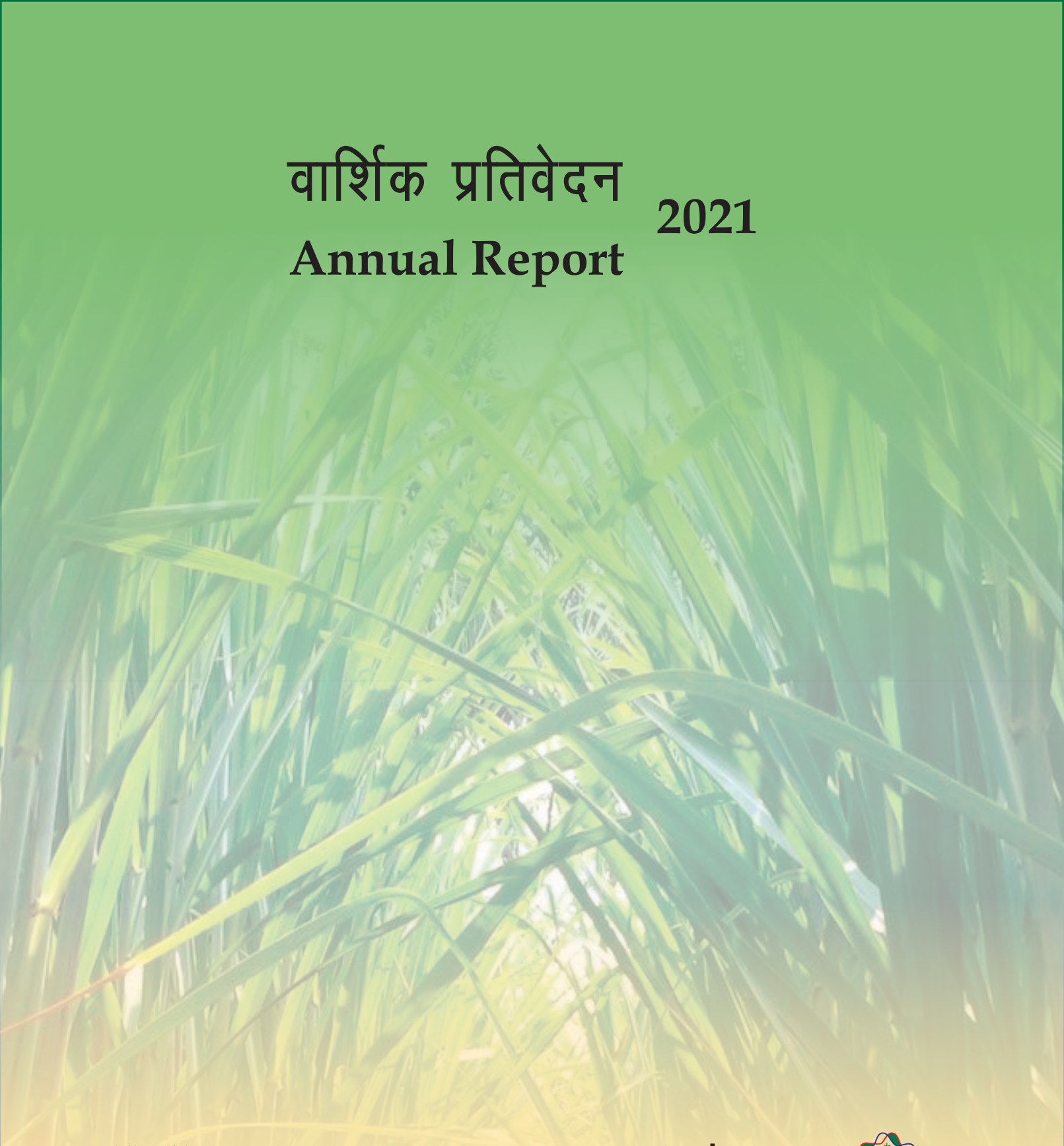
वार्षिक प्रतिवेदन 2021
Annual Report



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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Contents

Preface

ICAR-Sugarcane Breeding Institute celebrated its 110th Foundation day on 25-10-2021 and the long journey of the Institute has been wonderful, studded with an array of improved sugarcane varieties released in intervals to transform our Mother India into a sugar surplus country and as an exporter of sugar in the recent years. The total sugar production is expected to be a record figure of 38 MT in 2022, and achieving 10 per cent blending with petrol in 2022 would be a reality, a target fixed for 2025. The average sugarcane production of the country (81.98 t/ha) has also surpassed the world average sugarcane productivity of 77 t/ha. This spectacular achievement was mainly possible through its varieties which occupy about 80% area under sugarcane in the country, while over 98% of the area is occupied by the Co and Co allied varieties developed with the support of ICAR-SBI. The Institute's variety Co 0238, acclaimed as a wonder variety with extraordinary performance, continued its magical performance benefitting the farmers and millers and dominated subtropical India to cover about 22 lakh ha in 2021 in spite of red rot occurrence and identification of a new virulent pathotype CF 13 from it. The Institute released new varieties such as Co 13013 for Peninsular zone and Co 15023 and Co 14036 for North Western zone. Co 15023, an early maturing sugar rich variety is proving as a suitable complement to Co 0238 especially when planted in spring and summer months. Co 14012 was identified for release in Peninsular zone, which is an improved version of Co 86032, the ruling tropical cane, with increased sugar content and red rot resistance; Co 11015, released for Tamil Nadu has spread to 25000 acres and has proved to be a short duration/ early maturing variety with increased cane yield of 3-11 t/acre and sugar recovery of 0.4 to 1.5 units in different regions in Tamil Nadu. Waterlogging, an unusual phenomenon in sugarcane tracks in UP and adjoining places has been the serious bottleneck to cultivation of sugarcane, which necessitates the need of developing waterlogging tolerant varieties for the region and new varietal testing initives have been implemented in 2021.

Breeding superior varieties initiatives with increased resilience to climate change is a main focus of Crop Improvement Division and is taken up in a multidisciplinary mode. This year, seven genetic stocks possessing drought and water logging tolerance, ratooning ability, high biomass were registered with ICAR-NBPGR. Hitherto unutilized basic species clones for different traits are incorporated in the prebreeding programme. In order to support pre-breeding program, speed breeding facilities are under establishment. Sugarcane is a short-day plant, hence requires a different approach to induce flowering. Speed breeding protocols are being developed to study the effect on crop growth and flowering. The creation of this new facility would help in the development of new varieties and faster advancement of backcross generations in introgression breeding, production of inbred lines for genetic studies, transfer of GM events from a single cultivar into a range of backgrounds, in true seed production and population development through recurrent selection.

True seed based sugarcane agriculture needs the development of true breeding parental lines and significant progress was made through inbreeding approach aided with molecular genotyping and phenotyping to identify and advance the best performing near homozygous lines. Intercrossing of sixth generation selfs could produce

less segregating hybrid populations with increased hybrid vigour was demonstrated for the first time in sugarcane. More focused efforts are in progress.

Under the fluff supply programme, participating centers were facilitated to make crosses in the National Hybridization Garden and National Distant Hybridization Facility at ICAR-SBI RC, Agali. In order to develop genetic stocks for different stresses specific to the sugarcane growing tracks of India, a minimum of five wide crosses were made for each participating center. Constant demand of good quality sugarcane seed has been largely met with farmers' participatory seed production. During 2014-21 period, 7305 tonnes of quality breeder seed from Coimbatore and 8764.6 tonnes from Karnal were produced and supplied and has resulted in the substitution of old and degenerated seed and in controlling seed borne diseases, while ensuring realization of increased yield. Keeping in view of the occurrence of diseases, the institute has developed a Sett Treatment Device for disease management and healthy nursery programme in sugarcane and with its success, an inter-institutional project has been initiated to validate the device in other vegetatively propagated crops *viz.,* banana (ICAR-NRCB), tuber crops (ICAR -CTCRI), tapioca (TNAU), ginger and turmeric (ICAR-IISR, Calicut) and ornamental crops (ICAR-IIHR).

With the goal of establishing gene editing in sugarcane, more candidate genes such as Phytoene Desaturase (PDS) gene and eukaryotic translation initiation factor 4G (elF4G) were targeted to validate the genome editing through CRISPR/Cas9 mediated gene editing. Novel miRNAs were identified for drought and salinity tolerance. Through comparative transcriptome sequencing and analysis differentially expressing drought responsive genes *viz.,* Expansion *(EXPA1)* and *Glyoxalase (Gly III),* Nuclear Factor Y *(NFYB2)* and Aldehyde dehydrogenase *(ALDH)* were structurally and functionally validated and transgenic events were developed. A part of the transgenic events was multiplied after confirming increased drought tolerance and promising events for further screening under confined field conditions were identified. Insulin and Interferon *(Ifn2A)* gene constructs for vacuole targeting are also being used to develop for value addition. Genomic selection in sugarcane progressed and the prediction methods Bayes models and RKHS Single and RKHS- averaging were promising. As the field trials with *Bt*-62 caused 60% reduction in white grub population, whole genome sequencing of Bt 62 genome and further studies revealed the presence of two cry genes *viz.,* cry8Sa1 and cry8Ib of which Cry8Sa1 toxin caused significantly higher mortality up to to 95%.

A Sugarcane Based Farming system demonstration unit was inaugurated at the Institute by the Director General ICAR and Secretary, DARE Dr. Trilochan Mohapatra on 1-11-2021. This system consists of the components such as goat, dairy, poultry, fish culture, vermicompost, sugarcane settling production, and mushroom production, for demonstrating to small sugarcane farmers to double their income. Weed management using early post emergence application generation herbicide molecules, intercropping, water and radiation use efficiency in commercial and selected species clones were focused. Light interception under different spacings and basal temperature for flowering in different varieties, soil inference system (SIS) software with soil constraint identification and management measures and technology integration for maximising productivity and profitability also gave encouraging results. More number of new implements were developed in collaboration with the Central Agricultural Engineering Institute, Coimbatore station. A modified version of IISR Lucknow's tractor operated two row sugarcane sett cutter planter was developed as a technology with an efficiency of saving 54% cost of planting operation when compared to conventional planting.

Red rot management remained the major focus and 1524 resistant genotypes were identified from the breeding materials. Critical analysis of the role of sugarcane microRNAs and their target genes during sugarcane - *C. falcatum* interaction provided new insight into the miRNA mediated defence mechanism in sugarcane. Nano formulation application under field conditions could reduce fungal diseases significantly in susceptible varieties. Proteomics studies identi-

fied 13 proteins representing the smut pathogen. Pokkah boeng disease led to crop losses in Tamil Nadu along with mealy bug if spindle region is infested. Virus indexing service continued to index tissue culture raised plants from different tissue culture production labs. The field-release station standardized for the larval parasitoid *Cotesia flavipes* has been tested for egress of the egg parasitoid *Telenomus dignus*. Two novel *cry1* genes *viz cry1D* and *cry1E* were cloned in acrystalliferous Bt isolate SBI-KK 27. Bioassay indicated that *Cry1D* showed 90% growth and developmental retardation in pink boll worm resistant to Bollgaurd II cotton. In field trial with EPFs *Metarrhizium anisopliae* + *Beauveria brongniartii* against white grub also showed significant reduction of white grub. Three novel ICAR-SBI EPN formulations containing *Heterorhabditis bacteriophora* strain SBILN8, *Steinernema siamkayai* strain SBITNT1 and *Steinernema surkhetense* strain SBIP3 were developed with longer shelf life of 10-12 months with viable infective nematode juveniles. *Heterorhabditis indica* strain SBITNAUHI3 was found to be more virulent against fall Army worm causing 50% mortality of the 2nd instar larvae.

