed in Castilla and Listada and Foreign hybrid clones D1135, D1135 STR showed

mosaic symptom. In January 2018, 520 clones (200 *S. officinarum* and 320 Co canes) were treated with hot water cum fungicide (Carbendazim- 0.1%). In treated clones, germination of *S. officinarum* was less than 20% and the germination of 'Co' canes was 40.5%.

(R. Gopi)

Monitoring of insect pests : Sugarcane germplasm was monitored for occurrence of insects and their natural enemies. Internode borer, pink borer, Pyrilla, woolly aphid and leaf mites were found at various ranges. In addition, sporadic infestation of whitefly, mealy bugs, scale insects and sugarcane aphid, *Melanaphis sacchari* was noticed during monitoring period.

Internode borer incidence in *Saccharum* sp. ranged from 0-30%. Pink borer was noticed in secondary shoots in *S. officinarum* accessions *viz.*, Kajla, Fiji 24, Ireng Malang, Red ribbon and NC 49 in December with symptoms of boreholes, window pan holes and dead hearts. Pyrilla incidence revealed a mean number of 7.85 egg masses/leaf and 35.5 eggs /egg mass. Percent parasitization of pyrilla eggs ranged from 0-100% with mean percent parasitization of 40.75%. Occurrence of two parasitoids *viz.*, *Tetrastichus pyrillae* (Eulophidae: Hymenoptera) and *Ooencyrtus sp.* (Encyrtidae: Hymenotera) was recorded. Field incidence of entomopathogenic fungi, *Metarhizium sp* and *Hirsutella sp.* infecting nymphs and adults (Fig. 116) of *P. perpusilla* was studied based on percentage mummified cadaver. Cadavers were most abundant during August-September with a peak during early October (23.3%) after which incidence gradually reduced.

In a study to determine the natural incidence of scale insects in 79 accessions of world germplasm collection of *S. spontaneum*, two scale insects namely *Melanaspis glomerata* and *Aclerda takahashii* (Fig. 117) were found. Percent infestation of *M. glomerata* and *Aclerda takahashii* ranged from 0-100% and 0-73.33 across the accessions with average incidence of 26.28% and 7.69%, respectively.

A light trap was kept to monitor light attracted insects. Daily monitoring indicated a mean trap catch of internode borer (2.4/ day), Pyrilla (6.8/day), *Spodoptera* (3.14/day), *Maruca sp.* (3.5/day), fruit sucking moth (1.5/ day), Sphingid moth (1/ day), *Euproctis sp.* (3/ day), *Utetheisa sp.* (2.5/ day), *Creatonotos gangis* (1.8/day), *Catocala sp* (1.5/day), *Cyana sp* (1/day), *Herpetogramma sp.* (1/day), Lyclene sp.(1/day), Green emerald moth (1/day) and *Diaphania sp.* (1/day). Besides, many flea beetles, earwigs, crickets etc. were trapped in the light traps which are of less importance as pests.

Rugose spiralling whitefly (RSW) incidence in Saccharum spp.: In October 2017, regular monitoring was done in sugarcane germplasm and a number of spiraling egg masses (Fig.118 and 119) and adults of *A. rugioperculatus* were observed on the leaves of several clones of *S. officinarum, S. robustum, S. sinense, S. barberi and S. spontaneum*. Identification of *A. rugioperculatus* was confirmed through morphological as well as molecular basis (Gene Bank accession number: MH321182). This represents a new host plant record for RSW and also the first time that this species is recorded in a plant species belonging to the family *Poaceae* in India but very low level of incidence was recorded in germplasm accessions which varied from 3.22 to 13.04%. It was found that in most of the accessions, RSW eggs were able to hatch but failed to develop to

Fig. 116. Metarhiztum sp and Hirsutella sp

Fig. 117. Adults of Aclerda takahashii

Fig. 118. RSW adult with spiralling egg masses

119. Young stages of RSW

adults thereby RSW could not complete its entire life cycle under field conditions. Few accessions of *S. officinarum* namely Branchue, Azul De Caza and Javari Kabbu were observed with immature and pupal stages of RSW with trace amount of silvery wax thread secretion. *Saccharum spp* may not support the complete development of RSW but may still be used by adult whiteflies for feeding and laying eggs. Further study is required to find the level of feeding by adult whiteflies and development of other stages that will determine the impact RSW has on the host plant and if management is required.

(B. Mahendran)

In vitro conservation of germplasm : One hundred *S. officinarum* clones having poor crop stand in the field were multiplied *in vitro* through meristem culture and maintained through sub culturing. Experiments were conducted in eight clones of *S. robustum* to induce direct regeneration from leaf explants and 10 clones derived from shoot tip culture are maintained under in vitro.

(K. Chandran and M. Nisha)

DNA fingerprinting : Total genomic DNA was isolated from 142 *S. robustum*, 40 *S. barberi* and 30 *S. sinense* clones for further studies. Four clones each from *S. barberi* (Katha coimb., Kewali 14-G, Khari, Khatuia) and *S. sinense* (Archi, Chuckche, Khadya, Oshima) were genotyped using 25 SSR markers. The primers include NKS, mSSCIR, SMC and UGSM primers. Of the total 25 SSR markers, 17 primers produced scorable polymorphic alleles.

SSR profile of 18 *S. officinarum* clones collected from Fiji were developed using 12 primers that include NKS, SMC and UGSM primers. The 12 clones produced 78 alleles with an average of six alleles per primer. The primers *viz.*, NKS 2, NKS 6, NKS 22, SMC 569CS, SMC 36BUQ and mSSCIR9 produced high level of polymorphism. Similarity coefficient based UPGMA revealed that the markers were not able to differentiate between Black Fiji & Fiji 15, Fiji 62 yellow & Fiji 62 Stripe, Fiji 24 and Fiji 29. Morphological characterisation also showed similarity among these clones expect for few traits.

(M. Nisha and K. Chandran)

Harnessing antagonistic microbes for the management of wilt and rot diseases in sugarcane

Pathogens *Ceratocystis parodoxa* and *Pheocytostroma sacchari* were isolated from infected rhizosphere samples collected from 12 clones of *S. officinarum*, two clones of *S. robustum*, three clones of *S. sinense*, two clones of *S. spontaneum* and three Indian hybrids Co 86032, Co 62175 and Co 99006 and also eight clones of *Erianthus spp.* In total, 70 *Trichoderma* isolates and 188 bacterial isolates were isolated from the rhizosphere region of different germplasm and allied genera. Among the bacterial isolates, 73 isolates were found positive for protease production.

(R. Gopi and K. Nithya)

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

Inbreeding : Four hundred and thirty seedlings from selfing of 10 first inbreds were evaluated for rind colour and cane thickness. The progenies of first inbred TS 15-18 (NCO 310) showed more uniformity for rind colour and cane thickness. Similarly, of the 403 progenies evaluated from five selfing of new exotic hybrids, progenies of SP 80-320 and CP 94-1100 showed more uniformity for rind colour and cane thickness. Though 23 selfings was effected on the progenies from first and second inbreds, seed set was very poor and only 80 seedlings from nine inbreds were obtained which were planted in field and all the progenies used for further selfings were maintained.

(K. Chandran)

5.8 SUGARCANE BREEDING INSTITUTE-RESEARCH CENTRE, AGALI

Enhancement of sugarcane germplasm and development of pre-breeding material

Germplasm maintenance, hybridization and Off-season nursery

Germplasm maintenance: A total of 1271 accessions of sugarcane germplasm including species clones, Co clones, Co allied clones, exotic clones, inter-specific

and inter-generic hybrid clones, clones of *Erianthus sp.*, Sclerostachya and *Narenga* are being maintained in field in disease free condition.

Flowering in 2017 season: Out of 1271 accessions maintained at the Centre, 414 flowered in 2017 season with a flowering intensity of 2.5%. Forty seven clones of *S. officinarum* (Awela 68, Baragua, Chapina, Creoula, Creoula Rayada, Fiji-40, Fiji-62, Fiji-B, IJ 76-314, IJ 76-315, IJ 76-316, IJ 76-422, IJ 76-436, IJ 76-456, IJ 76-474, IJ 76-551, IJ 76-564, IJ 76-567, IK 76-002, IK 76-056, IK 76-060, Keong, Laukona-15, Mahona, Monget Gayam, Naz, NC-94, NG 77-092, NG 77-102, NG 77-142, NG 77-154, 28 NG 15, 28 NG 210, 28 NG 288, 28 NG 288 Sport, 51 NG 161, 57 NG 197, 57 NG 199, Penang, Shamsara, Sinense, SO hybrid, SS 60-1, Sugar Doctor, Mis-3, Vespertina and White Transparent) flowered during 2017 (19.36% of total clones). In *S. roustum*, IJ 76-545 alone flowered (tip emergence was on 28 October 2017). In S. barberi, five clones (Dhaulu, Khatuia, Kuswar Aligarh, Manjuria, Mankia) and in *S. sinense*, seven clones (Kavangire, Khakai, Kheli, Maneria IMP 1648, Tekcha, Uba ReUnion, Uba white) flowered this year. Intensity of flowering was high in ISH and IGH clones, 53 out of 69 clones flowered. In Co canes and Co allied clones, 162 out of 489 clones flowered. Fifteen percentage of clones of *Erianthus arundinaceus* and all the clones of *E. bengalensis, E. elephantinus, E. procerus* and *E. ravennae* flowered in 2017. One clone of *Erianthus fulvus*, brought from Wellington flowered but very late in the season (February 2018). Duration of flowering in *S. officinarum* lasted from 22 September to 27 November 2017. Tip emergence was first noticed in Naz, Monget Gayam and White transparent while IJ 77-092 and NG 77-092 were the last clones to flower. In *S. barberi, S. sinense and S. robustum*, tip emergence was observed during 12-28 October 2017. In Co and Co allied clones, flowering lasted from 23 September 2017 (CoLk 91238, CoLk 9110) to 20 November 2017 (Co 06033).

Hybridization: Crosses were made for Agali Centre as well as for AICRP(S) Centres participating in the crossing programmes. The number of crosses made for Agali Centre was 71 which includes crosses among commercial variety (CV) x CV (29), CV x *S. robustum* (1), CV x *S. officinarum* (3), *S. officinarum* x CV (4), *S. officinarum* x *S. sinense* (1), *S. officinarum* x *S. officinarum* (4), *S. officinarum* x *S. spontaneum* (1), CV x *S. sinense* (1), *S. sinense* x CV (1), *S. officinarum* x *S. barberi* (1), *S.barberi* x CV (2), CV x *S. spontaneum* (7) and *S. officinarum* x *Erianthus arundinaceus* (4). Sugarcane breeders from 15 Research Centres visited Agali Centre and made 55 crosses. The cross combinations chosen by them were of inter-specific or inter-generic in nature such as commercial variety (CV) x *S. barberi*, CV x *S. sinense*, CV x *S. officinarum*, CV x *S. robustum*, CV x *S. spontaneum*, CV x *Erianthus arundinaceus*, *E. arundinaceus* x CV, *E. procerus* x CV, *S. officinarum* x *Erianthus*, *S. officinarum* x CV and few CV x CV. Fluff of 24 GCs was collected and supplied to them. In toto 1.24 kg fluff was harvested and supplied to the fluff receiving centres.