The institute made a big head way in the commercialization of technologies like EPN, soil moisture indicator, settling planter, Sett Treatment Device, sugarcane settling mechanical planter, tractor operated two row sugarcane sett cutter planter, sugarcane jam, liquid jaggery and bio-control agents against white grub. The ICAR-SBI EPN Biopesticide formulation technology has been commercialized to five firms with the co-ordination of AGRINNOVATE INDIA, New Delhi. The AgriBusiness Incubator of the Institute, named as 'SugarcaneEdge' is fully operational. The incubatees for cane jam and liquid jaggery production were given training and handholding. Karnal and Kannur centres made a big progress in developing new products from sugarcane and their marketing.

Significant improvement in publication of articles in high NAAS rated journals, winning the prestigious "National Water award" by the team of scientists who developed SMI and, several awards and fellowships from various reputed scientific societies brought laurels to the Institute. The institute HRD activity covered all the categories of staff during the past five years. The Institute has successfully implemented Central Government flagship programmes including Mera Gaon Mera Gaurav, Swachchh Bharat Abhiyan, SPC, SCSP, Soil Health Cards etc. Azadi ka Amrit Mahotsav programme was launched at the institute from 16-7-2021 coinciding with the Foundation day of ICAR. Different activities including lectures, campaigns, contests and displays were organised at the main institute and its regional/ research centres. It is ensured that at least a function was organized every week. Eminent scientists from different streams of science, agriculture and medicine delivered talks useful to all employees, in addition to campaigns, competitions and events organized for the benefit of staff, students, children, women, farmers, and economically weaker sections of the society.

The year 2021 was an eventful year of many research achievements and with greater participation of staff members in various events. I wholeheartedly thank all scientists and other staff of the Institute towards this achievement. This Annual Report is presented encompassing the research summaries and other activities of the Institute. I thank the editorial board for their dedicated efforts to beautifully bring out this publication. I gratefully acknowledge the constant encouragements and support provided by Dr. T. Mohapatra, Secretary DARE and DG, ICAR, Dr. T.R. Sharma, DDG (CS) ICAR, Dr. R. K. Singh, ADG (CC) ICAR and Dr Bakshi Ram, who was the Director of the institute till June, 2021.

Jai Hind

G. Hemaprabha
Director (Acting)

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 77^0 E longitude and 11^0 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 31.12.2021

Category	Sanctioned	Filled	Vacant
Director	1	1 (Acting)	-
Scientific	77	69	8
Technical	73	47	26
Administrative	43	22	21
Supporting	56	50	6
Total	250	188	62

Financial Statement

Table 2. Abstract of expenditure during January-December 2021

Head	Amount in Lakhs (Rs.)
Government Grant	4765.80
Plan Schemes	29.93
Externally funded schemes	508.01
Contract Research Projects	3.68
Total	5307.42

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).

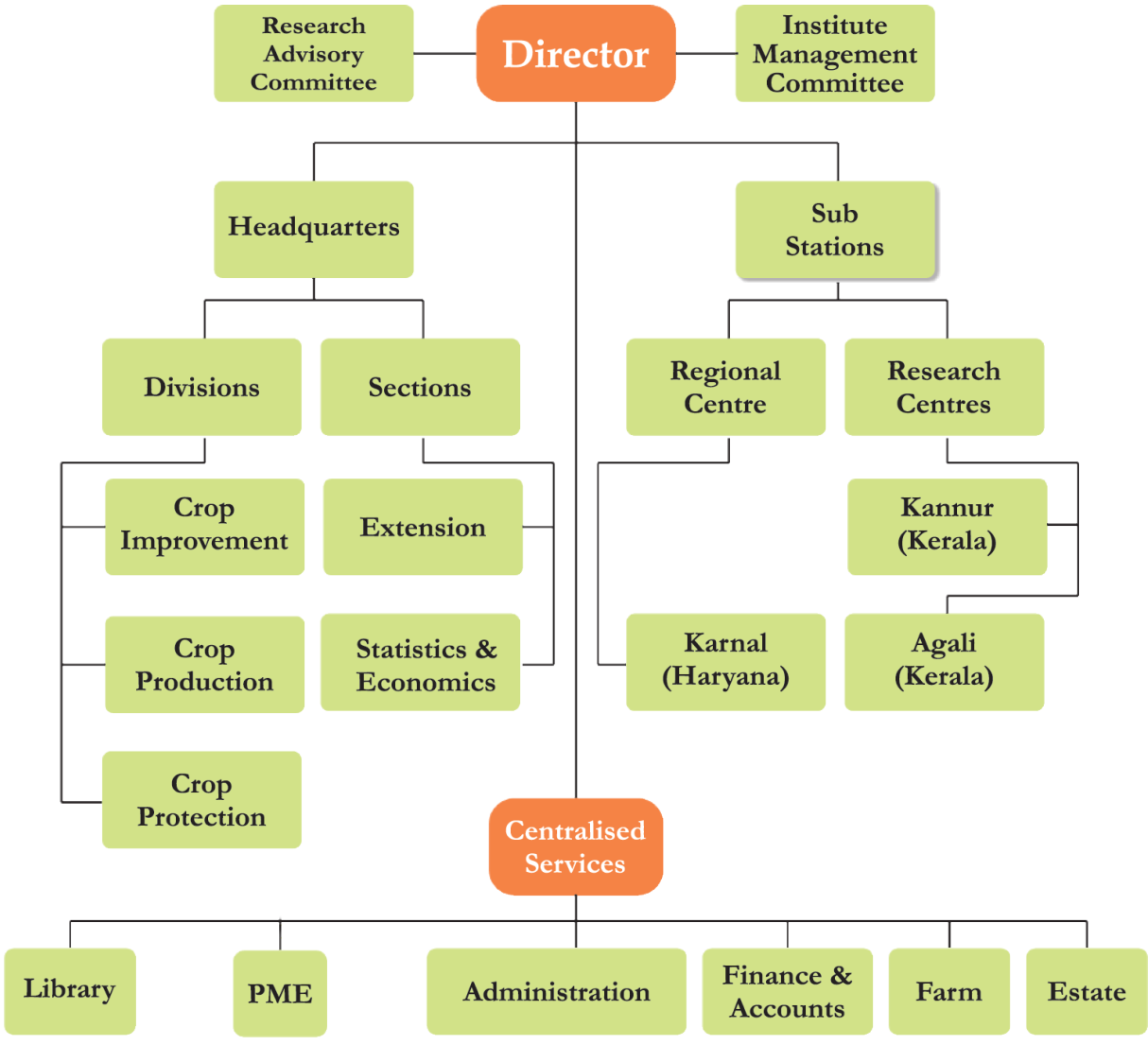


Fig.1 Organizational structure of SBI

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 14,024 books including bound volumes of journals. Library incurred an expenditure of Rs.2,55,013 towards purchase subscription of journals. Continued to provide IP based online access to e-journals and e-books through CeRA. Library has facilities *viz.*, internet terminals, digital access to holdings, scanning and photocopying for the users. Library has got ISBN and ISSN assigning facility for the publications of the Institute.

The priced publications of the Institute (25 nos.) were sold for an amount of Rs.5980.

Weather data

Table 3. Weather data for January to December 2021

Month	Temperature (°C)		RH (%)		Wind velocity (km per hour)	Open pan evaporation (mm/day)	Rainfall (mm)	No. of rainy days
	Maximum	Minimum	Fore noon	After noon				
January	28.3	19.9	89.1	68.3	0.3	2.0	95.5	6
February	32.7	18.6	86.6	54.6	0.5	4.0	4.6	1
March	35.2	21.3	87.5	50.4	0.8	5.6	-	-
April	35.5	23.3	88.4	50.1	0.6	4.5	50.4	5
May	33.9	24.0	85.1	55.0	1.0	4.4	54.2	3
June	32.1	23.5	87.3	57.2	1.8	5.0	66.2	6
July	31.9	21.9	89.0	61.4	1.7	3.8	53.8	7
August	29.8	21.3	87.4	63.6	1.5	4.2	31.4	5
September	28.0	22.2	84.5	64.0	1.7	4.3	29.8	4
October	26.0	22.5	80.0	72.9	1.1	3.9	148.7	10
November	23.2	22.1	76.9	76.6	0.6	2.0	191.5	7
December	22.0	20.5	79.6	66.2	1.0	3.7	47.0	4
Mean/ Total	29.88	21.76	85.11	61.69	1.05	3.95	773.1	58

कार्यकारी सारांश

फसल सुधार विभाग

को. 14012 (अवनि), जिसे उष्णकटिबंधीय क्षेत्र में राज कर रही को. 86032 प्रजाति में सुधार कर प्रायद्विपीय क्षेत्र में लोकार्पण के लिये पहचाना गया है। को. 86032 के मुकाबले इस प्रजाति में शर्करा की मात्रा में स्पष्ट सुधार देखा गया, और यह लाल सड़न रोग के लिये मध्यम प्रतिरोधिता भी दर्शाती पाई गई है। तमिलनाडू में बहुस्थानीय परीक्षणों में को. 18009 को रिलीज़ के लिये योग्य पाया गया है। इस अवधि में पंजीकृत किये गये आनुवांशिक स्टॉकों में से को. 13003 (आइ.एन.जी.आर.21068) को अ.भा.स.अनु.प. परीक्षणों में से पहचान कर उच्च रेशे और उच्च शर्करा की मात्रा वाले के रूप में पंजीकृत किया गया है। को. 2021 श्रंखला के 11 को. गन्नों में से 8 को. गन्नों, नामशः को. 21002, को. 21003, को. 21004, को. 21005, को. 21006, को. 21007, को. 21009 और को. 20010 को प्रायद्विपीय क्षेत्र में अ.भा.स.अनु.प. के परीक्षणों लिये चयनित किया गया है। ध्यान देने योग्य बात यह है कि इनमें से कुछ के पैतृक जलवायु लचीले भी हैं।

पुष्पण तीव्रता को एरोइंग प्लॉट में 68% के स्तर तक देखा गया जिसके कारण 251 द्विपैतृक क्रॉसेस उष्णकटिबंधीय और उपोष्णकटिबंधीय क्षेत्र के पैतृकों, अन्तरजातीय और अन्तरजेनेरिक संकरों और विविध सायटोप्लास्म लाइनों की भागीदारी से बनाये गये, ताकि चयन के लिये विविधता वाली अधिक जनसंख्यायें उपलब्ध हो सकें। वर्ष 2020 के दौरान बनाये गये क्रॉसेस से 287 विभिन्न जनसंख्याओं से 19,248 बीज जनित पौधों को खेत में जाँच के लिये स्थापित किया जा सका। रटून की गई नर्सरी के करीब 18,000 बीज जनित पौधों में से इच्छुक वर्गों का चयन कर उन्हें प्रथम कलोनल परीक्षण के लिये आगे बढ़ाया गया, तथा उच्च चयन तीव्रता वाले क्रॉसेस को व्यवसायी प्रजनन कार्यक्रम के लिये पहचाना गया है। विभिन्न स्तरों पर चल रहे परीक्षणों से विशिष्ट चयनों और सफल संयोजनों की पहचान की गई है। जैसेकि गन्ना एक प्रमुख ऊर्जा फसल के रूप में उभर रहा है, अतः जल्द उच्च शर्करा संग्रहित करने वाली प्रजातियों की पहचान पर ज़ोर दिया गया जिससे 8 कृन्तकों को 240 दिनों पर 18% से अधिक शर्करा के साथ, तथा 26 कृन्तकों को 300 दिनों पर 20.0% से अधिक शर्करा के साथ पाया गया। प्रजनन के माध्यम से अधिक अनुपात में लाल सड़न रोग प्रतिरोधी कृन्तकों के पाये जाने से सड़न रोग प्रतिरोधिता में आनुवांशिक सुधार देखा गया। कुल 162 कृन्तकों को खेत में अच्छे प्रदर्शन के साथ साथ उत्पादन और रस की गुणवत्ता वाला एवं लाल सड़न रोग प्रतिरोधी पाकर उन्हें आगे के मूल्यांकन के लिये पूर्व क्षेत्रीय प्रजाति परीक्षण के लिये पदोन्नत किया गया।

वर्ष 2020 श्रंखला के 14 को. गन्नों (को. 20001 से को. 20014) को कोयम्बत्तूर में विकसित कर उन्हें डस नियमावली के आधार पर वानस्पतिक विज्ञानिक रूप से वर्णित किया गया। हाल ही में विकसित किये गये को. गन्नों के आणविक फिंगर प्रिन्ट भी लिये गये। रिलीज़ के लिये सम्भावित को. 14012 और को. 15027 के आणविक फिंगर प्रिन्ट भी विकसित किये गये। को. गन्नों (38) का आणविक विश्लेषण कर जनसंख्या की बनावट को तीन उपजनसंख्याओं के रूप में पाया गया, और जब दूसरी उपजनसंख्या के एक एक जन को दूसरे दो समूहों के सदस्यों से क्रॉस किया गया तो अनुवांशिक विविधता तथा आक्रामक अलगाववादियों को सुनिश्चित किया जा सका।

कम अवधि में पकने वाले कृन्तकों की पहचान के लिये किये गये परीक्षण में एक कृन्तक आर.के.2020–12 को, पहले से रिलीज़ की गई कम अवधि की प्रजाति की रस में शर्करा के 240 दिनों पर 18.99% और 300 दिनों पर 21.09% से बेहतर पाया गया। स्थानीय विशिष्ट प्रजातियों की पहचान को सहज बनाने के लिये विभिन्न दक्षिणी राज्यों में किये गये अनुकूली परीक्षणों को चलाया गया। दो कृन्तकों, नामशः को. 17004 और को. 18009 का के.सी.पी. शूगर्स लिमिटेड, वुय्युरू, आन्ध्र प्रदेश से चयन किया गया और उन्हें पूर्व तट्टीय प्रदेश के अ.भा.स.अनु.प. (गन्ना) के परीक्षणों में शामिल करने के लिये अनुमति मिल गई। एस निजलिंगप्पा शूगर्स संस्थान, बेलगवी में 28 चयनित कृन्तकों का मूल्यांकन स्थानीय विशिष्ट प्रजातियों की पहचान उत्तरी कर्नाटक के लिये किया गया। उत्पादों में विविधता लाने के लिये विशिष्ट प्रजातियों के प्रजनन, उच्च जैव भार और कुल शर्कराओं का उत्पादन कोजनरेशन के लिये, इथेनॉल और चारा उत्पादन को महत्व दिया गया, जिसके अन्तरगत एस.बी.आइ.ई.सी. 14006 को जेनेटिक स्टॉक (आइ.एन.जी.आर.20112) के रूप में कटाई के समय उच्च जैव भार के लिये भा.कृ.अनु.प. – एन.बी.ए.जी.आर., नई दिल्ली में पंजीकृत करवाया गया। पशुधन के लिये पोषण मूल्यांकन, सुधार एवं उपयोग के नये खाद्य संसाधनों का विकास सेकेरम् संयोजन से किया गया, जिनका मूल्यांकन भा.कृ.अनु.प. – भारतीय चारागाह एवं चारा अनुसंधान संस्थान, झांसी में किया जा रहा है।

प्रायद्विपीय क्षेत्र के अ.भा.स.अनु.प. (गन्ना) के अन्तरगत किये जाने वाले सभी परीक्षणों का कार्यान्वयन कोयम्बत्तूर में किया गया। शुरूआती प्रजाति परीक्षण में को. 17001 और को. 17004 ने सी.सी.एस. उत्पादन और गन्ना उत्पादन के लिये एवं को. 17003 को रस में शर्करा की मात्रा के लिये सर्वोत्तम प्रदर्शक पाया गया। उन्नत प्रजाति परीक्षण, प्रथम पौधा फसल में को. 15015, को. 15017 एवं को. 15021 को सर्वोत्तम प्रदर्शक पाया गया, जबकि उन्नत प्रजाति परीक्षण, द्वितीय पौधा फसल में को. 14027 को गन्ना उत्पादन तथा रस की गुणवत्ता दोनों के लिये सर्वोत्तम पाया गया। गन्ना उत्पादन के लिये तीन प्रविष्टियों, नामशः को. 14002, को. 14027 और एम.एस. 14082

को पेड़ी फसल के लिये बेहतर पाया गया। दो पौधा और एक पेड़ी की फसलों का संयोजित विश्लेषण करने पर एम.एस. 14082, को. 14027, को. 14016 और को. 14002 को सर्वोत्तम मानक को. सी. 671 से सी.सी.एस. उत्पादन के लिये बेहतर पाया गया। को. 14012 और को. 14002 को सूखा सहनशील तथा को. 14027 एवं को. 14032 को मध्यम सहनशील आंका गया। जलवायु लचीले 49 कृन्तकों में से 18 जलप्लावन सहनशील और 8 सूखा सहनशील थे, जबकि 20 आइ.एस.एच. और 3 आइ.जी.एच. अनुवांशिक स्टॉक्स शामिल थे, जिन्हें बहुगुणित कर अ.भा.स.अनु.प. (गन्ना) के परीक्षणों में भाग लेने वाले केन्द्रों को वितरित किया गया ताकि उनकी प्राकृतिक तनाव ग्रस्त हालातों में जाँच की जा सके। अनुकूलनीय अनुसंधान परीक्षणों को तमिलनाडू के विभिन्न कृषि–जलवायु क्षेत्रों में तमिलनाडू कृषि विश्वविद्यालय के सहयोग से संचालित किया जा रहा है जिनमें से को. 14016 को सर्वोत्तम मानक से गन्ना उत्पादन में बेहतर पाया गया। बहुस्थानीय परीक्षणों में 6 प्रविष्टियों में से 4 कृन्तकों, नामशः को. 14012, को. 14014, सी. 14516 और जी. 10045 को 2021–22 के अनुकूलनीय अनुसंधान परीक्षणों के लिये आगे बढ़ाया गया।

स्वीट ब्लूम परियोजना के अन्तरगत 17 प्रविष्टियों के परीक्षणों को सम्पूर्ण कर लिया गया जिनमें से को. 12009, को. 14027, को. 14002 और को. 18009 को कटाई के समय गन्ना एवं चीनी उत्पादन के लिये मानक को. 86032 से बेहतर पाया गया, जबकि को. 14027 और को. 17003 को कृन्तकों के उच्च गुणवत्ता वाले वर्ग में डाला गया। सिसमा तमिलनाडू समिती की मीटिंग में को. 14002, को. 14027 और को. 18009 की तमिलनाडू में रिलीज़ के लिये सिफारिश की गई ताकि चीनी मिलों और किसान समुदाय को इनका लाभ मिल सके। तमिलनाडू में 6 कोऑपरेटिव चीनी मिलों पर 21 प्रविष्टियों को परीक्षित किया गया जिनमें से को. 12009, को. 15018, को. 16018, को. 11015, को. 17012 और को. 18009 में को. 86032 से 10 टन/हे. से अधिक गन्ना उत्पादन दर्शाया।

गन्ने में तीव्र गति से प्रजनन के लिये जल्द पुष्पण प्रक्रिया का मानकीकरण, व्यवसायी प्रजनन परियोजना के लिये एक महत्वपूर्ण कार्यकलाप है, जिसके लिये प्रकाश अवधि एवं तीव्रता के मानकीकरण के लिये एक मूल अध्ययन की शुरूआत की गई है। गन्ने में सूखा सहनशील और लाल सड़न रोग प्रतिरोधिता के लिये मारकर सहयोगी चयन की भी शुरूआत की गई है जिससे पहले वर्ष में 51 सूखा विशिष्ट मारकरों को 52 प्रतिरोधी और संवेदनशील जीनप्ररूपों को परिवर्धित किया गया जिनमें से 28 को बहुरूपी पाया गया। इस दिशा में आगे का कार्य प्रगति पर है।

गन्ने जर्मप्लास्म में वृद्धि एवं प्रजनन पूर्व समग्री का विकास पर संस्थान का ध्यान सदा से केन्द्रित रहा है। जलवायु स्मार्ट प्रजातियों के विकास के लिये, लम्बे समय से किये जा रहे अध्ययनों में इस वर्ष उत्साहवर्धक परिणाम प्राप्त हुए हैं। तमिलनाडू, आन्ध्र प्रदेश और कर्नाटक में अक्तूबर–नवम्बर के दौरान किये गये एक अन्वेषण से 52 नये जर्मप्लास्म एकत्रित किये गये, जिनमें 49 एस. स्पॉन्टेनियम और 3 इ. अरुंडिनेशियस् कृन्तक थे। जंगली जर्मप्लास्म उद्यान, कोयम्बत्तूर में 2,260 अभिप्राप्तियों को अनुरक्षित किया जा रहा है जिनमें से अधिकतर 1,709 एस. स्पॉन्टेनियम से, 230 इ. अरुंडिनेशियस से और 47 संग्रहणों को अरुणांचल प्रदेश से लाकर आइ.ए.आर. आइ. के क्षेत्रीय स्टेशन, वेलिंगटन में अनुरक्षित किया जा रहा है। योजनाबद्ध क्रॉसिंस परियोजना के अन्तरगत को. गन्नों के अनुरक्षित प्लॉट में 2,007 कृन्तक वांछित पैतृकों के रूप में उपलब्ध हैं। राष्ट्रीय क्रियाशील जर्मप्लास्म बैंक में 271 अधिसूचित और पंजीकृत जेनेटिक स्टॉकों तथा संस्थान एवं अन्य अनुसंधान केन्द्रों से प्राप्त 18 प्रविष्टियों को अनुरक्षित किये जा रहा है और इन कृन्तकों को सूचकांक नम्बर प्रदान किये गये हैं।

जर्मप्लास्म के उत्पादन सम्बंधित गुणों, पुष्पण व्यवहार तथा कोशिकाविज्ञानिक और शारीरिक गुणों के लक्षणवर्णन का कार्य जारी रखा गया। पश्चिमी घाटों से संग्रहित एस. स्पॉन्टेनियम के 64 अभिप्राप्तियों के शारीरिक गुणसूत्र नम्बर (2एन) को विभिन्न सायटोटाइपों 2एन = 48, 60, 62, 64, 68, 70, 72, 78 और 80 से पाया गया। पश्चिमी घाटों के संग्रहणों को मुख्यतः 2एन = 64, 72 और 80 सायटोटाइपों से पाया गया। इरिएन्थस अरुंडिनेशियस 2एन = 30 सायटोटाइप वाले कृन्तकों का डी.इ.एल.टी.ए. सॉफटवेयर द्वारा विश्लेषण किया गया। राष्ट्रीय कृषि प्रणाली के विज्ञानिकों द्वारा जेनेटिक सुधार के लिये संस्थान के अगली स्थित केन्द्र पर 1,390 कृन्तकों को अनुरक्षित किया जा रहा है, जिसमें मूल जर्मप्लास्म संग्रहण भी शामिल हैं। इस वर्ष असाधारण तरह से उच्चतर पुष्पण तीव्रता देखी गई जब 65.25% अभिप्राप्तियों में पुष्पण देखा गया, जो पिछले वर्ष 2020 के 46.01% से काफी अधिक था, इसके कारण कई सारे अब तक न पुष्पण करने वाले कृन्तकों को क्रॉसिंग प्रोग्राम में प्रजनकों द्वारा प्रयोग में लाया जा सका। इस वर्ष कुल 220 क्रॉसेस बनाये गये।