Seedling raising: From the fluff of 2016 season crosses, 336 seedlings were raised and transplanted in ground nursery during March 2018.

Clonal evaluation: A total of 755 clones are under evaluation in first clonal nursery in two batches. Out of 150 clone (1st batch) assessed for red rot resistance through CCT screening, 29 were 'S', three were 'HS' and others were either MS, MR or R. HR Brix of 150 clones were estimated at 8th and 10th month. Five clones namely, Agl 2017-11, Agl 2017-16, Agl 2017-171, Agl 2017-177 and Agl 2017-243 recorded better juice quality than the standard CoC 671.

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

DUS Testing Project-Sugarcane (Agali Centre)

Maintained 193 reference varieties in disease free condition in field. DUS traits of 190 reference varieties were verified and database of reference varieties was updated. First year DUS test for two farmers' varieties *viz.*, Kudrat ka Karishma and Desi 2 were conducted. Seed cane of two farmers' varieties *viz.*, Desi 1, Meitei Chu Angaugba and Meitei Chu Angangba received for DUS testing are under multiplication for testing in the next season.

(R. Karuppaiyan and K. Elayaraja)

6. EDUCATION AND TRAINING

6.1 EDUCATION

M.Phil. / Ph.D. PROGRAMME

Bharathiar University: The Institute has been recognized by Bharathiar University, Coimbatore to conduct M.Phil. / Ph.D. programme in the disciplines of Biotechnology, Botany, Zoology, Agricultural Chemistry, Agricultural Entomology and Plant Pathology.

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

Undergraduate and Postgraduate students training and project work: A total of 68 UG and PG students from different parts of the country participated in 21 or 30 days exposure training programme and 31 students carried out their UG/PG project work at the institute (Fig. 120). The revenue generated from training and project work is Rs. 9.6 lakhs.

Fig. 120. Dr Bakshi Ram, Director, ICAR-SBI interacting with UG and PG students

Ph.D. awarded: Ph.D. degree was awarded to Ms. M. Sathyabhama by Bharathiar University, Coimbatore for the thesis entitled 'Sugarcane defense responses to *Colletotrichum falcatum:* An understanding at the molecular level through transcriptomic approach' under the guidance of Dr.R.Viswanathan, Head, Division of Crop Protection.

Ph.D. awarded: Ph.D. degree was awarded to Ms. K. Bagyalakshmi by Bharathiar University, Coimbatore for the thesis entitled 'Genome characterization of viruses causing sugarcane mosaic in India' under the guidance of Dr. R. Viswanathan, Head, Division of Crop Protection.

M.Sc. (Sugarcane Technology) course in Open and Distance Learning mode is being offered in collaboration with Tamil Nadu Agricultural University, Coimbatore. Two batches of students, 21 in their IV semester and 18 in their second semester are undergoing the course.

6.2 TRAINING PROGRAMMES ORGANIZED

At Coimbatore

- Training was organized to 20 TSLs of the institute on 'Basic official work flow and rules and regulations' during 01 January 2018 to 02 April 2018.
- Five national level training programmes on 'Scientific Sugarcane Cultivation' were organized during September-October 2017 for cane development personnel from the states of Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Odisha, Uttar Pradesh, Puducherry, Uttarkhand, Bihar, Punjab and Gujarat.
- A state level training program sponsored by Lal Bahadur Shastri Ganna Kisan Sansthan, Lucknow was organized for 18 senior cane officials from Uttar Pradesh during 17-22 April 2017.
- A Model Training Course on 'Best management practices for sustained sugarcane productivity' sponsored by Department of Agriculture and Cooperation, Ministry of Agriculture and Farmers Welfare, Government of India was organized during 4-11 January 2018 for 18 officers from the State Department of Agriculture from the states of Chattisgarh, Haryana, Himachal Pradesh, Jharkhand, Kerala, Maharashtra, Odisha, Tamil Nadu, Telengana and Uttarkhand.
- A state level one-day training program on 'Recent Advances in Sugarcane Cultivation'

sponsored by Directorate of Sugarcane Development, Lucknow was organized for 90 farmers from Coimbatore, Erode and Tirupur districts on 31 January 2018.

- A district level Scientists-Extension Workers-Farmers Interface Meet was organized in collaboration with Shri Avinashilingam KVK on 29 March 2018 with the participation of 22 farmers and district level officials.
- Organized seven one-day training programs on 'Sugarcane Agriculture' for farmers / cane officials.

At Karnal

- Conducted a training on 'Insect pest management in sugarcane' to cane development officials of Mawana sugar mills, Meerut, Uttar Pradesh on 19 April 2017.
- Conducted a training on 'Management of sugarcane diseases and insects' to farmers and cane development officials at Harinagar Sugar Mills Ltd., Harinagar during 18-19 April 2017.
- Conducted a practical training on 'Identification and management of sugarcane insect pests' to the cane development officials and progressive farmers of Co-operative Sugar mills Ltd. Panipat (Haryana) on 06 July 2017.
- Conducted a practical training on 'Identification and management of sugarcane insect pests' to the cane development officials and progressive farmers of Co-operative Sugar mills Ltd. Jind (Haryana) on 11 July 2017.
- Conducted a practical training on 'Identification and management of sugarcane insect pests' to the cane development officials and progressive farmers of Co-operative Sugar mills Ltd. Palwal (Haryana) on 15 July 2017.
- Conducted a training on 'Insect pest management in sugarcane' to cane development officials of Triveni Engineering Works Pvt. Ltd., Moradabad, Uttar Pradesh on 22 July 2017.
- Conducted a training on 'Insect pest management in sugarcane' to cane development officials of Triveni Engineering Works Pvt. Ltd. Deoband, Saharanpur, Uttar Pradesh on 23 August 2017
- Conducted a training to sugar mill officials at Palwal, Jind, Panipat (Haryana), Mawana, Deoband, Khatoli and MNP (UP) sugar mills during June to August 2017.
- Organized one-day training program for 24 cane development officials of Balrampur Chini Mills, Balrampur, Uttar Pradesh on 18 July 2017. (Fig. 121).

Fig. 121. Participants of the training program (18 July 2017)

- A one-day training program was organized under National Food Security Mission funded by Directorate of Sugarcane Development, Lucknow on 8 December 2017 for 108 sugarcane farmers from Haryana, Uttar Pradesh, Punjab and Rajasthan (Fig. 122). Dr. Bakshi Ram, Director, ICAR-SBI, Coimbatore inaugurated the training program and released a Hindi training manual on 'New techniques for increasing sugarcane productivity'.

Fig. 122. Release of Training Manual

- Organized a six-days training program sponsored by LBS Ganna Kisan Sansthan, Lucknow for 20 farmers of Uttar Pradesh during 12-17 February 2018 (Fig. 123).

Fig. 123. Particiapnts of the training program

- Organised one day 'Kisan Mela' for 'Doubling the income of sugarcane farmers' at ICAR-SBI, RC, Karnal on 17 February 2018 (Fig. 124).

Fig. 124. Kisan Mela at ICAR-SBIRC, Karnal

- Visits were made to Shree Madhi Sugar mill, Madhi, Surat, Gujarat during 8-12 January 2018. Nearly 2000 farmers were educated about the cultivation practices of Co 0238 in a series of four interactive lectures cum field visit of variety Co 0238 in four different circles. The farmers and mill staff were sensitized about the importance of healthy seed. The Institute's free mobile app "Cane Adviser" was demonstrated to the farmers and mill staff and were advised to download the app. Based on this visit, a team of four management committee members (one Vice President and three Directors) visited ICAR-SBIRC, Karnal during 16-18 February 2018 and fields of progressive sugarcane farmers at Karnal. They interacted with Director, ICAR-SBI, Coimbatore and all scientists of ICAR-SBIRC, Karnal during Kisan Mela 2018 on 17 February 2018 (Fig. 125).

Fig. 125 An interaction with Gujarat farmers

- Organised one-day program on 'Healthy seed production' under Seed Project for 100 progressive farmers on 21 March 2018 (Fig. 126).

Fig. 126. Training on Healthy Seed Production

6.3 INTERNATIONAL VISIT

- Dr. Bakshi Ram, Dr. G. Hemaprabha, Dr. R. Viswanathan and Dr. R. Manimekalai attended the project workshop at Sugar Research Australia during 19 - 26 August 2017.
- Dr. R. Manimekalai, Principal Scientist, Division of Crop Improvement visited Sugar Research Australia and attended the joint collaborative meeting of the research team of Sugar Research Australia and CSIRO from 24 February to 16 March 2018.
- Dr. K. Mohanraj, Senior Scientist, Division of Crop Improvement visited Sugar Research Australia and attended the joint collaborative meeting of the research team of Sugar Research Australia and CSIRO, from 24 February to 12 March 2018.

- Dr. P.T. Prathima carried out post-doctoral research program as a recipient of the Indo-Australian Career Boosting Gold Fellowship funded by the Department of Biotechnology, Government of India at the Queensland Alliance for Agriculture and Food Innovation Institute (QAAFI), The University of Queensland, Brisbane, Australia from 29 March 2016 to 29 March 2018 under the supervision of Prof. Dr. Robert Henry, Director, QAAFI.

6.4 TRAINING AND CAPACITY BUILDING

- Dr. R. Arun Kumar: Short term training on 'Phenomics: Perspectives for application in the improvement of abiotic stress tolerance in crop plants' during 20 - 29 July 2017 at ICAR-NIASM, Baramati, Maharashtra.
- Dr. V.Vinu: Training on 'The use of Power Core software for the development of core collection' during 1 - 11 August 2017 at NBPGR, New Delhi.
- Mr. M. Radhakrishnan: Training on 'OSP for ICAR on GFR 2017' during 9 - 11 August 2017 at ISTM, New Delhi.
- Dr. B. Parameshwari: Winter school training on 'Harnessing NGS data for genetic enhancement in crops' during 03-13 October 2017 at ICAR-Indian Institute of Wheat and Barley Research, Karnal.
- Mrs. P. Bhuvanamuzhuthudaiyal: Training programme on 'Enhancing efficiency and behavioural skills for Stenographers Grade III, PA, PS, PPS and Sr.PPS of ICAR' during 25-31 October 2017 at NAARM, Hyderabad.
- Mr. Ramesh, Supporting Staff: Training under ICAR-HRM programme 2017-18 during 28-30 November 2017 at IIWBR, Karnal.
- Dr. T. Rajula Shanthy and Dr. A. Selvi: Management Development Programme on 'Leadership development' during 12-23 December 2017 at ICAR-NAARM, Hyderabad.
- Dr. R. Manimekalai and Dr. K. Mohanraj: Training on 'Multivariate data analysis' during 14-20 December 2017 at ICAR-NAARM, Hyderabad.
- Mr. Pramod Kumar, Senior Technical Officer and Mr. Manoj Kumar, Senior Technician: Training on 'Proficiency enhancement for working in Biochemistery & Biotechnology Laboratory' under ICAR-HRM programme at ICAR-IIWBR, Karnal during 14-16 December 2017.
- Dr. K. Nithya: Training on 'Whole genome sequencing of plant pathogens: Methods and applications' from 29 December to 18 January 2018 at ICAR- Indian Agricultural Research Institute, New Delhi.
- Dr. S. Anusha: Training on 'Advanced weed management technology options for crop production in Indian agriculture' from 22 February to 14 March 2018 at Tamil Nadu Agricultural University, Coimbatore.
- Dr. R. Valarmathi: ICAR-HRM training on 'Genomics assisted breeding for crop improvement' during 1-21 March 2018 at ICAR-Indian Agricultural Research Institute, New Delhi.
- Dr. R. Manimekalai and Dr. K. Mohanraj: Workshop on 'Genomic selection' during 5-10 March 2018 at Centre for Animal Science, Queensland Alliance for Agriculture and Food Innovation, Queensland Bioscience Precinct, Australia.
- Mr. M. Gnanavel: Training on 'Capacity building and skill upgradation programme for technical staff on farm management' during 06 - 10 March 2018 at ICAR-Indian Institute of Farming Systems Research, Meerut.