जैवकि और अजैविक तनावों के लिये जर्मप्लास्म का मूल्यांकन जारी रखा गया और 170 जंगली एस. स्पॉन्टेनियम कृन्तकों में से 3 अभिप्राप्तियों, नामशः मोंडाले, आइ.एन.डी. 03–1318 और आइ.एन.डी. 03–1292 ने 20 प्रतिशत से कम जैवभार उत्पादन में गिरावट और कलोरोफिल और केरोटिनॉयड की उच्च मात्रा सूखे के हालातों में देखी गई। इरिएन्थस अरुंडिनेशियस की 96 अभिप्राप्तियों में से 14 कृन्तकों को अति सूखा सहनशील पाया गया। सूखा और जलप्लावन प्रतिरोधी जेनेटिक स्टॉक 04–1687 के नर और मादा के तने की बाहरी कोशिका परत में विशिष्ट शारीरिक परिवर्तनों को देखा गया। इन अभिप्राप्तियों को गुण वृद्धि कार्यक्रम में प्रयोग में लाया जायेगा।

बहुपैतृक उन्नत पीढ़ी अन्तर–क्रॉस जनसंख्या के विकास से गन्ने में सूखा सहनशीलता का विकास कार्य अन्तिम वर्ष में पहुँच गया है, जिसके दौरान 8–मार्गी क्रॉसेस को दो स्थानों पर मूल्यांकित किया जा रहा है। दो, 2–मार्गी अन्तरक्रॉस संकरों, नामशः टी.डब्लयू.सी. 45 और टी.डब्लयू.सी. 23 को को. गन्नों, नामशः को. 21003 और को. 21007 के रूप में पहचाना गया, जिसमें से को. 21003 ने मानक को. 86032 110.75 टन गन्ना/हे. के मुकाबले परीक्षण में 1542.66 टन गन्ना/हे. का सार्वधिक उत्पादन दर्शाया। द्विमार्गी संकरों के आणविक कोशिकाविज्ञानिक लक्षणवर्णन में इनमें इरिएन्थस के 3–7 गुणसूत्र देखे गये। इनका 5एस डी.एन.ए. स्थान के साथ पी.सी.आर. विश्लेषण करने पर इन्होंने जी.आइ.एस.एच. के परिणाम का समर्थन किया और एक के बाद एक अगली 5 पीढ़ियों तक इनमें इरिएन्थस जीनों को संकरों में पाया गया। इ. प्रोसेरस की भागीदारी से बनाये गये संकरों में से 15 बी.सी.2 संकरों में 370 बीपी घटक, जो जंगली जीनस् विशिष्ट है, को पहचाना गया। अन्तरजेनेरिक संकरण में गुणसूत्रों के स्थानान्त्रण को जानने के लिये जी. आइ.एस.एच. को उपयोगी साबित होने के बाद इसकी सम्भावित प्रयोग सेकेरम संकरों की जिनोमिक संरचना को समझने के लिये इ. प्रोसेरस और सेकेरम् के बीच एक अन्तर जेनेरिक संकर, और इसके बैक क्रॉस संकरों का पारम्परिक एवं आणविक कोशिकानुवांशिक अध्ययन किया गया। दूसरी पीढ़ी के संकर सी.वाइ.एम. 08–922, एक पंजीकृत जेनेटिक स्टॉक, ने सूखे के हालातों में सार्थक उच्च गन्ना उत्पादक गुणों वाली पीढ़ियों को जन्म दिया, और यह अब जलवायु लचीले प्रजनन कार्यक्रम में इसे प्रथम स्थान दिया जाता है। एक अन्य जेनेटिक स्टॉक जी.यू. 07–2276 (आइ.एन.जी.आर.21067; आइ.सी.636676) को जेनेटिक स्टॉक के रूप में एन.बी.पी.जी.आर. नई दिल्ली के यहाँ पंजीकृत किया गया, सूखे के हालातों में उच्च गन्ना उत्पादन (89.66 टन/हे.) और कम से कम एकल गन्ना भार में गिरावट के कारण। तनावों के हालातों में बहुत सारे अन्तर जातीय संकरों को चीनी उत्पादन मापकों के लिये पहले ही लक्षणवर्णित कर लिया गया है। इनके सपैड मान, सापेक्ष जल मात्रा और तल छत्र के तापमान में गिरावट में सार्थक विभिन्नता देखी गई और चयन किये गये संकरों को सूखे व लाल सड़न रोग के लिये लगाया गया। नवीन संकरों में से एस. ऑफिश्नेरम – ऊबा वाइट, लाउकोना, मंजूरिआ, 28 एन.जी. 210, बारागुआ, चापीना, ओराम्बू और 51 एन.जी. 159 – की भागीदारी से बनाये गये संकर बेहतर पाये गये। दो नये अनुसंधान क्षेत्र, जिनमें लक्षित पूर्व–प्रजनन के लिये अजैविक तनाव सहनशीलता के लिये लक्षण वर्णित किये गये एस. स्पॉन्टेनियम के विभिन्न सायटोटाइपों को मादा पैतृक के रूप में और सेकेरम् जाति चयन किये गये अन्तरजातीय एवं अन्तरजेनेरिक सकरों की कई पेड़ियां देने की क्षमता थी, के लिये मूल्यांकन की शुरूआत की गई ताकि जलवायु लचीले प्रजनन को मज़बूत किया जा सके। लम्बे समय के लिये जर्मप्लास्म संरक्षण (ठंड में भंडारण) के लिये एस. स्पॉन्टेनियम और सम्बंधित जेनेरा में पुनर्जनन करने के लिये उपयुक्त मीडिया के संयोजकों को मानकीकृत करने से शुरूआत की गई।

ट्रान्सक्रिप्टोम नियंत्रित जीनों, एमआइआर.एन.ए.ओं का खनन और मानकिकरण और जल कमी के तनाव के लिये सम्भावित लक्ष्य पर कार्य जारी रखा गया। विभिन्नता से प्रकटन दर्शाते नवीन एमआइआर.एन.ए.ओं को पहचाना गया जिनमें सूखा संवेदनशील प्रजाति को. 8021 में 5 और सहनशील प्रजाति को. 06022 में 9 एमआइआर.एन.ए. शामिल थे। पौधे के संरक्षण में सूखा तनाव सम्बंधित जीनों को नवीन लक्षित जीनों ने मुख्यतः कूटलेखन किया। सूखा सहनशील प्रजाति में सूखा प्रतिक्रियाशील एमआइआर.एन.ए.ओं में से नेटवर्क विश्लेषण द्वारा 144 संरक्षित एमआइआर.एन.ए.ओं को 32 परिवारों से पहचाना गया और उन्होंने 28 तनाव सहनशील जीनों का कूटलेखन किया।

गन्ने में सुक्रोस नियंत्रक जीनों की ट्रान्सक्रिप्ट विविधता और समरूपों/ट्रान्सक्रिप्ट परावर्तों के विश्लेषण करने पर स्वीटस (एस.डब्लयू.इ.इ.टी.एस) को उच्च स्तर पर विभिन्नता से प्रकट होते पाया गया। उच्च एवं निमन्न शर्करा वाले कृन्तकों का वास्तविक समयानुसार मात्रात्मक पी.सी.आर. विश्लेषण करने पर विभिन्नता से प्रकटन इसे सुनिश्चित करता है कि स्वीटस परिपक्वता की प्रवस्था के दौरान नियन्त्रक भूमिका निभाते हैं। स्वीट1, स्वीट2ए, स्वीट3ए और स्वीट14 की पूरी लम्बाइयों का अध्ययन करने पर उच्च शर्करा वाले जीनप्रारूपों में प्रकटन का स्तर 10 गुना बढ़ गया। गन्ने के एकलगुणसूत्री जिनोम डाटाबेस से पुनःप्राप्त उच्च जल उपयोग दक्षता से सम्बंधित स–टाइप एनायन चैनल जीनों की उच्च शर्करा वाले को.एम. 0265 से 54% समरूपता देखी गई।

एस. स्पॉन्टेनियम को लवणता तनाव (8 डेसी सीमन/मीटर) के दौरान एस. स्पॉन्टेनियम का दमन घटाव संकरण करने पर मुख्य जीनों और मार्गों के गतिशील होने का पता चला। सबसे अधिक क्रियाशील मार्ग मैदा और चीनी चयापचय मार्ग थे। गन्ने के संकर, जिन्हें सूखा एवं लवणता तनावों से रूबरू करवाने पर दमन घटाव लाइब्रेरी से गहन अनुक्रमण करने पर विभिन्नता से प्रकटन करती जीनों/ट्रान्सक्रिप्ट घटकों को जानने के कार्य की शुयआत की गई। गन्ने में कल्लों के उत्पादन को नियंत्रित करने वाले आणविक प्रक्रिया को समझने के लिये कार्यकारी जिनोमिक्स प्रणाली, स्ट्राइगोलेक्टोन ब्रांचिंग अवरोधक जीन (एम.ए.एक्स.) का उपयोग किया गया। इस अध्ययन में अधिक और कम कल्ला उत्पादक जीन प्रारूपों में साकारात्मक विभिन्नता देखी गई तथा टहनी उगने वाले अवरोधक को अधिक कल्ला उत्पादक जीन प्रारूपों में अधिक पाया गया।

गन्ने में महत्वपूर्ण गुणों के लिये जिनोमिक चयन के अन्तरगत, और विशिष्ट भारतीय एवं ऑस्ट्रेलियन जर्मप्लास्म की तुलना,

जिनोमिक अनुमान मॉडलों – बेयस ए., बेयस बी., बी.एल., जी.बी.एल.यू.पी., आर.के.एच.एस. सिंगल मॉडलों ने सुक्रोस और लाल सड़न गुण के लिये सकारात्मक एस.एन.पी.एस दर्शाये, जिनमें से आर.के.एच.एस. सिंगल और आर.के.एच.एस. – के औसतीकरण सुक्रोस के लिये अधिक आशाजनक थे, जबकि बेयस ए. और बेयस बी. लाल सड़न रोग प्रतिरोधिता के अनुमान के लिये बेहतर थे।

इ. अरुंडिनेशियस और व्यावसायिक प्रजाति को. 86032 के जड़ और पत्ते के ऊतकों से सूखा सहनशील जीनों के पूरे ट्रान्सक्रिप्टोम भारत में पहली बार उत्पादित किये गये। जल की कमी वाले तनाव के हालातों में विशिष्ट कार्यों और ट्रान्सक्रिप्शनल घटकों के लिये बहुत सारी प्रतिक्रियाशील यूनीजीनों को पहचाना गया। महत्वपूर्ण सूखा सहनशील जीनों, नामशः इ.एए.एल.डी. एच., इ.एइ.एक्स.पी.ए. 1, इ.एगलाइ 1, इ.एगलाइ 2, इ.एगलाइ 3 और गहरी जड़ों 1 के लिये (डी.आर.ओ. 1) जीनों तथा ट्रान्सक्रिप्शनल घटक इ.एएन.एफ.वाइ.बी. को कलोन कर पूरी लम्बाई का अनुक्रमण किया गया। एक सौ दस से अधिक पराजीनी घटनाओं जिनमें विभिन्न अजैविक तनाव सहनशील जीनों इ.एइ.एक्स.पी.ए. 1, इ.एगलाइ 3, इ.एन.एफ.वाइ.बी. 2, ए.एल.डी.एच. और डी.आर.इ.बी. जीनों को उत्पादित किया गया।

भा.कृ.अनु.प. – गन्ना प्रजनन संस्थान द्वारा विकसित वैक्योल लक्षित तकनीक का विधिमान्यकीकरण, गन्ने में व्यावसायिक पुनर्संयोजन प्रोटीन उत्पादन का कार्य 3 जीनों, नामशः गलुकोसेरिब्रोसाइडेस (जी.सी.एस.), इंसुलिन और इन्टरफेरोन (आइ.एफएन2ए.), पर जारी है। जैन्बैंक से अनुक्रमों को पुनःप्राप्त कर, गन्ने में बेहतर प्रकटन के लिये कोडोन को इष्टमीकृत कर टी.आर.ए.एन.ए. लैब द्वारा संस्लेशित किया गया। को. 86032 को रूपान्त्रण के लिये प्रयोग में लाकर उनसे उत्पादित 89 घटनाओं में से 56 को धनात्मक पाया गया और उन्हें आगे के विश्लेषण के लिये बढ़ाया गया। एक नवीन लैकेस उत्पादन करने वाला, उच्च तापमान सहनशील सूक्षम जीव की पहचान कर उसके संवर्धन के हालातों को इष्टमीकृत कर लिया गया है ताकि लिगनिन को प्रभावी ढंग से हटाया जा सके। चयन किये गये परिवर्तनशीलों की अनुकूलतम सांध्रताओं को जानने के लिये सतह प्रतिक्रिया विधि का प्रयोग बॉक्स–बेहन्केन डिज़ाइन अनुसार किया गया, और एन्ज़ाइम की उच्चतम मात्रा को 450 इकाइ/माइक्रो लिटर को प्राप्त किया गया 460 सी. और 6.0 पीएच. पर 120 घंटे के इनक्यूबेशन के बाद।

राष्ट्रीय कृषि विज्ञानिक निधी परियोजना के अन्तरगत गन्ने में सफेद गिंडार (होलोट्राइकिआ सेरेटा) प्रतिरोधिता के विकास के लिये नवीन क्राइ विष होलोटाइप जीनों के प्रयोग की शुरूआत की गई। बेसिल्स थुरिंजीएन्सिस विलगन बी.टी 62 जिनोम की पूरी लम्बाई का अनुक्रमण कर दो क्राइ जीनों, नामशः क्राइ8एस.ए 1 और क्राइ8आइ.बी की उपस्थिती का पता चला। इन दोनों की विषाक्ता का अलग से जैव परख द्वारा अध्ययन करने पर पता चला कि क्राइ8एस.ए 1 के साथ सार्थक रूप से अधिक मृत्युशीलता देखी गई।

इरिएन्थस से एक नये प्रोत्साहक (इ.आरआइपी.एचटी) को विलगित किया गया जिसने संरचनात्मक प्रकटन दर्शाया और इससे ऊतक विशिष्ट प्रोत्साहक को विकसित करने के लिये विलोपन वाले अध्ययन किये जा रहे हैं। तीन विलोपन निर्माणों – डी.2, डी.3 और डी.5 को अस्थाई प्रकटन सुनिश्चितिकरण के पश्चात एग्रोबैक्टीरिअम की मध्यस्ता रूपान्त्रण से स्थान्त्रित किया गया। टी.1 के सम्भावित पराजीनि पौधों से प्राप्त बीजों से टी.2 की बीज जनित पोध तैयार की गई ताकि आगे के प्रकटन का विश्लेषण किया जा सके।

बहुगुणसूत्री जिनोम होने के कारण गन्ने में जिनोम सम्पादन का कार्य चुनौति पूर्ण है। इ. अरुंडिनेश्यिस के सायटोटाइपों एस.इ. एस. 153 (2एन = 30) और एस.इ.एस. 133 (2एन = 60) तथा सेकेरम् का व्यावसायिक संकर को. 86032 (2एन = 112) को फाइटोईन देसटुरेस (पी.डी.एस.) जीन के लिये लक्षित किया गया ताकि जिनोम सम्पादन के कार्य को, सी.आर.आइ.एस.पी. आर./सी.एएस9 के माध्यम से विधिमान्य किया जा सके। एक अन्य जीन, एक शुद्धनाभिक अनुवादक शुरूआत घटक इएलएफ. 4जी. को व्यावसायिक गन्ना प्रजाति से विलगित कर उसका विषाणु के साथ कार्यकारी अन्तरक्रिया का अध्ययन किया जा रहा है ताकि गन्ने में विषाणु संक्रमण को नियन्त्रित किया जा सके। गन्ने में पुष्पण व्यवहार को बदलने का कार्य प्रगति पर है जिसके लिये दिशानिर्देशक आर.एन.ए. की कलोनिंग की जा रही है ताकि पुष्पण जीन को लक्षित किया जा सके।

समयुग्मक पैतृक लाइनों के विकास विभिन्न पद्यतियों द्वारा प्रगति पर है। क्रमिक सैल्फिंग द्वारा बड़ी संख्या में 8वीं पीढ़ी तक के सैल्फ विकसित किये गये हैं। आणविक प्रोफाइलिंग और बाहरी जाँच द्वारा समयुग्मक एवं वांछित सैल्फों को छाना गया और उनकी उत्पादन क्षमता, रस की गुणवत्ता एवं रोग प्रतिरोधिता के लिये मूल्यांकन किया गया। छटी पीढ़ी के 2 अपेक्षाकृत सैल्फों का प्रयोग क्रॉसिंग के लिये 1148–13–11–2–237–2–61 के साथ और सैल्फ किये गये ताकि प्रत्येक की दो दो सैल्फ और संकर जनसंख्याऐं पैदा की जा सकें। संकरित जनसंख्याओं में सैल्फों की तुलना में अपेक्षाकृत काफी सुधार के सभी अध्ययन किये गये गुणों में देखा गया, एच.आर. ब्रिकस को छोड़कर। संकरित जनसंख्याओं में सभी गुणों के लिये अपेक्षाकृत कम विभिन्नता गुणांक गन्ने में इसके वास्तविक बीज का उपयोग आगे के लिये किये जाने की धारणा को मज़बूती प्रदान करता है। अगर यह वास्तविक्ता में सम्भव हो सका तो गन्ने की उत्पादक्ता बढ़ाने एवं इसकी खेती की लागत को कम करने की दिशा में एक सार्थक उपलब्धी होगी। विभिन्न द्विपैतृक संयोजनों, जिनमें इस प्रकार के सैल्फों की भागीदारी रही जिनमें शारीरिक विभिन्नता कम से कम थी जिसे 775–102 x एम. एस.68/47–27 (एस.1 x एस.1) में देखा गया। परागकोष

से विकसित पौधों को खेत में उगाने पर उनके मूल स्त्रोत और सूत्रगुणता के स्तरों का पुष्टीकरण आवश्यक है। को. 775 के पाँच सी.इ.एन.एच.3 उत्परिवर्ती कृन्तकों का प्रयोग क्रासिंग में किया गया और उनके बीजों से जनित पौधों को उगाकर उनमें गुणसूत्रों का एक साथ निष्कासन को चैक किया जायेगा। इसी प्रकार इरिएन्थस के चार उत्परिवर्ती समूहों को सी.इ.एन.एच.3 के परिवर्धन के लिये डाला गया। सी.इ.एन.एच.3 परिवर्धित क्षेत्र में एकाधिक पट्टियों ने उत्परिवर्तीयों की सम्भावना व्यक्त की जिसका पुष्टीकरण बाकी है। कवकनाशियों से उपचारित बीजों को 11 महीने तक भंडारित करने पर भी किसी प्रकार का पादप विषाक्त प्रभाव अंकुरण पर नहीं देखा गया।

फल्फ आपूर्ति कार्यक्रम के अन्तरगत संस्थान ने कोविड 19 के दौरान 2020 मौसम के दौरान क्रॉसिंग का भार अपने कंधों पर लेते हुए 401 द्विपैतृक क्रॉसेस, 342 समान्य संग्रहण और 10 पोली क्रॉसेस बनाये जिनसे 17.27 किलोग्राम फल्फ को प्राप्त कर 21 केन्द्रों को वितरित किया। इसके अलावा संस्थान के अगली अनुसंधान केन्द्र पर राष्ट्रीय सुदूर संकरण सुविधा के अन्तरगत 25 द्विपैतृक क्रॉसेस बनाकर 775.1 ग्राम फल्फ केन्द्रों को वितरित किया। कुल मिलाकर 18.04 किलोग्राम फल्फ भी 21 केन्द्रों को वितरित किया। मौसम 2021–2022 के दौरान 7 केन्द्रों के प्रजनकों ने क्रॉसिंग में भाग लेते हुए 24 केन्द्रों के लिये 424 द्विपैतृक क्रॉसेस बनाये।

डस परीक्षण को तकनीकी कार्यक्रम के अनुसार संस्थान के तीन परीक्षण केन्द्रों पर चलाया गया। किसानों की प्रजातियां जीत कटारी और सुगम कटारी को संदर्भ प्रजातियों से भिन्न मगर आपस में एक जैसा पाया गया।

भा.कृ.अनु.प. की बीज परियोजना के अन्तरगत कुल 1,335. 71 टन गन्ना प्रजनक बीज को. 86032 और को. 11015 का उगाकर तमिलनाडू की चीनी मिलों को उनकी मांग अनुसार वितरित किया गया। ऊतक सवंर्धित 1,13,555 पौधों को चीनी मिलों और चयनित किसानों को प्रजनक बीज उत्पादन के लिये वितरित किया गया। चीनी मिलों की मांग के आधार पर 42 मदर कल्चर फलास्कें भी वितरित की गई।

फसल उत्पादन विभाग

बारह महीने की 7 प्रजातियों की गन्ना फसल से कलिका चिप्स और एकल कलिकाओं को जैव इनाक्यूलेंटों, नामशः फरेटयूरिआ आउरेंशिया (एफ.ए.), गलुकोनएसिटोबैक्टर डाइएज़ोट्रोफिकस (जी.डी.–01), गलुकोनएसिटोबैक्टर ज़ाइलिनस (जी.एक्स.–01), गुलाबी रंग वाली विकल्पिक मिथाइलोबैक्टीरिअम (पी.पी.एफ. एम.–03), बइजेरिंकिया (बी.इ.–03), एज़ोस्पिरिलम ब्रैसिलेंस (ए.बी.–01) और कन्ट्रोल के साथ गन्ना बीज टुकड़ा यन्त्र से 150 मिलि मीटर/पारा दाब पर 15 मिन्ट के लिये इनाक्यूलेशन किया गया। जैव इनाक्यूलेंटों में से कलिका चिप्स का बइजेरिंकिया के साथ उपचार से उच्च फुटाव (58%) और एकल कलिकाओं में (80%) फुटाव 30 दिन बाद देखा गया। कलिका चिप्स और एकल कलिकाओं से उत्पादित पौधों को ताज़ा और सूखा भार के आधार पर अधिक बलशाली पाया गया। अतः गन्ने में बइजेरिंकिया 0.5 पी.पी.एम. सान्द्रता के साथ उपचार कर रोपण करने पर बेहतर फुटाव और पुनः रोपित पौधों को बलशाली पाया जाता है।

खरपतवारनाशी अणुओं, जैसेकि टोपरामीज़ोन, टेम्बोट्रिओन, हेलोसल्फयूरॉन मिथाइल और एमेट्रिन को उनके पादप विषाक्त प्रभाव के लिये को. 86032 और को. 212 के साथ मूल्यांकित किया गया। को. 86032 पर किसी भी खरपतवारनाशी का कोई भी पत्तों पर बाहर से देखने पर प्रभाव नहीं देखा गया। एमेट्रिन को 2,4–डी. के साथ मिलाकर देने पर शुरुआती प्रवस्था में पत्तों पर जलाने वाला प्रभाव और गन्ना उत्पादन में सार्थक गिरावट देखी गई।

नौ विशिष्ट गन्ना जीन प्रारूपों को. 14002, को. 14004, को. 14012, को. 14016, को. 14027, को. 14030, को. 14032, को. 86032 और को.सी. 671 उर्वरकों के दो स्तरों (100% और 125% सिफारिश की गई मात्रा का) पर पंक्तियों की अधिक दूरी पर रोपित कर उनका सस्य विज्ञानिक प्रदर्शन का मूल्यांकन किया गया। विशिष्ट गन्ना जीन प्रारूपों में से को. 14016 ने 122.56 टन/हे. और को. 14012 ने 117.98 टन/हे. के साथ सार्थक उच्चतर गन्ना उत्पादन देखा गया। को. 14012 को 18.26 टन/हे. के उच्च सी.सी.एस. उत्पादन के साथ आशाजनक पाया गया जबकि चैक प्रजातियों में यह को.सी. 671 में 12.28 टन/हे. और को. 86032 में 14.46 टन/हे. देखा गया। उर्वरकों के स्तर ने गन्ना उत्पादन और रस की गुणवत्ता पर कोई सार्थक प्रभाव नहीं डाला।