7. AWARDS AND RECOGNITIONS

A district level function was organized by Shri D.K. Singh, District Magistrate, Muzaffarnagar on 28 April 2017 for felicitating Dr. Bakshi Ram, Director, ICAR-SBI for his contributions in improving farmers' income and sugar recovery through the variety Co 0238. Dr. Sanjeev Baliyan, Honourable Minister of State for Water Resources, Rivers Development and Ganga rejuvenation honoured Dr. Bakshi Ram. Others present were Shri. Naresh Tikait, (President BKU), Shri. Kapil Dev Agarwal (MLA), Shri. Umesh Malik (MLA), Shri. Vijay Kashyap (MLA), Shri. Bablu Kumar (SSP), Dy CC, DCO, sugar factories personnel and farmers (Fig. 127).

Fig. 127. Dr. Bakshi Ram being honoured by Dr. Sanjeev Kumar Balyan, MoS, Water Resources, River Development and Ganga Rejuvenation

Fig. 128. Dr. Bakshi Ram, Director, ICAR-SBI being honoured by the Honourable Union Minister for Agriculture and Farmers Welfare

- Dr. Bakshi Ram, Director, ICAR-SBI was honoured by Shri Radha Mohan Singh, Honourable Minister for Agriculture and Farmers Welfare during the National Seminar on 'Hundred years of sweet revolution in India: Co 205 to Co 0238' at NASC, ICAR, New Delhi on 29 August 2017 (Fig. 128).

The following Scientists received Best Poster Awards during the International Symposium on 'Sugarcane Research Since Co 205: 100 Years and Beyond' (SucroSym 2017) during 18-21 September 2017 held at Coimbatore (Fig. 129):

- Genetic enhancement of sugarcane through wild related species- Adhini S. Pazhany, M.N. Premachandran, Mayalekshmi and A.K. Remadevi.
- Assessing the inheritance of red flesh color and antioxidant activity from the polycross progenies of *Saccharum robustum* genotypes – G.S. Suresha, K. Chandran, M. Nisha, K. Arun Kumar and K. Hari.
- Mixed model analysis in sugarcane varietal evaluation programme in India- Rajesh Kumar, A.D. Pathak and Bakshi Ram.
- Co 205: The Coimbatore legacy - Adhini S. Pazhany, A. Anna Durai and P. Govindaraj.
- Transcriptome characterization of lignin and cellulose genes of sugarcane genotypes contrasting for fiber content- Lakshmi Kasirajan, Nam V. Hoang, Agnelo Furtado, and Robert J. Henry.
- Isolation and *in silico* analysis of expansin genes and functional characterization of EXPA1 in sugarcane through genetic engineering- J. Ashwin Narayan, V.M. Manoj, S. Dharshini, T. Sarath Padmanabhan, N. Subramonian, M.N. Premachandran and C. Appunu.

Dr. Adhini S.Pazhany

Dr. K. Lakshmi

Dr. Arjun S. Tayade

Dr. P. Geetha

Dr. G.S. Suresha

Dr. T. Rajula Shanthy

Dr. K. Hari

Fig. 129. Best Poster Awardees

- Expression of the recombinant human growth hormone (Somatotropin) in transgenic sugarcane for molecular farming- M. Sivaji, S. Dharshini, Ashwin Narayan, Gauri Nerkar, C. Appunu and N. Subramonian.
- Revelation of gene families attributes to pathogenicity during sugarcane and *Colletotrichum falcatum* interaction using

transcriptomics - N.C. Naveen Prasanth, R. Viswanathan, P. Malathi and A. Ramesh Sundar.

- Profitability assessment of sugarcane based intercropping system under wide row planting- P. Geetha, A.S. Tayade, T. Selvan and Rajesh Kumar.
- Standardizing agro-techniques for true seed seedling with special reference to intra-row spacing and planting depths - A.S. Tayade, P. Geetha, S. Anusha and Bakshi Ram.
- Freeze dried sugarcane juice - process development and product characterization - K. Hari, G.S. Suresha, K. Sivaraman, C. Tamilselvi, B. Hariharan, C. Antony Leo, R. Lavanya, S. Ramalakshmi, P. Sivaraj and P. Murali.
- Transformation in sugarcane agriculture: From setts to settlings - T. Rajula Shanthy and S. Ramanjaneyalu.
- Drs. S. Alarmelu, G. Hemaprabha, C. Appunu, A. Anna Durai and Bakshi Ram received Noel Deerr Gold Medal for the paper 'Co 0212- A high yielding, high sugar midlate variety for Tamil Nadu'. In: Sugarcane Agriculture Section, presented in 74th Annual Sugarcane Technologists Association of India Convention, 2016-2017.
- Dr. K. Lakshmi received Young Scientist award (NESA) for the paper 'Characterization and expression profiling of cell wall genes in sugarcane genotypes contrasting for lignin content'. In National Conference on Biotechnology and Environment (NCOBE-2017) organized by Department of Biotechnology, Jamia Millia Islamia (A Central University), New Delhi.
- Dr. Neeraj Kulshreshtha, Head, ICAR- SBI RC, Karnal received Unnat Bharat Sewashri Award 2017 at Constitution Club, New Delhi on 17 August 2017 for contributions towards varietal development and agricultural research.
- Dr. M.L. Chhabra, Principal Scientist (Plant Pathology) was selected as Executive Councillor of SSRD, ICAR-SBI, Coimbatore for the year 2017-19.

ICAR-Sugarcane Breeding Institute Research Centre, Kannur received Rajbhasha Shield III place in the Town Official Language Shield Competition 2016-17 held at TOLIC, Kannur (Fig. 130). The Shield was awarded during the 56th half yearly meeting of TOLIC, Kannur held on 27 November 2017.

Fig. 130. Receiving Rajbhasha Shield III place in the Town Official Language Shield Competition

Shri. K. Krishnakumar, Skilled Support Staff, Kannur won 2nd Prize in 800m running race in ICAR-South Zone Sports Meet held during 09-13 October 2017 at Coimbatore (Fig. 131).

Fig. 131. Shri Krishnakumar receiving prize from Director, ICAR - SBI

8. LINKAGES AND COLLABORATIONS IN INDIA INCLUDING EXTERNALLY FUNDED PROJECTS

The Institute has established linkages with ICAR Institutes like IARI, NBPGR, NRCPB, NBAIR, IISR, Sugarcane Research Centres (24 Nos.) of SAUs under AICRP, International Centre for Genetic Engineering and Biotechnology (ICGEB), Ministry of Consumer Affairs, Food and Public Distribution, Ministry of Agriculture-and Farmers Welfare, GoI, Ministry of Food Processing Industries, DST, DBT/GoI, Directorate of Sugarcane Development, TNPL (a Govt. of Tamil Nadu Undertaking), MSSRF, Chennai and sugar industry in critical areas in emerging technologies for deriving maximum benefit.

Project title and scientist involved	Source of funding	Total outlay (Rs. in lakhs)
DNA finger printing of *S. officinarum* clones using simple sequence repeat markers- M. Nisha	DST-SERB	12.00
Molecular cloning and characterization of genes involved in lignin biosynthesis pathway of sugarcane - K. Lakshmi	DST-SERB	12.00
Whole transcriptome sequencing of sugarcane for sucrose regulating genes - P.T. Prathima	DST-SERB	12.00
National Level training for implementation of Sugarcane Development Programme under NFSM (Commercial crops) -T. Rajula Shanthy	Min. of Agri, GoI	3.00
Model training course on 'Best management practices in sugarcane'- T. Rajula Shanthy	Min. of Agri, GoI	3.13
Extramural research project on 'Pyramiding of transcriptional factor and ROS candidate genes for improved drought tolerance in sugarcane' - C. Appunu	ICAR	45.0
Application of Drone in surveillance and diagnosis for biotic and abiotic Stresses in sugarcane - T. Arumuganathan	ICAR	48.35
Climate resilience in sugarcane agriculture: Metabolic and molecular response to high temperature - R. Gomathi	DST-SERB	10.80
Identification and characterization of proteinase inhibitors influencing resistance against shoot borer, *Chilo infuscatellus* (Snellen) and internode borer, *Chilo sacchariphagus indicus* (Kapur) (Lepidoptera: Crambidae) in sugarcane - M. Punithavalli	DST-SERB	4.32
Characterisation of virus suppressor proteins in RNA viruses infecting sugarcane and developing transgenic sugarcane lines resistant to SCSMV and SCYL through RNAi approach - R. Viswanathan, P. Malathi, K. Lakshmi and B. Parameswari	DBT	64.23

Project title and scientist involved	Source of funding	Total outlay (Rs. in lakhs)
Isolation functional characterisation and evaluation of water deficit stress tolerance responsive genes from high drought tolerant *Erianthus arundinaceus* by comparative drought transcriptome analysis - C. Appunu, G. Hemaprabha and G.S. Suresha	DBT	53.916
Sub cellular targeting of invertase inhibitory proteins : A novel approach to enhance sucrose yield in sugarcane- G.S. Suresha	DST-SERB	30.48
Disecting the molecular interface between biotrophic pathogen *Sporisorium scitamineum* and its host sugarcane - A.Ramesh Sundar, R.Viswanathan and P. Malathi	DBT	48.9
Identification of new genetic resources for drought tolerance from *Erianthus*, a related wild genus of sugarcane through GWAS- R. Valarmathi	DST-SERB	42.2
Characterisation of root system traits in sugarcane germplasm- Krishnapriya Vengavasi	DST-SERB	36.37
Identification of salt responsive genes and micro RNA Targets from salt tolerant arundinaceus clone IND 99-884 through transcriptome analysis - C. Mahadevaiah	DST-SERB	12.99
A whole genome based reduced representation approach for identification of resistance against sugarcane yellow leaf virus in Indian sugarcane- B. Parameshwari	DST-SERB	45.24
Genetic control and genomic selection for important traits in sugarcane and comparison of elite Indian and Australian germplasm- R. Manimekalai, G.Hemaprabha, R.Viswanathan, A.Selvi, K.Mohanraj and S. Vasantha	DBT	175
Tribal Sub Plan - T. Rajula Shanthy, C. Jayabose, C. Sankaranarayanan and A.S.Tayade	Ministry of Tribal Affairs	28.00
ICAR-CRP on Development and application of diagnostics to viruses infecting sugarcane-R.Viswanathan, B. Parameswari, D. Neelamathi and K. Nithya	ICAR	75.82
Identification, characterization and verification of new sugarcane varieties for DUS testing-Karnal M.R. Meena	MoA/GoI	5.50
Network project of transgenics in crops - Transgenic Development in Sugarcane - C. Appunu and R. Valarmathi	ICAR	10.18
Physiological approaches for winter ratoon management in sub-tropical conditions - Pooja	RKVY	100.00

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:

- Fluff supply to various sugarcane research institutes / centres.
- Evaluation of 'Co' canes for different sugarcane growing regions and acting as the coordinating unit for identification of 'Co' and other Co-regional selections.
- To gather information on general and specific combining ability of biparental crosses.
- Collaboration for development of national varieties.
- Collaborative research on Agronomy, Soil science, Plant Physiology, Entomology and Plant Pathology.

Dr. Bakshi Ram, Director is the Principal Investigator of Crop Improvement and Dr. R. Viswanathan, Head I/c, Division of Crop Protection is the Principal Investigator of Plant Pathology.

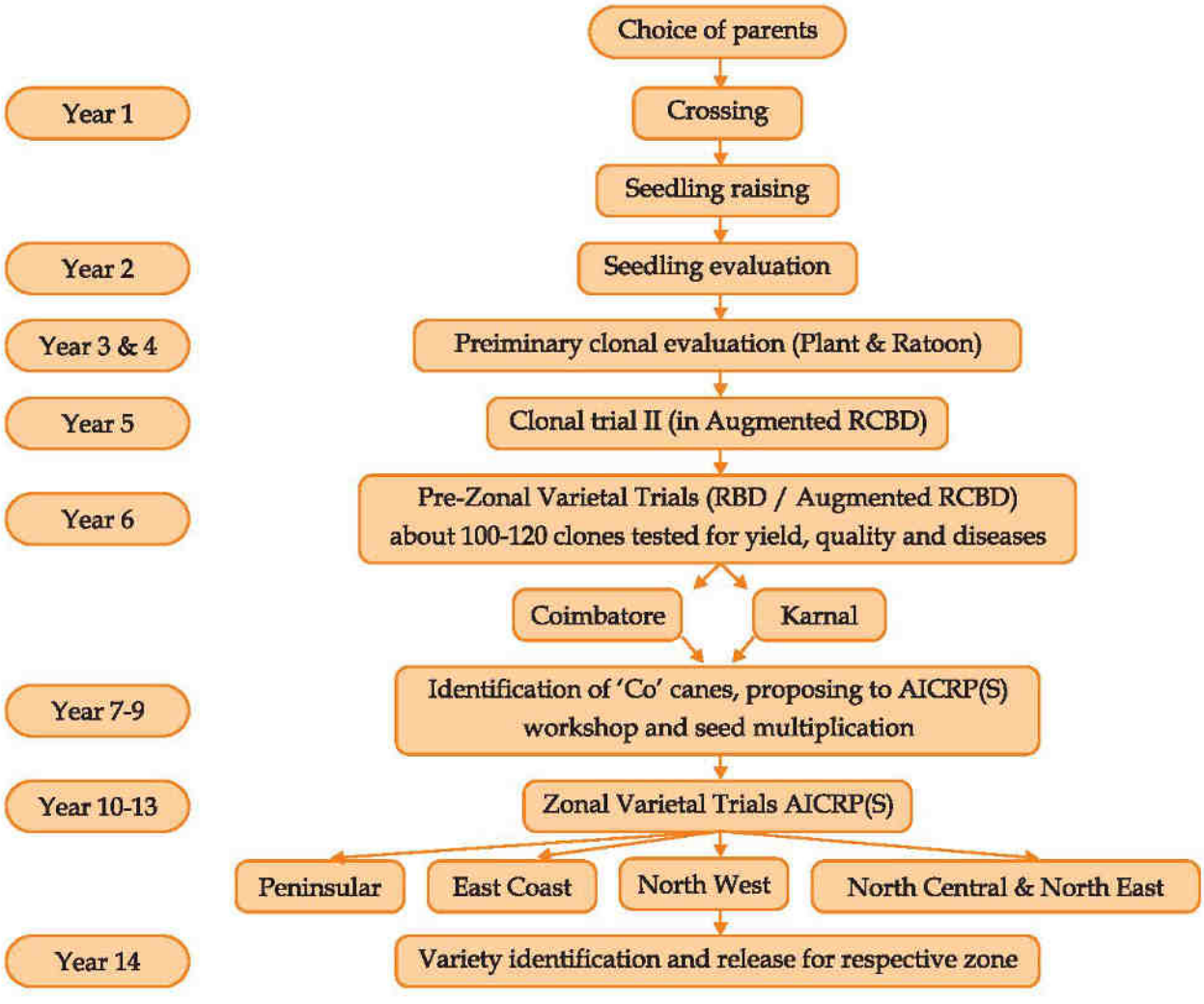


Fig. 132. Varietal development – Schematic Diagram

10. PUBLICATIONS

Research papers

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11. RESEARCH PROGRAMMES

1. Breeding superior sugarcane varieties of different maturity with improved cane yield, quality and resistance to biotic and abiotic stresses
2. Enhancement of sugarcane germplasm and development of pre-breeding material
3. Sugarcane genomics and molecular markers
4. Gene discovery and genetic transformation in sugarcane
5. Development of cropping systems and improved agronomic practices to enhance sugarcane productivity
6. Enhancing physiological efficiency of sugarcane
7. Natural resource management for enhancing productivity and sustainable sugarcane production
8. Host resistance, interactomics, pathogen variability, diagnosis and disease management in sugarcane
9. Studies on sugarcane pests and their management
10. Basic and applied studies of sugarcane phytonematodes and entomopathogenic nematodes
11. Economic and statistical studies in sugarcane and sugar production system
12. Transfer of sugarcane technologies
13. Standardization of true seed production technique through developing homozygous parental lines and apomixes
14. All India Coordinated Research Project (Sugarcane)

12. CONSULTANCY, PATENTS, PRODUCTS, COMMERCIALIZATION OF TECHNOLOGIES

- Three ITMC meetings were conducted to discuss different aspects pertaining to patent registrations and commercialization of technologies of ICAR-SBI.

Patents/Registrations

- Co 0238 was registered as a new variety with PPV and FRA (Reg. No. 281 of 2017). Varieties registered with PPV and FR *viz.*, (1) KARAN-2 (Co 0118), 2) KARAN-8 (Co 0237), (3) KARAN-9 (Co 05011), (4) Co 0403 (REG/2013/482), 5) Co 94012 and 6) DAMODAR (Co 99004) were renewed for 2017-18.
- A design application for 'Quatro Sugarcane Single Bud Cutter' (application No. 297432) was filed with patent office on 10 September 2017.

MoUs Signed

- A MoU was signed for commercialization of the technology 'Two row tractor drawn mechanical planter for sugarcane bud chip/single bud settlings raised in protrays' jointly developed by ICAR-CIAE and ICAR-SBI on 16 May 2017 with M/s Rohitkrishi Industries, Private Limited, Chinchwad, Pune (Fig. 133).

Fig. 133. Signing of MoU between ICAR-SBI, ICAR-CIAE and M/s Rohitkrishi Industries Private Limited, Pune on 16 May 2017 for commercialization of Two row tractor drawn mechanical planter for sugarcane bud chip/single bud settlings raised in protrays

- MoUs were signed for commercialization of the technology "Soil moisture indicator" on 26 February 2018 with two firms *viz.*, Parashar Agrotech Biotech Pvt Ltd., Varanasi (Fig. 134) and Gayathri Agri Inputs, Hyderabad (Fig. 135).

Fig. 134. Signing of MoU between ICAR-SBI and Parashar Agrotech Biotech Pvt Ltd., Varanasi on 26 February 2018 for commercialization of Soil Moisture Indicator

Fig. 135. Signing of MoU between ICAR-SBI and Gayathri Agri Inputs, Hyderabad on 26 February 2018 for commercialization of Soil moisture indicator

- A MoU was signed between M/s. MSM Bioclean Energy Ventures Private Limited, Kakinada and ICAR-SBI on 23 March 2018, on the evaluation of energy canes for energy production. Once potential energy canes are

identified, the company will utilize the energy canes for commercial energy production.

At Karnal

MoU with Sugar Mills: The Institute had signed MoU for the evaluation of pre-release elite clones in factory locations with the two Sugar Mills of M/s Saraswati Sugar Mills Ltd, Yamunanagar, Haryana, M/s Dhampur Sugar Mills Ltd, Dhampur, Bijnor, Uttar Pradesh, M/s Modi Sugars Ltd, Modinagar, Gaziabad Uttar Pradesh of NWZ. Clones Co 12029, Co 13034, Co 13035, Co 14034, Co 14035, Co 15023, Co 15024, Co 15025, Co 15026 and Co 15027 along with latest release early variety Co 05009 were supplied to above mentioned sugar mills.

PRODUCT DEVELOPED

'Cane Adviser' – A mobile app for transfer of sugarcane technology

Cane Adviser is a computer program designed to run on mobile devices such as smart phones and tablet computers to provide farmers, cane staff, students and line department officials timely access to information on scientific sugarcane production, advice on appropriate technology, and other related services.

Basis of App Development:As an initial step, the requirement of the sugarcane growers / cane staff was analyzed through focus group discussions conducted in the villages as well as during other interface meetings. The information was collected in terms of the type of mobile phones used, pattern of mobile use, content needs in the app, services required through the app, format of the messages, preferred medium of communication etc. The information gathered was analyzed and accordingly the app was developed.

Modules in 'Cane Adviser'

The features of the app developed include static as well as dynamic platforms. A few modules available in the mobile app are listed below:

Login dialogue: This go-ahead user-interface is the first step towards registration. The particulars needed comprise name, mobile number, address and email (optional).

Downloader: This static downloadable display of knowledge base contains information on sugarcane agriculture right from planting to harvesting, otherwise referred as technical part. The content involves mainly text and graphics in the form of still pictures. The text runs to around 220 pages with more than 650 digital stills describing the content depicted. The information is given as state-wise varieties, crop production technologies, pest identification and management, disease identification and management and ratoon management. The general contents include history of the institute, mandate, Sugarcane Research Stations etc.

Scheduler app: This is a unique feature of the mobile app ingrained in the module, which is tailor-made for each individual registered user. The basic inputs for registration include date of planting, choice of crop (plant / ratoon) and option of season (autumn / spring). Corresponding to the date of planting, continued advice and reminder messages on the calendar of cultural operations to be carried out are popped up on real-time mode.

Fertilizer schedule: Apart from the information on nutrient management detailed in the knowledge base, the app contains information on recommended dose of fertilizer for all the sugarcane growing states.

Query handler: As the eventual dialogue window, user has the option to raise queries either as text messages or in graphic form, be it as live images or from the gallery. The queries are then replied by the administrator via message sorting, short message service, email etc.