गन्ना आधारित कृषि प्रणाली मॉडल को स्थपित किया गया जिसके पशुघन घटक में 2 दुधारु गाय + 4 बछड़े (2 हाइफर और 2 सांड बछड़े), 22 बकरियां (12 मादसा + 10 बच्चे), 15 बतखें और मछलियों का मिश्रण (ऊपरी सतह पर भोजन करने वाली – कटला, स्तम्भ में भोजन करने वाली – रोगयु और तल पर भोजन करने वाली – मरिगाल) को 300 वर्ग मीटर के तालाब में पाला गया । राष्ट्रीय खाद्य सुरक्षा मिशन परियोजना के अन्तरगत खेतों पर भागीदारी वाले अनुसंधान परीक्षणों में गन्ना + उड़द के अन्तर फसलीकरण प्रणाली को 40 हेक्टेयर में किसान के खेतों पर लगाया गया। अकेली गन्ना फसल के 122.30 टन/हे. के मुकाबले अन्तर फसलीकरण से 134.73 टन/हे. का सार्थक उच्च गन्ना उत्पादन देखा गया। उत्पादन क्षमता 369.13 किलोग्राम/दिन, 3,53,000.87 रुपये की सकल राशि/हे., 1,46,673.87 रुपये/हे. का शुद्धलाभ और 1.71 का लाभ/लागत अनुपात अकेली गन्ना फसल से बेहतर थे। अतः उष्णकटिबंधीय भारत के हालातों में गन्ना + उड़द का अन्तर फसलीकरण एक लाभप्रद विकल्प है, जो खाद्य सुरक्षा को सुनिश्चित करेगा।

भा.कृ.अनु.प. – गन्ना प्रजनन संस्थान की प्रौद्योगिकीयों के लाइसेंस इस प्रकार दिये गये – मृदा नमी संकेतक प्रौद्योगिकी 5 फर्मों को, कीट रोगनाशी सूत्रकृमि जैवहानिकार जीवनाशी संरूपण 3 फर्मों को, गन्ने का जैम प्रौद्योगिकी 2 फर्मों को, तरल गुड़ उत्पादन प्रौद्योगिकी 6 फर्मों को, कुआत्रो गन्ना एकल कलिका कट्टर मशीन, गन्ना पत्ति उतारने वाला यन्त्र, गन्ना आहारीय रेशे खाद्य उत्पाद, भा.कृ.अनु.प. –सी.आइ.ए.इ. –एस.बी. आइ. गन्ना बीज टुकड़े उपचार यन्त्र, भा.कृ.अनु.प. –सी.आइ. ए.इ. –एस.बी.आइ. गन्ना छिलका उतारने वाला यन्त्र, भा.कृ. अनु.प. –सी.आइ.ए.इ. –एस.बी.आइ. मोटरयुक्त दोहरे सिर वाली गन्ना एकल कलिका कटिंग मशीन और भा.कृ.अनु.प. –आइ. आइ.एस.आर. –एस.बी.आइ. गहरी नालियों में गन्ना कट्टर रोपण मशीन में प्रत्येक को एक फर्म को दिये गये। कुल मिलाकर भा.कृ.अनु.प. – गन्ना प्रजनन संस्थान को इन प्रौद्योगिकीयों के लाइसेंस से 38,25,398 रुपये की आय हुई।

मिन्नी ट्रैक्टर संचालित कीट रोगनाशी सूत्रकृमि अनुप्रयोग को भा.कृ.अनु.प. – सी.आइ.ए.इ., क्षेत्रीय केन्द्र, कोयम्बत्तूर के साथ मिलकर विकसित किया गया है। अनुप्रयोग में 150 लिटर आयतन वाला टैंक, एक आंदोलक और निकासी के लिये 2 लचीली ट्यूबें हैं। खेत में परिचालन की गति 1 किलोमीटर/घंटा पर कीट रोगनाशी सूत्रकृमि अनुप्रयोग 0.18 हेक्टेयर/घंटा क्षेत्र को उपचारित किया जा सकता है। अनुप्रयोग की प्रति हेक्टेयर लागत 2,550 रुपये है।

पेड़ी फसल प्रबंधन के लिये स्टब्बल शेविंग और मेढ़ें तोड़ने के लिये आइ.आइ.एस.आर. मॉडल डिस्क टाइप पेड़ी फसल प्रबंधन यन्त्र की तुलना हाथों द्वारा प्रबंधन के साथ, अधिक दूरी पर रोपित को. 86032 फसल में की गई और दोनों से उत्पादन बराबर पाया गया। मिन्न ट्रैक्टर संचालित गन्ना कटाई मॉडल विकसित कर भा.कृ.अनु.प. – गन्ना प्रजनन संस्थान और तमिलनाडू कृषि विश्वविद्यालय में परीक्षित किया गया है।

कलोरोफिल स्पैड सूचकांक में 5.8 और 11.4% का गिरावट सीमित सिंचाई उपचारों की क्रमशः आइ.–1 (सिंचाई पानी की मात्रा को आधा किया गया) और आइ.–2 (सिंचाई की संख्या को आधा किया गया) में निर्माणत्मक प्रवस्था के दौरान और को. 15007, को. 15018, को. 12009 और को. 13014 में उच्च स्पैड सूचकांक इन दोनों उपचारों में देखा गया। को. संकरों में सिंचाई जल उपयोग क्षमता और मुर्झाने के पॉइंट को इन दोनो सीमित सिंचाई उपचारों में सुधार देखा गया। जाति कृन्तकों के लिये आइ.–2 अधिक घातक था।

स्पैड कलोरोफिल सूचकांक लालरी में 11.2 से 2019–75 में 41.37 के बीच विभिन्न जीन प्रारूपों में देखा गया जिनकी औसत 29.95 थी। कलोरोफिल फलूरेसेंस फिजी 55 में 0.584 से को. 17013 में 0.774 के बीच दर्ज किया गया जिसकी औसत 0.714 थी, जो इस बात का संकेतक है की शुरुआती वृद्धि प्रवस्था में ज़्यादा जीन प्रारूपों में उच्च प्रकाश–रसायनिक दक्षता उपस्थित थी। कार्यकि गुणों, नामशः स्पैड सूचकांक, कलोरोफिल की कुल मात्रा, फसल छत्र के तापमान का गन्ना उत्पादन के साथ धनात्मक सहसम्बंध था जबकि फसल छत्र के तापमान का सी. सी.एस. के साथ सार्थक सहसम्बंध शुरुआती वृद्धि प्रवस्था के दौरान था। यद्यपि इन सभी गुणों का सर्वोत्तम वृद्धि प्रवस्था के दौरान गन्ना उत्पादन के साथ साथ सी.सी.एस. टन/हे. के साथ सार्थक सहसम्बंध देखा गया।

चयापचय गुणों, नामशः कलोरोफिल की कुल मात्रा, नाइट्रेट रिडक्टेस क्रियाशीलता, घुलनशील प्रोटीन, कुल घुलनशील शर्करायें, सुक्रोस संश्लेषण एवं संग्रहण एन्ज़ाइमों की क्रियाशीलता को उपोष्णकटिबंधीय क्षेत्र के मुकाबले उष्णकटिबंधीय क्षेत्र की प्रजातियों में उच्च स्तरों पर देखा गया। घुलनशील प्रोटीनों की औसत मात्रा उष्णकटिबंधीय क्षेत्र की प्रजातियों में 55.38 मिलिग्राम/ग्राम उपोष्णकटिबंधीय क्षेत्र की प्रजातियों में 47.08 मिलिग्राम/ग्राम से उच्च देखी गई। उष्णकटिबंधीय क्षेत्र वर्ग की प्रजातियां जैव भार उत्पादन के लिये प्रकाश–संश्लेषण कार्यकुशल थी।

रोपण पंक्तियों की निकट दूरी में अधिक दूरी वाली पंक्तियों के मुकाबले गन्ना कृन्तकों ने बेहतर जैव भार संग्रहण और सापेक्ष उपयोग क्षमता वृद्धि की सभी प्रवस्थाओं के दौरान दर्शाई। कृन्तकों में से को. 86032 और को. 99004 में 30 से अधिक उच्च स्पैड सूचकांक और कलोरोफिल की मात्रा दूसरे कृन्तकों के मुकाबले सभी तरह की पंक्तियों में देखी गई। गन्ना कृन्तकों, नामशः फिजि 55, खाक्कई, आइ.एस.एच. 107, आइ.एस.एच. 111 और पथरी ने बेहतर जैव भार उत्पादन, अत्याधिक जल की कमी के हालात में भी, दर्शाया।

निमन्न नाइट्रोजन के तनाव ने भूतल से ऊपर कुल जैव भार उत्पादन को सार्थक रूप 46% से गिराया, जबकि निमन्न फास्फोरस ने 61% और पोटाश की कमी ने 29% कन्ट्रोल के मुकाबले गिराया। निमन्न फास्फोरस तनाव ने सभी परीक्षित की गई प्रजातियों में 50% से अधिक गिरावट दर्ज की। प्रजातियों में को. 10026 को कम नाइट्रोजन के तनाव में, जबकि को. 09004 को निमन्न फास्फोरस और पोटाश के हालातों में बेहतर जैवभार उत्पादक पाया गया।

गन्ना कृन्तकों, नामशः को. 8021, को. 10026 और को. 86032 को हाइड्रोपॉनिक्स के हालातों में उगाकर उन्हें जल कमी तनाव एवं जलप्लावन तनाव के हालातों से उपचारित किया गया। प्रोलीन, फिनॉलिक्स, मेलोनएल्डीहाइड, सुपरऑक्साइड डिसमुटेस, परऑक्सिडेस क्रियाशीलता में सार्थक वृद्धि देखी गई और पी.सी.आर. पत्तों एवं जड़ के ऊतकों में सार्थक वृद्धि गन्ना कृन्तकों को जल प्लावन एवं कमी के हालातों को सहन करने में सहायक सिद्ध होते हैं।

गन्ने के जर्मप्लास्म चयनित कृन्तकों को निर्माणात्मक प्रवस्था में सूखा एवं जल प्लावन के हालातों में मूल्यांकित किया गया।

पंसाही और ओशिमा ने सूखा एवं जल प्लावन के हालातों में उच्च सार्थक आर.एस.ए. दर्ज किया। आइ.एन.डी. 85–490, पुतली खिलजी और आइ.के. 76–166 ने उच्चतर एकल गन्ना भार सूखे के हालतों में, जबकि डी.जनटोएर–1 ने जल प्लावन के हालातों में उच्चतर एकल गन्ना भार दर्ज किया।

तीसरी पेड़ी में कल्लों की संख्या, गन्ने की मोटाई, पेराई योग्य गन्नों की संख्या, गन्ना उत्पादन और सी.सी.एस. उत्पादन पर कोई सार्थक प्रभाव (पी = 0.05) नहीं देखा गया, शायद अन्तरफसलीकरण के अवशिष्टों के प्रभाव के कारण। यद्यपि गन्ने की लम्बाई, पोरियों की और एकल गन्ना भार संख्या पर सार्थक प्रभाव देखा गया। अन्तर फसलीकरण के अवशिष्टों का रस की गुणवत्ता, और औसत ब्रिक्स, शर्करा, शुद्धता और सी. सी.एस. पर प्रभाव सार्थक नहीं थे। मृदा ऑरगेनिक कार्बन को मेढों पर (1.08%) नालियों के (0.91%) मुकाबले सार्थक रूप से अधिक पाया गया। को. 14027 और को. 11015 को उड़द और धनिया के साथ अन्तर फसलीकरण कर मूल्यांकित किया गया। इससे उड़द 952 किलोग्राम/हे. और धनिया के ताज़े पत्ते 2,658 किलोग्राम/हे. प्राप्त हुए।