Languages: The entire matter was developed in English and then translated to Hindi and Tamil so as

to have the app in trilingual. The app was named as 'Cane Adviser' in English, 'Ganna Salahkar' in Hindi and 'Karumbu Aalosakar' in Tamil in accord with ICAR norms.

How to use 'Cane Adviser'?

'Cane Adviser' is available in google play store for free download (Fig. 136). This app would fit in any android-based smart phone irrespective of the configuration, which is a stand-alone module. It has been made in a way that one-time internet connection alone is required for downloading the app. Further query mode needs to be internet based so as to function on real time basis.

Fig. 136. Home page of 'Cane Adviser'

The Release

The Hindi version of the mobile app 'Ganna Salahkar' was released by Shri Radha Mohan Singh, Honourable Minister for Agriculture and Farmers Welfare in the presence of Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR on 29 August 2017 at New Delhi (Fig. 137) and the English version was released by Shri Subhashish Panda, IAS, Joint Secretary, Sugar, Food and Civil Supply Ministry, Government of India on 21 September 2017 (Fig. 138). The Tamil version was released by Padma Bhushan Dr. R.S. Paroda, former Director General, ICAR and Secretary, DARE during the Research Advisory Committee meeting on 4 November 2017 (Fig. 139).

Fig. 137. Release of 'Ganna Salahkar' mobile app on sugarcane by Shri Radha Mohan Singh, Honourable Minister for Agriculture and Farmers Welfare

Fig. 138. Release of 'Cane Adviser' mobile app on sugarcane by Shri Subhashish Panda, IAS, Joint Secretary, Sugar, Food and Civil Supply Ministry, GoI

Fig. 139. Release of 'Karumbu Aalosakar' mobile app by Padma Bhushan Dr. R.S. Paroda, former Director General, ICAR and Secretary, DARE

(T. Rajula Shanthy, S. Alarmelu, P. Malathi and C. Jayabose)

13. EVENTS

World Soil Day celebration

World Soil Day was celebrated on 5 December 2017 at Ponni Sugars (Erode) Ltd., Odapalli, Cauvery R.S, Namakkal (Dt.) (Fig. 140). Dr. Bakshi Ram, Director, ICAR-SBI was the Chief Guest. Soil Health Cards were distributed to sugarcane farmers on the occasion and the contents of the soil health card were explained to the farmers. The mobile app 'Cane Adviser' was demonstrated to the participating farmers. A detailed interactive session was held with the ICAR-SBI Scientists, farmers and factory officials.

Fig. 140. Dr. Bakshi Ram, Director, ICAR-SBI issuing Soil Health Card to a progressive sugarcane farmer

Hindi Workshop

Quarterly Hindi Workshops were conducted on 01 June 2017, 03 August 2017, 25 November 2017 and 20 March 2018 wherein Dr. Kaveti Rangan, BSNL, Coimbatore was the Chief Guest and he spoke on noting and drafting in Hindi.

Hindi Day

Hindi Day was celebrated on 25 September 2017. Shri Sameer Kumar, Assistant Provident Fund Commissioner, EPF Office, Coimbatore was the Chief Guest of the celebration (Fig. 141). Various competitions were conducted and the winners were awarded. A Hindi magazine 'Ganna Prakash' was released during the Hindi Day by the Chief Guest.

Fig. 141. Hindi Day celebration

At Karnal

- Quarterly meeting of Rajbhasha Hindi was organized at the Centre on 29 June 2017.
- Dr. Neeraj Kulshreshtha, Dr. M. R. Meena and Shri B.N. Manjhi participated in *Nagar Rajbhasha Kariyanvayn Samiti* (NARAKASH) held at ICAR - NDRI, Karnal on 09 June 2017.
- Hindi Pakhwara was celebrated at this centre during 14-29 September 2017 and various events were organized such as Hindi essay competition, Agricultural quiz in Hindi for technical and administrative staffs including causal labourers and staff from other ICAR Institutes (Fig. 142).

Fig. 142. Hindi Day celebration at ICAR-SBIRC, Karnal

International Yoga Day

International Yoga Day was celebrated at the Institute on 21 June 2017. Shri. S. Jeladharan Nair, Yoga Expert, Coimbatore was the Chief Guest and

he gave a lecture on 'Yoga for Positive Health' followed by demonstration on yoga postures (Fig. 143).

Fig. 143. Demonstration of yoga postures

National Seminar

A National Seminar on 'Hundred years of sweet revolution in India: Co 205 to Co 0238' was organized at National Agricultural Science Complex, ICAR, New Delhi by ICAR-SBI Regional Centre, Karnal on 29 August 2017 on the centenary of world's first inter-specific sugar cane hybrid Co 205 released in 1918. More than 350 farmers from Bihar, Haryana, Uttar Pradesh and Uttarakhand, representatives of sugar mills, state government officials and sugarcane scientists participated in the seminar.

Shri Radha Mohan Singh, Honourable Union Minister for Agriculture and Farmers Welfare inaugurated the Seminar (Fig. 144). The Minister lauded ICAR-SBI, Coimbatore for the incomparable contribution to sugarcane and sugar production of the country through the development of high yielding sugar rich 'Co' varieties. He said that 'Co' varieties have made unprecedented contributions to the spread of sugar industry in India and in 28 other countries of the world and have assumed the status of ancestors in the lineage of sugarcane varieties of the world. This is a matter of great pride for the country. The increase in area under sugarcane from 1.17 million hectares in 1930-31 to 5 million hectares in 2015-16 with corresponding sugarcane production from 36.35 million tonnes to 359 million tonnes and sugar production from 0.12 million tonnes to 26.5 million tonnes happened due to improved sugarcane varieties developed by the Institute, hard work of sugarcane farmers and modernization of sugar mills, he said.

Fig. 144. Shri Radha Mohan Singh, Honorable Union Minister for Agriculture and Farmers Welfare addressing the gathering

The Regional Centre at Karnal has developed a lot of high yielding sugarcane varieties combining better sugar content for North India, of which many became very popular. During the last three years due to more emphasis on quality seed production at farmer's field under National Food Security Mission, there has been a large expansion of area under Co 0238, a wonder sugarcane variety developed by Karnal centre in North India causing a record shift in sugarcane yield and sugar recovery. In 2016-17, Co 0238 has occupied 36% cane area in Uttar Pradesh, 63% in Punjab, 39% in Haryana, 17% in Uttarakhand and 12% in Bihar. Today due to high cane yield and better sugar content, Co 0238 has become the first choice of sugarcane farmers and sugar mills across North India. The region of western Uttar Pradesh and Haryana near ICAR-Sugarcane Breeding Institute, Regional Centre, Karnal witnessed 80 tonnes per hectare average yield of sugarcane against 60 tonnes per ha of North India, reflecting the commendable contribution of this centre said the minister. Shri Radha Mohan Singh called upon the scientists to develop such varieties of sugarcane, which can produce good yields in flood, drought and high temperature situations. 'Our government wants that when we

celebrate 75th anniversary of independence in 2022, the income of the farmers of the country to be doubled' said the minister. For this, sugarcane farmers will have to cultivate oilseeds and vegetables as intercrop along with sugarcane so as to get additional income. He said that ICAR-SBI has developed a low cost machine for cutting single bud setts, a small machine for seed treatment and seedling transplanting machine (Sugarcane Settling Transplanter) towards complete mechanization of planting operation in sugarcane.

Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR said that in the year 1912, Sir T.S. Venkatraman has given the country the first inter-specific hybrid 'Co 205' developed for sub-tropical climate, which was released in 1918 for commercial cultivation (Fig. 145). Due to this hybrid, there was about 50% increase in sugarcane production in Northern India. ICAR-SBI, Coimbatore has developed many amazing varieties for the country suitable for various climatic conditions. From 2013-14 to 2016-17, sugar industry in Uttar Pradesh has earned an additional amount of Rs. 8,697 crores due to increased sugarcane yield and high sugar recovery from the spread of variety Co 0238.

Fig. 145. Dr. T. Mohapatra, Secretary, DARE and DG, ICAR addressing the gathering

Dr. A.K. Singh, DDG (Crop Science) said that ICAR-SBI has established National Hybridization Garden facility for the development of location specific varieties in the country. Sugarcane is cultivated in about 50 lakh hectares area of the country, which provides employment to 7.5% population of rural India. The average yield of the country is 69.5 tonnes per hectare, which is much higher than its neighboring countries like Pakistan, Bangladesh, Nepal, Sri Lanka and equal to China.

Dr. Bakshi Ram, Director, ICAR-SBI while highlighting the achievements of the Institute in his address, said that about 40 percent of the country's sugarcane area is occupied by two varieties from the Institute, Co 86032 and Co 0238. Sugarcane and sugar yields have been affected in Gujarat, Maharashtra, Tamil Nadu, Andhra Pradesh and Karnataka due to drought in the last 2-3 years. This damage was compensated by the cultivation of Co 0238 in North India resulting in continuous increase in sugarcane production and sugar recovery. Farmers are earning additional income of Rs. 35-40 thousand per hectare and mills are getting record high sugar recovery. He said that cultivating sugarcane in trench method of planting at 4-5 feet spacing with intercrops can help farmers achieve high income from sugarcanefarming. He said that an ambitious project of true seed production has been started for seed rate minimization (from truck to pocket) for commercial cultivation of sugarcane.

Later, the Minister honoured Dr. Bakshi Ram for the development of Co 0238 a wonder sugarcane variety of North India; Dr. Bhagyalakshmi for Co 86032, a wonder sugarcane variety of South India; Uttar Pradesh Council of Sugarcane Research, Shahjahanpur for developing CoS 767 and Dr. Narendra Singh, Balrampur Sugar Mill for his excellent services in spreading Co 0238 variety.

Eight pogressive farmers were honoured by Honorable Minister of Agriculture and Farmers Welfare for their contribution to scientific sugarcane farming and seed production: Shri Krishna Dev Rai (Begusarai) and Shri Inder Bhushan Singh (Western Champaran) from Bihar, Shri Sumerchand Mohan (Karnal) and Shri Gurmail Singh (Yamunanagar) from Haryana, Shri Satendra Singh (Udhamsinghnagar) and Shri Mahipal Singh (Haridwar) from Uttarakhand and Shri Umesh

Kumar (Muzaffarnagar) and Shri Ashok Kumar (Meerut) from Uttar Pradesh.

During the panel discussions held in the afternoon, the measures on how to double farmers' income were discussed and they were given information on new sugarcane varieties, integrated pest and disease management, irrigation management, nutrient management, healthy seed production, crop rotation and mechanization. Measures to reduce losses to sugar mills such as varietal diversification in the reserved mill area, modernization of mills, use of co-products such as ethanol, co-generation, paper production, pricing of co-products etc. were discussed.