चूनेदार मृदा में गन्ने के लिये पोषण प्रबंधन पैकेज को मानकीकृत करने के लिये अध्ययन में 350 किलोग्राम नाइट्रोजन, 62.5 किलोग्राम पी.2ओ.5 एवं 90 किलोग्राम के.2ओ. के साथ खलिहान खाद 5 टन/हे. की आधार मात्रा दी गई जिसमें फास्फोरस की सारी मात्रा शुरूआत में और नाइट्रोजन और पोटाश को तीन भागों में बांट कर दिया गया। इसके अलावा पत्तों पर बाह्य लक्षणों के आधार 5 स्परे यूरिया, फैरस सल्फेट और ज़िंक सल्फेट रोपण के 120 दिन बाद तक देने से दूसरे उपचारों के मुकाबले 147.77 टन/हे. का उच्च गन्ना उत्पादन दिया। विभिन्न पोषक उपचारों के बीच पुष्पण व्यवहार में भिन्नता देखी गई। पुष्पण तीव्रता केवल कन्ट्रोल में 10.14% केवल खलिहान खाद के 6.82% के बराबर जबकि अन्य उपचारों से सार्थक रूप से उच्च थी। पुष्पण वाले गन्नों के अवशेष में पोटाश की मात्रा 0.65% बिना पुष्पण वाले गन्ने के अवशेषों के 0.94% से सार्थक रूप से कम थी।

पुष्प्ण के लिये कुल डिगरी दिन का आकलन पेड़ी की शुरूआत से लेकर एरोइंग (पेड़ी) प्लॉट में कृन्तकों की पुष्पण तिथी के आधार पर 2021 पुष्पण मौसम के दौरान, पिछले वर्षों (2019 और 2020) के दौरान निकाले गये आधार तापमान का प्रयोग कर, किया गया। कुल 35 कृन्तकों में 2021 में पुष्पण देखा गया। आधार तापमान 7 से 230 सी. के बीच रहा। कुल डिगरी दिन 1,065 से 5,566 के बीच पुष्पण करने वाले कृन्तकों के लिये आकलित किये गये। इस पेड़ी और इसकी पिछले साल पौधा फसल से मुकाबला करने पर पाया गया कि पेड़ी की फसल ने 200–300 कुल डिगरी दिन कम लिये। राष्ट्रीय संकरण उद्यान (पौधा फसल) में 2021 में पुष्पण दिखाने वाले कृन्तकों में से 65 कृन्तकों का आधार तापमान पिछले वर्षों (2019 और 2020) के दौरान निकाले गये आधार तापमान जैसे ही थे। कुल डिगरी दिन और आधार तापमान 65 कृन्तकों में 2021 के दौरान 786 से 7,576 और 3 से 240 सी. के बीच आकलित किये गये। पौधा फसल में 2021 के दौरान पिछले वर्षों (2019 और 2020) के दौरान निकाले गये 200 से 300 बीच कुल डिगरी दिन कम थे। अतः गन्ने में पुष्पण व्यवहार को समझने के लिये विस्तृत अनुसंधान की आवश्यक्ता है।

कुल 1,000 लिटर गन्ने के रस से 200 लिटर तरल गुड़ का उत्पादन हुआ। अतिरिक्त वाष्पिकरण पैनों को खरीदकर अधिक गुड़ बनाने की क्षमता का विकास किया गया। उत्पाद के लिये अन्तिम स्टीफिकेट 18.09.2021. को मिला जिसकी वैधता 17.09.2022 तक थी। चूनेदार मृदाओं में सुधार के लिये जिप्सम और गन्धक का मूल्यांकन को. 06022, को. 09004 और को. 86032 में किया गया। सुधारकों के प्रभाव में रोपण के 90 दिन बाद कल्लों की संख्या और रोपण के 120 दिन बाद स्पैड मूल्यों पर कोई सार्थक अन्तर नहीं था।

फसल सुरक्षा विभाग

फसल सुधार विभाग के विभिन्न परीक्षणों, जिनमें कृन्तक परीक्षण, विशिष्ट संकर, राष्ट्रीय संकरण उद्यान से पैतृक कृन्तक, सम्बंधित जेनरा, इन्ब्रैड्स, जेनेटिक स्टॉक्स, जर्मप्लास्म और जल प्लावन सहनशील पूर्व क्षेत्रीय प्रजाति परीक्षण–2021 श्रंखला, आइ.एस.एच. और आइ.जी.एच. कृन्तकों, पराजीनि कृन्तकों, पूर्व क्षेत्रीय प्रजाति परीक्षण–2021 श्रंखला, इन्डो–ऑस्ट्रेलियन कृन्तकों इत्यादि को मिलाकर करीब 3,036 कृन्तकों की लाल सड़न रोग प्रतिरोधिता के लिये नियन्त्रित हालातों में सी.एफ.06 (सी.एफ671) रोगजनक के विरुद्ध जाँच कर करीब 1,543 कृन्तकों को लाल सड़न रोग प्रतिरोधी/मध्यम प्रतिरोधी पाया गया। राष्ट्रीय संकरण उद्यान से आये करीब 107 पैतृक कृन्तकों को सी. फाल्केटम के सी. एफ.12 रोगजनक के विरुद्ध मूल्यांकन करने पर 51 प्रतिरोधी/मध्यम प्रतिरोधी पाया गया। करीब 103 पैतृक कृन्तकों को गन्ने के कंडुआ रोग के लिये मूल्यांकित किया गया, जिनमें से 53 कृन्तकों को प्रतिरोधी/मध्यम प्रतिरोधी पहचाना गया। गन्ना प्रजातियों की खेत में लाल सड़न रोग प्रतिरोधिता से पता चलता है कि नया आइसोलेट अधिक विषैला है, नामित सी.एफ.06 और सी.एफ.12 रोगजनकों के मुकाबले।

सी. फाल्केटम के उष्णकटिबंधीय क्षेत्र से एक नये विलगन की 29 गन्ना प्रजातियों में रोगजनक विभिन्नता और विषैलेपन्न में वृद्धि से पता चला कि को. 11015 और को.एम. 0265 से इस मौसम के दौरान विलगित किये गये विलगन का विषैलापन्न अन्य विलगनों से अधिक था। सी.एफ11015 विलगन ने हमेशा नई प्रजातियों पर संवेदनशील प्रतिक्रिया दर्शाई, जबकि को. 86032 और को.वी. 09356 ने इन विलगनों के प्रति संवेदनशील से मध्यम संवेदनशील प्रतिक्रिया दर्शाई।

नेनो संरूपणों एस.ए.आर. उत्प्रेरक अणुओं, नामशः बैंज़ोथायाडायाज़ोल और सैलिसिलिक अमल को गन्ने के

लाल सड़न, कंडुआ और विल्ट रोगों के विरुद्ध प्रभाव जानने के लिये परीक्षित किया गया, जिससे इसका पता चला कि काइटोसान से लिपित हुए बैंज़ोथायाडायाज़ोल नेनो संरूपणों से बैंज़ोथायाडायाज़ोल धीरे धीरे निकलता रहा, जिससे इसने मेज़बान की प्रतिरोधिता को उत्प्रेरित किया और गमलों के हालातों में पूरी फसल को कटाई के समय तक बचाये रखा। कंडुआ रोग का घटनाओं में 62.5 से 90.0% तक की कमी बैंज़ोथायाडायाज़ोल नेनो संरूपणों के कारण देखी गई। को.सी. 671 और को. 11015 में लाल सड़न रोग की घटनायें बैंज़ोथायाडायाज़ोल नेनो संरूपणों के कारण कन्ट्रोल के मुकाबले कम से कम देखी गई।

गन्ना बीज टुकड़ों का थायोफेनेट मिथाइल को पायनिबेसिलस एल्वेआइ का 50% सान्द्रता पर मशीनीकृत उपचार करने से दूसरे उपचारों के मुकाबले अधिक सार्थक प्रभाव देखा गया। इसके अलावा गन्ना बीज टुकड़ों का मशीनीकृत उपचार जैवनियन्त्रकों और कवकनाशियों के साथ अकेले अकेले और मिलाकर करने से कोई बुरे प्रभाव नहीं देखे गये जबकि इनसे रोग की घटनाओं में कमी, पौधों की वृद्धि तथा उपज सम्बंधित गुणों में सुधार देखा गया। एक कामचलाऊ गन्ना बीज टुकड़ों को उपचार करने के लिये मशीन बनाई गई जिसमें गर्म पानी से उपचार करने के लिये आन्दोलक एवं उपयुक्त संकेतक लगे थे ताकि गन्ना के घासीय रोग फाइटोप्लास्मा का प्रबंधन, कवक रोगों के अलावा, किया जा सके। इस अध्ययन के परिणामों से पता चला कि उच्च तापमान का कवकों के अलावा अन्य रोगजनकों पर निष्क्रियन का प्रभाव अस्थाई था, अतः तकनीकी विकास का कार्य जारी है ताकि लक्षित रोजनकों का जड़ से विनाश हो सके।

गन्ने में लाल सड़न रोग प्रबंधन के लिये प्रभावी ट्राइकोडर्मा जाति से नेनो समग्री के जैवउत्पादन के लिये मानक संचालन क्रमाचार को विकसित किया गया।

गन्ना बीज टुकड़े उपचार यन्त्र – गर्म पानी उपचार 52 से 540 सी. को अलग से या फिर पोषक तत्वों के साथ मिलाकर देने से गन्ना बीज टुकड़ों का उपचार करने पर देखा गया कि उच्च तापमान 540 सी. को पोषक तत्वों के साथ मिलाकर देने से फुटाव, पेराई योग्य गन्नों की संख्या एवं गन्ना उत्पादन में सार्थक सुधार देखा गया। खेत के हालातों में भी निर्वात आधारित गन्ना बीज टुकड़े उपचार यन्त्र – गर्म पानी उपचार इकाई द्वारा बीज टुकड़ों को उच्च तापमान 540 सी. पर उपचारित कर रोपित करने पर घासीय रोग में 80% से अधिक सार्थक गिरावट देखी गई।

विषाक्त जीनों के ट्रान्सक्रिप्टोम डाटा का तुलनात्मक विश्लेषण करने पर कार्बोहाइड्रेट्स गतिशील एन्जाइमों (सी.ए.ज़ाइम्स –जी. एच.16, जी.एच.128, जी.एच30 और जी.एच. 45), प्रतिलेखन नियामकों और झिल्ली परिवाहकों में बदलाव एस. साइटेमिनिअम के द्विरूपी बदलाव के दौरान घटने वाली प्रतिलेखन घटनाओं को रोशन करते हैं। गन्ने के साथ एस. साइटेमिनिअम के विभिन्न विलगनों की अन्तरक्रिया के दौरान सम्पूर्ण ट्रान्सक्रिप्टोम का विश्लेषण करने पर संक्रमण की शुरूआती प्रवस्था में अधिकतर जीनों को नीचे की तरफ नियंत्रित, दोनो उच्च एवं कम विषाक्त विलगनों के साथ, शायद जो कवक के विरुद्ध मेज़बान की प्रतिरक्षा या आक्रमण रणनीति है। गन्ने की एस. साइटेमिनिअम के साथ गतिशील अन्तरक्रिया के दौरान इसके ट्रान्सक्रिप्टोम में बदलाव को इस परीक्षण के परिणामों ने प्रकाशमान किया। स्वस्थ एवं संक्रमित ऊतकों (सुसंगत अन्तरक्रिया के दौरान) के अपलवक प्रटीनों का, आइटी.आर.ए.क्यू. चिन्हित कर, एल.सी. –एम.एस./एम.एस. विधि द्वारा तुलनात्मक प्रोटियोमिक विश्लेषण करने पर 1,453 और 1,601 पैप्टाइडों की पहचान की गई, जिन्होंने क्रमशः 56 और 67 प्रोटीनों को दर्शाया। सुसंगत और असुसंगत अन्तरक्रिया के दौरान, विकास की विभिन्न प्रवस्थाओं पर कुछ सार्थक प्रकटन और विभिन्नता से प्रकटन दिखाते कुछ प्रत्याशी प्रोटीनों को प्रतिलेखन द्वारा मानकीकृत किया गया।