International Symposium

An International symposium on 'Sugarcane Research Since Co 205: 100 Years and Beyond' (SucroSym 2017) was organized to commemorate the 100th year of the release of 'Co 205', the first commercial variety of sugarcane by ICAR-Sugarcane Breeding Institute, Coimbatore that paved a new direction to the entire contemporary and future sugarcane breeding programmes in almost all the sugarcane growing countries. The symposium was jointly organized by ICAR-SBI, Tamil Nadu Agricultural University, Coimbatore, South Indian Sugar Mills Association (SISMA)-TN and Society for Sugarcane Research and Development, Coimbatore during 18-21 September 2017 at Hotel Le Meredien, Coimbatore.

Professor Robert Henry, Director, Queensland Alliance for Agriculture and Food Innovation, Australia inaugurated the symposium (Fig. 146). In his Inaugural Address, he said that the unconventional uses of sugarcane should be identified and tapped to face the future challenges. Research on using sugarcane as bio-fuel crop involving burning of lignin for electricity and cellulose for feedstock conversion and obtaining bio-plastic should be strengthened, he added. He envisioned that by 2050, high energy density liquid from sugarcane for operating aircrafts will be realized.

Fig. 146. Inauguration of the International Symposium

In his Special Address, Dr. K. Ramasamy, Vice Chancellor of Tamil Nadu Agricultural University, Coimbatore stressed the importance and need for identifying and popularizing location-specific varieties to improve sugarcane productivity. Smt. Anu George, IAS, Director of Sugar, Government of Tamil Nadu in her Address said that the area under sugarcane as well as the yield of Co 86032 have come down drastically in Tamil Nadu state and it is the responsibility of the researchers, policy makers, sugar industry and cane growers to turn this around. Dr. R.K. Singh, Assistant Director General (Commercial Crops), Indian Council of Agricultural Research, Dr. Palani G. Periasamy, President of SISMA-TN, Shri Shivaji Rao Deshmukh, IAS (Retd.), Director General, Vasantdada Sugar Institute, Pune and Dr. A.D. Pathak, Director, Indian Institute of Sugarcane Research, Lucknow delivered Special Addresses.

Dr. Bakshi Ram, Director, ICAR-SBI, in his introductory remarks said that since the release of Co 205 the first inter-specific commercial hybrid, the institute had been playing a pivotal role of catering to the needs of sugarcane farmers by developing cane varieties with high yields coupled with high recovery. Two wonder varieties of sugarcane evolved at this Institute *viz.*, Co 86032 (Tropical India) and Co 0238 (Sub-tropical India) occupy about 40% of the sugarcane area in the country, he added.

Professor M.S. Swaminathan, in his video-address said that Coimbatore canes were and are still being

cultivated in South Asia and parts of Africa. Remembering the services of Sir T.S. Venkatraman in developing the first interspecific hybrid, Co 205 which revolutionized sugar industry and sugarcane agriculture, he said that 'Co' canes are being recognized globally for combination of all characters.

Three former Directors of ICAR-SBI, Dr. K. Mohan Naidu, Dr. N. Balasundaram and Dr. N. Vijayan Nair were felicitated during the Inaugural Function.

There were three plenary papers on sugarcane and sugar research. Eighteen lead papers and 67 oral papers were presented and 202 posters were displayed under nine theme areas. The theme areas were:

1. Sugarcane genetic resources and pre-breeding for enriching gene pool
2. Breeding strategies-Past, present and future
3. Biotechnology, bioinformatics, gene discovery, genetic engineering and nanotechnology
4. Recent trends in sugarcane pest and disease management
5. Crop management technologies for maximising productivity
6. 'Cane to Sugar'-technological advancement in process engineering and cane for non-conventional purposes
7. Mechanization of sugarcane production system and cane machinery
8. Innovations in knowledge management, digital inclusion, economic impact analysis and doubling farmers' income
9. Climate change and climate resilient technologies

The symposium provided a platform for the exchange of knowledge and innovative approaches among the 456 researchers and sugar industry and agricultural machinery manufacturers from India, Australia, Iran and Tanzania. The symposium stressed the need for reinventing sugarcane research by addressing issues in biotechnology, nanotechnology and bio-informatics and the results shared among sugarcane researchers of the world. The need for funding research by the industry for developing new location specific and special varieties for various traits and alternate uses was emphasized for making a breakthrough in sugarcane improvement by 2050. Apart from sugarcane researchers, there was good participation from the sugar industry. The themes 6-8 and the exhibition with twelve stalls provided avenues for the efficient exchange of innovations and recent developments to the industry personnel engaged at improving efficiency and lowering the cost of sugar production (Fig. 147).

Fig. 147. Delegates visiting the Exhibition stalls

In the Valedictory Session chaired by Shri Subhasish Panda IAS, Joint Secretary, Sugar and Administration, GoI, he cautioned the future of sugarcane for alternate uses as fuel and energy in light of the pace of research outcome in the energy sector (Fig. 148). He stressed the need for a symbiotic relationship between farmers, industry and scientists to make India the largest exporter of sugar. Dr. K.V. Bhagyalakshmi, former Scientist and Dr. K. Mohan Naidu, Former Director of ICAR-SBI were felicitated for their efforts. He also gave away the Best Poster awards.

Dr. Bakshi Ram Director, ICAR SBI was the Chairman of the local organizing committee, Dr. G. Hemaprabha and Dr. R. Viswanathan served as the Organizing Secretary and Member Secretary respectively.

Fig. 148. Shri Subhasish Panda IAS, Joint Secretary, Govt of India delivering the Valedictory Address

Sports Meet

ICAR Southern Zone Sports Meet was organized during 09-13 October 2017 with the participation of 23 Sports Contingents (563 players - 509 male and 54 female) from the States of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu (Fig. 149-150).

Fig. 149. March Past by contingents

Fig. 150. Dr. Bakshi Ram, Director, ICAR-SBI distributing prizes to the winners

Shri Ravichandran, MSc, M.Phil, District Revenue Officer, Coimbatore inaugurated the meet on 09 October 2017. Dr. Bakshi Ram, Director, ICAR- Sugarcane Breeding Institute, Coimbatore presided the closing ceremony of the meet on 13 October 2017.

Tribal Sub Plan Initiatives

Surveys were made in nine villages in Paalamalai hill range and 21 tribal villages near Pilloor dam for selecting beneficiary tribal villages (Fig. 151). Based on the benchmark survey, six villages *viz.*, Neelampathi, Ikkapatti, Mottiyoor, Ukkaiyanoor, Perukkupatti and Pasumani in Paalamalai hills with 463 tribal families and seven villages *viz.*, near Pilloor dam were selected.

Fig. 151. Survey in tribal villages

A mulit-crop thresher was given to Kuliyoor tribal village, wherein developmental activities are being done by the Institute since 2016. The mini tractor and flour mill given to them earlier are being used by the villagers in Kuzhiyur and nearby five tribal villagers. The flour mill has been put to use to grind over one metric tonne of wheat, ragi, sorghum and other minor millets.

Success Story

Development of tailoring skills among women from marginalised communities: Development of tailoring skills among the tribal women is a field action project which was started in April 2016, with the objective of training women from marginalised tribal groups and help them gain employment or self-employment. The women from these groups have responded to this activity enthusiastically as it is helping them to not only develop skills, but also gain self-confidence to earn money. Six sewing machines were earlier given to them, of which two tribal women had opened a tailoring unit in Melbaaviyur village and they reported that they earn Rs. 3500 to Rs. 4000 per month. As a follow-up of skill development, these tribal women had furthered their skill with training through a local tailor. They are guided to start their own ventures and further advance short term training will be given to them if needed. Taking cue from this success story, we have upscaled this activity in Paalamalai hills.

This year, we have provided 23 sewing machines (Fig.152) for 23 tribal women in Neelampathi, Ikkapatti, Mottiyoor, Ukkaiyanoor, Perukkupatti and Pasumani who were Certificate holders in tailoring as a means to improve their livelihood and the activities are being monitored.

Fig. 152. Supply of Sewing Machines

Bee hives - A mode of income and a tactic to ward off elephants: To prevent crop damage by elephants and create business opportunities, we have given forty honey-bee hives to Paalamalai tribal villages in the Western Ghats (Fig. 153). During our earlier interaction with the tribal villagers, we learnt that the villagers were worried about their livelihoods as the elephants pose a threat to their cultivation. Also, we could notice the availability of varied sweet smelling flowers like Pavetta indica, wild jasmine and a variety of creepers. So, we thought to make the villagers cultivate honey by rearing honey bees.

Honey bee-hives were ordered from a cultivator in Erode and it was transported in the night as the bees are night blind and will not try escaping the hive and they are also sensitive to change in surroundings. We foresee that the villagers can successfully shoo away elephants and get a substantial income from their venture into apiary. Another 50 bee-hive units were given to Agali village as well.

Fig. 153. Supply of honey-bee hives

Other items like 40 hp tractor, trailer, cultivator, rotavator, field operation kits, brush cutter, tarpaulin sheets, multipurpose pan, country plough etc. were procured for distribution to tribal villages.

(T. Rajula Shanthy, C. Jayabose, C. Sankaranarayanan, Arjun Tayade, Malakappa B. Medegar, Kannaian)

Mera Gaon Mera Gaurav

Eighteen teams comprising four scientists had identified 90 villages (Coimbatore - 75, Karnal - 10 and Kannur - 5) for adoption. Baseline surveys were conducted initially and information on the demographic details, description of farming situation, major crops grown, cropping pattern,

infrastructural facilities available, problems in agriculture and organizations working in the village were collected. Preliminary analysis indicated that the major crops in Coimbatore district were coconut, banana, paddy, pulses, vegetables, turmeric, onion and arecanut. Major problems were drought, non-availability of inputs in time, poor marketability of the produce, high cost and unavailability of labour and livestock health issues. Wheat, paddy and sugarcane were the major crops grown in Karnal district whereas paddy, coconut and banana were the major crops grown in Kannur district. Regular visits were made to the adopted villages and technical guidance was provided to the farmers for improving their livelihood.

Regular group meetings and demonstrations on important technologies were organized in the adopted villages. Extension literature on 'Using Soil Moisture Indicators', 'Drought management', 'Soil health management' was distributed.

New Year Day Celebration

New Year was celebrated in the Institute on 1 January 2018. Dr. Bakshi Ram, Director of the institute presided over the function. He gave the New Year message to the staff of the Institute followed by cutting New Year cake (Fig. 154).

Fig. 154. New Year Day celebration at ICAR-SBI

Republic Day celebration

Republic Day was celebrated on 26 January 2018 by hoisting the National Flag by Dr. Bakshi Ram, Director, ICAR-SBI. Later, he addressed the staff of the Institute (Fig. 155).

Fig. 155 Dr. Bakshi Ram, Director, ICAR-SBI addressing the staff on Republic Day

Seed Day

Seed day was celebrated at ECC Farm of ICAR-Sugarcane Breeding Institute, Coimbatore on 02 February 2018 under the ICAR Seed Project. All the Scientists participated and interacted with the farmers.

Field Day

- An interaction programme was conducted on 15th February 2018 at the farmers's field in Vellamadai village, Coimbatore. Progressive farmers of the location and seed personnel from all the indented sugar factories participated in the meeting.

Interactive Meetings

- Interactive workshop of ICAR-SBI-SISMA (Tamil Nadu) was conducted on 08 March, 2017 at Rajshree Sugars and Chemicals Limited, Mundiampakkam. The cane officials of all nine participating factories participated in the meeting.
- An interaction meeting of ICAR-SBI, Coimbatore and SISMA (TN) was organized on 26 March 2018 at ICAR-SBI, Coimbatore for reviewing the progress of the 'Sweet Bloom Project'. All the participating Scientists and the concerned sugar factory personnel and invited representatives from Co operative sugar factories of Tamil Nadu attended the meeting.

Swachchh Bharat Abhiyan

Cleanliness campaigns were conducted at the Institute and the residential quarters among the employees and the residents. Campaigns were also conducted in the adopted tribal villages among the tribal people. The participants were made to realize the importance of clean surroundings, collection and segregation of household and office wastes as bio-degradable, non-degradable, recyclable and toxic wastes. In each campaign, all the participants were involved in cleaning the pathways and surroundings, collection and segregation of wastes.

'Swachta Abhiyan' was observed in the Institute with special cleanliness drive campaigns from 15 September to 2 October, 2017.

Swachhta Pledge: Swachchhta Pledge was taken by the staff on 15 May 2017 as an initiation towards the Swachchhta Pakwada, which was followed by the other events (Fig. 156).

Fig. 156. Director and staff of ICAR-SBI taking the Swachchh Bharat oath

Fig. 157. Cleaning of Institute campus

Fig. 158. Cleanliness Drive at ICAR-SBI

Fig. 159. Parthenium Eradication Drive in the campus

Cleanliness Drive: Cleanliness campaigns for general cleaning and especially for eradicating Parthenium was taken up by the institute staff in the main campus and Research Centres (Fig. 157 - 159).

Vermicomposting: Efforts for creating awareness in the Institute and the residential quarters among the employees and the residents were intensified. Bio-degradable wastes are being collected and collected in the vermicompost pit erected for the purpose and left for composting.

Fig. 160. Scientists educating tribal villagers about cleanliness of village surroundings

Village campaigns: A tribal village campaign was conducted in Kuzhiyur tribal village, a beneficiary village under Tribal Sub Plan of the institute. They were educated about the importance of cleanliness in keeping their houses and livestock sheds clean (Fig. 160).

At Karnal

- Swachta Abhiyan was observed at this centre from 15 September to 2 October, 2017 (Fig. 161).

Fig. 161. Cleanliness Campaign at SBI-RC Karnal

Other Meetings

- Senior Officers Committee meeting held on 03 April 2017, 04 May 2017, 17 June 2017, 21 July 2017, 08 September 2017, 27 October 2017, 29 November 2017, 06 January 2018, 05 February 2018 and 15 March 2018.
- Farm Advisory Committee meeting held on 03 April 2017, 04 May 2017, 05 June 2017, 7 July, 01 August and 07 September 2017, 03 October 2017, 31 October 2017, 4 December 2017, 06 January 2018, 05 February 2018 and 05 March 2018.
- IJSC meeting held on 03 April 2017, 10 August 2017 and 14 March 2018.
- Grievance Committee meeting held on 13 April 2017, 11 May 2017 and 09 June 2017, 14 July 2017, 18 August 2017 and 14 September 2017, 27 October 2017, 14 November 2017, 15 December 2017, 18 January 2018, 14 February 2018 and 14 March 2018.
- Women Cell meeting held on 04 May 2017, 11 September 2017, 18 December 2017 and 20 February 2018.
- Selection Committee meeting for the post of Senior Research Fellow held on 15 May 2017.
- Department Promotion Committee Meeting for selection of Assistant Administrative Officer by LDCE held on 11 July 2017 and for probation clearance of Supporting Staff held on 17 July 2017.
- Screening Committee meeting for grant of MACP to Skilled Support Staff held on 26 September 2017.
- Selection Committee meeting for the post of Senior Research Fellow held on 16 August 2017 and 18 August 2017.
- Selection Committee meeting for post of Lab Assistant held on 17 August 2017.
- 'Sankalp Se Siddhi' Pledge to commemorate the spirit of completion of 75 years of launch of Quit India Movement taken on 09 August 2017.
- 'Sadbhavana Diwas' Pledge taken by the staff on 18 August 2017.
- Vigilance Awareness Week observed from 30 October 2017 to 04 November 2017 at this Institute and its Regional/ Research Centres.
- Constitution Day was observed on 27 November 2017 at the Institute and its Regional / Research Centres.
- Rashtriya Ekta Diwas (National Unity Day) was observed on 31 October 2017.
- 91st Institute Management Committee meeting was held on 20 December 2017.
- Selection Committee meeting held on 27 January 2018, 05 February 2018, 12 February 2018, 26 February 2018 and 21 March 2018.
- Assessment Committee meeting held on 17 January 2018, 22 January 2018 and 24 January 2018.
- Assessment Committee meeting for CAS in respect of Scientists held on 08 January 2018.
- Departmental Promotion Committee meeting held on 18 January 2018, 19 January 2018 and 25 January 2018.
- Martyr's Day was observed on 30 January 2018.
- Women's Day was celebrated on 08 March 2018.

14. COMMITTEES

Research Advisory Committee Meeting

The 23rd Research Advisory Committee meeting of ICAR-Sugarcane Breeding Institute, Coimbatore was held during 3-4 November 2017 at Coimbatore (Fig. 162 - 163). Dr. R.S. Paroda, former Secretary, DARE and Director General ICAR and Chairman, RAC of the Institute presided over the meeting. The members of the committee who were present include Dr. Bakshi Ram, Director, ICAR-SBI, Dr. S.R. Sreerangaswami, Former Director, Centre for Plant Molecular Biology, TamilNadu Agricultural University, Coimbatore, Dr. O.K. Sinha, Former Project Coordinator, AICRP(S), Dr. M. Velayutham, former Director NBSS and LUP, Nagpur, Dr.R.K. Sairam, former Head, Plant Physiology, IARI, New Delhi, Dr. G. Hemaprabha, PS and Head i/c, Division of Crop Improvement and Member Secretary, and Mr. P. Kanakasabapathi, and Mr. N. Pointmani, Non-official members.

Fig. 162. Dr. Bakshi Ram, Director, ICAR-SBI presenting the Institute Report

Fig. 163. RAC meeting in progress

Dr. Bakshi Ram welcomed the Chairman and presented the research highlights of the year 2016-17 including a brief account of the national and international sugarcane / sugar scenario. The Action Taken Report of the previous meeting was presented by Dr. G. Hemaprabha followed by the presentation of salient achievements of Divisions/ Sections by Dr. G. Hemaprabha, Dr. R. Viswanathan, Dr. C. Palaniswami, Dr. T. Rajula Shanthy, Dr. P. Murali, Dr. Neeraj Kulshrestha, Dr. K. Chandran and Dr. R. Karuppaiyan.

During the deliberations, the experts gave constructive points to strengthen the research output of the institute, which are summarized: Dr. S.R. Sreerangaswami appreciated the work done by the Institute in networking with the industry, research on true seed and suggested to incorporate biotechnology, bioinformatics and nanotechnology in a relevant manner for better results. He also stressed the need for maintenance breeding to avoid seepage of potential sources. While appreciating the efforts in true seed development initiative, he gave tips from the potato true breeding programme for programming sugarcane work to realize better output. He urged the need of a great corpus fund for sugarcane research. Prof M. Velayutham stressed the need to have intensive programme on intercropping, sub-surface drip fertigation, trash management and mechanized cultivation of cane by pooled arrangement amongst cane farmers. He also wanted to have a long term demonstration field to be in place for getting targeted yield with estimation of costs for production/ha and production/tonne and sustainability and soil quality indices measured over medium and long term. Dr. O.K. Sinha expressed the need to give emphasis on biocontrol of diseases and insect-pests in sugarcane and inducer nano particles as smart delivery system for harnessing disease resistance in sugarcane. Though the major disease namely red rot could be contained with resistant lines, he emphasized the need for

research in biocontrol and chemical control. The occurrence of white grub in several areas is alarming and suggested more research in biocontrol to contain the problem. Dr. S.R. Sairam stressed the need for better carbon fixation as a means for doubling productivity. Choice of right variety, reduced cost of production and derivation of more products from sugarcane are sought for doubling the income of farmers. Agronomy for nitrogen and water use efficiency is needed to be intensively pursued. Mr. N. Pointmani and Mr. P. Kanagasabapathi, Non-official members were happy to know the progress of the institute and the efforts for improving the activities of the Institute to improve the income of farmers. They promised all help for the extension of the technologies of the institute to the farmers of the state.

Dr. R.S Paroda, Chairman of the RAC wrapped up the views of the RAC and stressed the need for a strong programme on genetic resources and cryopreservation of germplasm, so also registration of elite material and wild species including S. *spontaneum* for use in future breeding and pre-breeding programmes. Success stories of the Institute including the march of the institute for a sweet revolution have to be brought out as small attractive publications. Quoting Prof. M.S. Randhawa, he said that our soils are more hungry than thirsty, hence the need for long term experiment on trash decomposition. Organic farming needs to be linked with market so as to ensure that farmers do not lose income following the practice. HRD of the Institute should take efforts to train the scientists in frontier areas. The Institute should also organize an International Conference on Sugarcane once in 3-4 years. Finally, RAC complimented the Director and the scientists for excellent progress made both in basic and applied areas in sugarcane research. There were eight recommendations each for the Divisions of Crop Improvement and Crop Production, and five for the Division of Crop Protection, whereas two recommendations were suggested for Agricultural Extension and Economics and one for Regional Station, Karnal in addition to three general recommendations.

Institute Research Council Meeting

The Institute Research Council meeting was conducted during 12-17 June 2017. The progress of the ongoing research projects was reviewed and suggestions were offered. Eighteen sub-projects were concluded and 11 new sub-projects were approved for the coming year.

15. PARTICIPATION IN CONFERENCES, MEETINGS, WORKSHOPS, SYMPOSIA AND SEMINARS

Title	Date	Participant(s)
National Conference on Emerging Technologies in Food Processing (NCETFP' 17) at Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, Tamil Nadu	5 April 2017	Dr. T. Arumuganathan
Collaborative workshop between ICAR-Sugarcane Breeding Institute, Coimbatore and Sugar Research Australia at ICAR-SBI, Coimbatore	17-18 April 2017	All Scientists
National Conference on Sustainable development goals: Preparedness and role of Indian Agriculture at New Delhi	11 May 2017	Dr. Bakshi Ram
Second Annual Convention of NISSTA held at ICAR-IISR, Lucknow, Uttar Pradesh	12 -13 May 2017	Dr. Bakshi Ram
Pre SLSC meeting of the RKVY Project at Krishi Bhawan, New Delhi	24 May 2017	Dr. Neeraj Kulshreshtha Dr. Pooja
Meeting of RKVY Projects at Chandigarh	29 May 2017	Dr. Neeraj Kulshreshtha Dr. Pooja
63rd Review Meeting of Nagar Rajbhasha Karyanyavan Samittee at ICAR-NDRI, Karnal	24 June 2017	Dr. Neeraj Kulshreshtha Dr. M. R. Meena Mr. B.N. Manjhi
Workshop on Survey Grade UAV Revolution at Sri Ramakrishna Engineering College, Vattamalaipalayam, Coimbatore	7 July 2017	Dr.T. Arumuganathan
Meeting of State level committee to suggest ways to promote sugarcane variety Co 0118 and CoH 160	10 July 2017 and 24 July 2017	Dr. Neeraj Kulshreshtha
Seminar on sugarcane and its by-products organized by VC Farm at Mandya, Karnataka	15 July 2017	Dr. A. Bhaskaran
Agri-intex, 2017 at CODISSIA Trade Fair Complex, Coimbatore	14-17 July 2017	Dr. T. Rajula Shanthy Dr. R. Selvakumar Dr. S. Anusha Dr. P. Geetha Dr. L. Saravanan Dr. C. Appunu Dr. P. Mahesh

Title	Date	Participant(s)
AICRP(S) monitoring team of the AICRP (S) trials under Peninsular zone II	31 July- 12 August 2017	Dr. S.K.Pandey
National Conference on Agricultural Scientific Tamil held at Tamil Nadu Agricultural University, Coimbatore	12-13 August 2017	Dr. A. Suganya
Meeting on Prioritization of projects under RKVY for the year 2017-18 at Krishi Bhawan, Panchkula	22 August 2017	Dr. Neeraj Kulshreshtha Dr. Pooja
National Seminar on Hundred years of sweet revolution in India: Co 205 to Co 0238 at NASC, ICAR, New Delhi	29 August 2017	Dr. Bakshi Ram Dr. Neeraj Kulshsrestha Dr. S.K. Pandey Dr. T. Rajula Shanthy Dr. M.L. Chhabra Dr. Ravinder Kumar Dr. Vishal Goel Dr. Parameshwari Dr. Minturam Meena Dr. Pooja
International Symposium on Sugarcane Research since Co 205: 100 Years and Beyond (SucroSym 2017) organized by ICAR-Sugarcane Breeding Institute at Coimbatore, Tamil Nadu	18-21 September 2017	All Scientists of the Institute
AICRP (S) Group Meeting at Tamil Nadu Agricultural University, Coimbatore	22-23 September 2017	Dr. Bakshi Ram Dr. G. Hemaprabha Dr.P. Govindaraj Dr. R.M. Shanthi Dr. S. Alarmelu Dr. A. AnnaDurai Dr.R. Karuppaian Dr. K. Mohanraj Dr. Adhini S. Pazhany Dr. S. Anusha Dr. A. S. Tayade Dr. R.Viswanathan Dr. K.P.Salin Dr. A.Ramesh Sundar Dr.J.Srikanth Dr. Neeraj Kulshreshtha Dr. S. K.Pandey

Title	Date	Participant(s)
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Varietal Identification Committee meeting at Tamil Nadu Agricultural University, Coimbatore	23 September 2017	Dr. Bakshi Ram Dr. T. Rajuala Shanthy Dr. A. Selvi
Institute Management Committee meeting held at ICAR-IIWBR, Karnal	27 September 2017	Dr. Neeraj Kulshreshtha
PFMS Review meeting chaired by AS & FA, DARE, ICAR at ICAR- NDRI, Karnal	04 October 2017	Dr. Neeraj Kulshreshtha
Annual Review Meeting of CRP on Vaccines and Diagnostics at IVRI, Bangalore campus, Bangalore	6-7 October 2017	Dr. R.Viswanathan
Seed Day and Rabi Workshop at ICAR-Indian Institute of Wheat and Barley Research, Karnal	10 October 2017	Dr. Neeraj Kulshreshtha
Meeting of Cane Control Board with Cane Commissioner, Haryana at Krishi Bhavan, Panchkulla	13 October 2017	Dr. Neeraj Kulshreshtha
48th Meeting of Sugarcane Research & Development Workers of Tamil Nadu and Puducherry at Salem	1-2 November 2017	Dr. Bakshi Ram Dr. G. Hemaprabha Dr. Prathap D. Puthira Dr. A. Bhaskaran
Meeting of varietal idenfication of sugarcane at IISR, Luckow	22 November 2017	Dr. Bakshi Ram Dr. Viswanathan
National monitoring of AICRP on sugarcane to Pusa, Motipur, Lucknow and Shajahanpur	20-24 November 2017	Dr. Viswanathan
' Dairy Mela' at ICAR-NDRI, Karnal, Haryana	25 November 2017	Dr. Neeraj Kulshreshtha Dr. B. Parameswari Dr. Ravinder Kumar Dr. M.R. Meena, Dr. K. Rajasekar
National Seminar on improved production technologies usage and processing of onion, garlic and potato in Haryana at NHRB, Salaru	30 November 2017	Dr. Neeraj Kulshreshtha Dr. B. Parameswari Dr. Ravinder Kumar Dr. M.R. Meena Dr. K. Rajasekar

Title	Date	Participant(s)
World Soil Day at Ponni Sugars Erode Ltd, Erode	05 December 2017	Dr. Bakshi Ram Dr. C. Palaniswami Dr. A. Vennila
Regional Committee Meeting at ICAR-Central Soil Salinity Research Institute, Karnal	12 December 2017	Dr. Neeraj Kulshreshtha
Institute Management Committee at ICAR-Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh	15 December 2017	Dr. Neeraj Kulshreshtha
Interaction meeting and training for seed farmers organized by ICAR-SBI at Vellamadai, Coimbatore	15 December 2017	Dr.A. Bhaskaran
Meeting of South Zone ZTMC of ICAR at IIMR, Hyderabad	16 December 2017	Dr. K. Hari
Meeting of Board of Directors, Punjab Sugar Federation	22 December 2017	Dr. Neeraj Kulshreshtha
A meeting organized by M/s Dhanuka Agrochemicals at New Delhi	04 January 2018	Dr. Neeraj Kulshreshtha Dr. K. S. Pandey Dr. L. M. Chhabra
12th Review Meeting of DUS Test Centres at ICAR- IISR, Lucknow	15-17 January 2018	Dr. S. Alarmelu Dr. M. R. Meena
International Symposium on Agriculture and Environment 2018 (ISAE 2018) at Faculty of Agriculture, University of Ruhuna, Sri Lanka	17-18 January 2018	Dr.T. Arumuganathan
Breeders Meet at ICAR-IISR, Lucknow, Uttar Pradesh	19 January 2018	Dr. Ravinder Kumar
Member of the Expert team for examining the sugar recovery aspect of M/s. Rana Sugars Limited, Buttar Seviyan, Amritsar, Punjab.	01-06 February 2018	Dr. C. Palaniswami Dr. A. Bhaskaran
Seed day Function at ICAR-SBI, Coimbatore	02 February 2018	All Scientists
Foundation Day celebration of ICAR-IIWBR at Karnal	09 February 2018	Dr. Neeraj Kulshreshtha
Silver Jubilee celebration of Krishi Vigyan Kendra-Peruvannamuzhi , Kozhikode organized by ICAR-KVK, Indian Institute of Spices Research, Kozhikode	12 February 2018	Dr.T. Arumuganathan
ICFA Inaugural Session as Member of the District Agriculture Council, Karnal at ICAR-CSSRI, Karnal	22 February 2018	Dr. Neeraj Kulshreshtha

Title	Date	Participant(s)
Review meeting of ICAR-Extramural projects convened by DDG (Engineering), ICAR, New Delhi at Tamil Nadu Agricultural University, Coimbatore	23 February 2018	Dr.T. Arumuganathan
Brain storming Session-cum-Interaction meet on Engineering interventions for production and processing of different crops at ICAR-Central Institute of Agricultural Engineering (CIAE), Bhopal	26-27 February 2018	Dr.T. Arumuganathan
Seminar on 'Learning of infrared technology and use of thermal imaging to our advantage on the job every day' organized by FLIR at Coimbatore	27 February 2018	Dr. K. Hari Dr. R. Arun Kumar
Delivered a lecture on Overview of plant varieties protection and DUS characterization in sugarcane in 10 days ICAR short course on 'Empowering knowledge on protection of plant varieties, IPRs and PGR' at ICAR-IIWBR, Karnal	4 March 2018	Dr. R. M. Meena
National Conference on 'Abiotic stress agriculture: Constraints and strategies at Annamalai University, Chidambaram, Tamil Nadu	6-7 March 2018	Dr. R. Gomathi
NADP 2018-19 Co-ordinating meeting at Directorate of Agriculture, Chennai	8 March 2018	Dr.G.Hemaprabha
'Rabi Kisan Mela' at ICAR-CSSRI, Karnal, Haryana	10 March 2018	Dr. Neeraj Kulshreshtha Dr. Ravinder Kumar Dr. R. M. Meena Dr. B. Parameswari
'Krishi Unnati Mela'-2018 at ICAR-IARI, New Delhi	16 March 2018	Dr. K. S. Pandey Dr. L. M. Chhabra Dr. Ravinder Kumar Dr. B. Parameswari Dr. M.R. Meena
Meeting at ICAR- KVK MYRADA, Gobichettipalayam, Erode, Tamil Nadu	17 March 2018	Dr. S. Alarmelu
Monitoring team for monitoring the implementation of drip irrigation load under SDF at M/s. Shri Prabhulingeshwar Sugars and Chemicals Ltd., Karnataka.	22 -24 March 2018	Dr. C. Palaniswami Dr. A. Bhaskaran

16. DISTINGUISHED VISITORS

At Coimbatore

Five Australian Scientists visited ICAR- Sugarcane Breeding Institute on Collaborative workshop between ICAR-SBI and Sugar Research Australia held during 17-18 April 2017.

An Indonesian delegation headed by H.E. Mr. Longki Djanggola, Governor of Central Sulawesi Province of the Republic of Indonesia visited on 07 April 2017 to know the sugarcane production technology being adopted in the Institute.

Shri Devendra Kumar Sharma, Food and Trade Policy Analyst, Government of India visited the institute on 3 August 2017 (Fig. 164).

Fig. 164. Shri Devendra Kumar Sharma, Food and Trade Policy Analyst, Government of India visiting institute museum

Shri Chhabilendra Roul, Secretary, ICAR and Additional Secretary, DARE visited the Institute on 26 December 2017 (Fig. 165). He held an interaction with the scientists of the Institute and lauded the achievements of the Institute towards increased sugarcane and sugar production. He stressed the need for climate smart agriculture in sugarcane and importance of intercropping to sustain the income of sugarcane farmers. Later, he visited the Institute Museum, biotechnology laboratory, tissue culture laboratory and the experimental fields.

Fig. 165. Shri Chhabilendra Roul, Secretary, ICAR and Additional Secretary, DARE interacting with Scientists

At Karnal

- An Indonesian delegation headed by H.E. Mr. Longki Djanggola, Governor of Central Sulawesi Province of the Republic of Indonesia visited on 07 April 2017 (Fig. 166).

Fig. 166. Indonesian team visiting ICAR-SBIRC, Karnal

- Dr. S.K. Malhotra, Agriculture Commissioner, Govt. of India, visited on 29 November 2017 and interacted with the Scientists and Staff about the research programmes, seed production and other activities at the centre.

Fig. 167. Dr. S.K. Malhotra visiting ICAR-SBIRC, Karnal

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