प्रत्याशी जीनों, नामशः सी.एफ इ.पी.एल.1 और सी.एफ पी.डी.आइ.पी.1, का तम्बाकु के पत्तों में एग्रोबैक्टीरियम द्वारा घुसपैठ करवा कर, प्रतिरक्षण उत्प्रेरणता का अध्ययन करने के लिये, प्रतिरक्षण सम्बंधित जीनों के प्रकटन को क्यूपी.सी.आर. द्वारा निरीक्षित किया गया। ट्रान्सक्रिप्टोम विश्लेषण ने, इन दोनो प्रोटीनों की, एस.ए.आर. मारकर जीनों के उच्च नियन्त्रण द्वारा, प्रतिरक्षण उत्प्रेरक क्षमता को स्पष्टतौर पर दर्शाया। सी. फाल्केटम 671 को प्रोटियोप्लास्ट की मध्यस्तथा से रूपान्त्रित कर सी.एफ इ.पी. एल.1 और सी.एफ पी.डी.आइ.पी.1 के उत्परिवर्तीयों को विकसित किया गया ताकि इन क्षमतावान पी.ए.एम.पी.एस/प्रभावकों की कार्यकि भूमिका को वर्णित किया जा सके।

विल्ट और पोक्काह बोइंग के विकास को, 11 प्रजातियों के संक्रमित गन्ना बीजों से खेत के हालातों में अनुरूप बनाकर पता चला कि फयूसेरियम सेकेराइ के मृदा में इनाक्यूलम को जवार के दानों और काटे गये विल्ट प्रभावित गन्नों पर बहुगुणित कर, कलिका फुटाव और खेत में फसल के स्टैंड को प्रभावित किया।

गन्ने के पैतृक कृन्तकों में रस्ट प्रतिरोधी जीन ब्रू1 की उपस्थिति के संकेत मिले, 570 बीपी उत्पाद के आर.12एच.16 मारकर के साथ और 200 बीपी उत्पाद के 9020–एफ.4–पी.सी.आर.–आर. एसए1 मारकर के साथ प्रवर्धन द्वारा। राष्ट्रीय संकरण उद्यान से करीब 100 पैतृक कृन्तकों को आर.12एच.16 मारकर के साथ परीक्षित करने पर ब्रू1 जीन की उपस्थिति 20 कृन्तकों में पता चला। क्योंकि हमारे जर्मप्लास्म में कई ऐसे कृन्तकों ने रस्ट प्रतिरोधिता दर्शाई जिनमें ब्रू जीन नहीं थी, जिससे इस बात के संकेत मिलते हैं वैकल्पिक रस्ट प्रतिरोधी जीन हमारे जर्मप्लास्म उपस्थित हैं।

को. 775, को. 7201, को. 87252, को. 2000–10 और को. 05010 पर विल्ट का प्रभाव, गन्ना उत्पादन और रस की

गुणवत्ता मापकों की दृष्टि से अध्ययन करने पर गन्ने की ऊँचाई में 24 से 50% की सार्थक गिरावट देखी गई, जबकि गन्ना भार में 16.1 से 57.5%, रस के आयतन में 17.0 से 66.6% और शर्करा% में 5.1 से 33.6% गिरावट अनुमानित की गई। पूरी तरह से मुर्झाये हुए गन्नों में रस की गुणवत्ता मापकों – ब्रिक्स, शर्करा%, शुद्धता% और सी.सी.एस. % में बुरी तरह से गिरावट देखी गई, शायद ऊतकों में प्रणालीगत क्षति होने के कारण। पोषक तत्वों, विशेषकर सूक्ष्म तत्वों, की कमी से प्रभावित पौधों को विल्ट से क्षतिग्रस्त होते पाया गया।

कोयम्बत्तूर और अगली केन्द्र पर अनुरक्षित विभिन्न जर्मप्लास्म और पैतृक लाइनों में पीली पत्ति विषाणु रोग की उग्रता का अध्ययन करने पर अधिकतर जाति कृन्तक अभिप्राप्तियों, नामशः एस. ऑफिश्नेरम्, एस. बारबेरी, एस. साइनेंस और एस. रोबस्टम को करीब करीब रोग लक्षणों से स्वतंत्र पाया गया। मगर राष्ट्रीय संकरण उद्यान के पैतृक कृन्तकों में पीली पत्ति विषाणु रोग का संक्रमण 24.36% तक अनुमानित किया गया। को. 86032 में पीली पत्ति विषाणु रोग का विस्तृत अध्ययन करने पर देखा गया कि यदि पीली पत्ति विषाणु रोग मुक्त स्वस्थ फसल को उगाया जाये तो बेहतर फसल स्टैंड और फसल वृद्धि के साथ मध्यम पुष्पण तीव्रता प्राप्त होती है, जबकि रोगग्रस्त प्लॉट में निर्बल फसल स्टैंड, हल्के पीले हरे रंग के फसल छत्र के साथ पोषक तत्वों की कमी के लक्षण भी देखे गये। उत्पादन मापकों – गन्ने की ऊँचाई, गन्ने की मोटाई, गन्ना भार और रस के आयतन को स्वस्थ प्लॉटों में रोगी प्लॉटों की तुलना में सार्थक रूप से बेहतर अनुमानित किया गया।

गन्ना घासीय रोग के नमूनों, जो विभिन्न प्रकार के शारीरिक लक्षण दर्शा रहे थे, का नेस्टेड पी.सी.आर. परख द्वारा जाँच, सार्वदेशिक पी.1/पी.7 मारकरों का प्रयोग करने पर 85% से अधिक नमूनों ने अनुमानित 1.8 किलोबाइट के परिवर्धन दर्शाये। को.सी. 671 के नमूनों से, ग्रेडिएंट पी.सी.आर. द्वारा क्यूपी.सी. आर. निदानिक प्राइमरों को विधिमान्य किया गया।

ईस्ट प्रकटन वैक्टर पिचिया पास्टोरिस (पीपी.आइ.सी.जैड. ए बी.) का प्रयोग किया गया ताकि एस.सीवाइ.एल.वी. कोट प्रोटीन जीन के प्रकटन को सार्वधिक किया जा सके, जिसमें पुनर्संयोजित प्रोटीनों ने प्रकटन किया सी.–अंत पेपटाइड, जिसमें सी–एमवाइसी एपिटोप और एक पोलीहिस्टीडिन टेग था, के साथ संलगन कर प्रकटन दर्शाया। पिचिया में हमारे मतलब की जीन का उच्च स्तर पर मीथेनॉल उत्प्रेरण प्रकटन इस वैक्टर ने दर्शाया। इसी प्रकार का एक अध्ययन गन्ने के विषाणुओं पर इनके निकट सम्बंधित मेज़बान जातियों पर कर, मक्का और गन्ने के गन्ना पच्चीकारी विषाणु के अनुक्रमों में सबसे अधिक समानार्थी न्यूक्लिओटाइड पाये गये।

गन्ना बेसिलीफॉर्म विषाणु में अनुवांशिक विविधता का अध्ययन करने पर गन्ना बेसिलीफॉर्म विषाणु–यू., एक नये जीन प्रारूप को भारत में आमतौर पाया गया, विशेषकर सैकेरम् संकरों और अन्तर जातीय संकरों में से विलगित करने पर। पुनर्संयोजन घटनाओं का लक्षणवर्णन और गन्ना बेसिलीफॉर्म विषाणु के जीन प्रारूपों के बीच जीन वर्गीकरण करने पर पीढ़ी दर पीढ़ी विकास के बारे में अन्तरदृष्टि प्राप्त होती है।

विषाणु अनुक्रमण सेवा के अन्तरगत करीब 106 ऊतक संवर्धित पौधों, जिन्हें विभिन्न उत्पादन इकाइयों, नामशः मैसर्स इ.आइ. डी. पैरी, पुगालुर और गन्ना प्रजनन संस्थान की ऊतक संवर्धन प्रयोगशाला से प्राप्त किया गया था, को एस.सी.वाइ. एल.वी., एस.सी.एम.वी., एस.सी.एस.एम.वी. और घसैला रोग फाइटोप्लास्माओं के लिये मानक प्रचालन विधियों का प्रयोग करते हुए अनुक्रमित किया गया। प्राइवेट ऊतक संवर्धन प्रयोगशालाओं से विषाणु अनुक्रमण सेवा के अन्तरगत शुल्क के रूप में 20,400/– रुपये प्राप्त हुए।

पोरी बेधक के विभिन्न समूहों के बार बार आक्रमण करने से कटाई के समय गन्ना उत्पादन में हानि का आकलन करने पर गन्ना उत्पादन मापकों पर कोई सार्थक प्रभाव नहीं देखा गया।

मीलीबग, फीनेकोकस सेकेरिफोलिआइ को, कुछ गन्ना उगाये जाने वाले क्षेत्रों में, कल्ले उत्पादन की प्रवस्था में, पोक्काइ बोइंग के साथ काफी क्षति का कारण बनते देखा गया। इ. अरुंडिनेश्यिस से विकसित 18 अन्तर जेनेरिक संकरों में पोरी बेधक के आक्रमण को 0 से 70% के बीच देखा गया। प्रविष्टियों में से 9 जीन प्रारूपों को कम से कम संवेदनशील पाया गया। सी.वाइ.एम. 06–212, सी.वाइ.एम. 09–167 और सी. वाइ.एम. 07–981 को पोरी बेधक के आक्रमण से स्वतंत्र पाया गया। सी.वाइ.एम. 09–565 में 0.39% की न्यूनतम तीव्रता और सी.वाइ.एम. 04–388 में 0.73% की सार्वधिक तीव्रता पाई गई।

इ. अरुंडिनेश्यिस की 22 संततियों में से 5 सेल्फ, 2 बी.सी.1 तथा 15 बी.सी.2 थी। बी.सी.1 को पोरी बेधक के आक्रमण से स्वतंत्र पाया गया। बी.सी.2 संततियों में पोरी बेधक के आक्रमण को 0 से 80% के बीच पाया गया, जिनमें से 14 संततियों को कम से कम संवेदनशील, 3 को मध्यम संवेदनशील और 1 को अतिसंवेदनशील आंका गया।

सिलिकॉन की मात्रा को 7 खेती की जा रही प्रजातियों और 2 इ. अरुंडिनेश्यिस में अनुमानित करने पर इसे पत्ति > शीथ > मध्य शिरा > गन्ने के छिल्के में पाया गया। खेती की जा रही प्रजातियों के मुकाबले में इसे इ. अरुंडिनेश्यिस कृन्तकों में उच्च मात्रा में पाया गया।

महत्वपूर्ण आणविक कार्यों, नामशः काइटिनेस गतिविधि, काइटिन सिंथेस गतिविधि, एकडिसोन गतिविधि, पी.टी.टी.एच. गतिविधि और वोल्टेज–गेटेड सोडियम चैनल गतिविधि से सम्बंधित ट्रान्सक्रिप्टों को पोरी बेधक के ट्रान्सक्रिप्टोम में पहचाना गया। ट्रान्सक्रिप्टों के विभिन्नता से प्रकटन को विश्लेषित करने पर काइटिनेसों, तरुण हारमोन दमनकारी प्रोटीन, पी.450 एन्जाइमों

और गलुटाथायोन–एस–ट्रान्सफरेसेस को पोरी बेधक के उन्नत इनस्टारों में उच्च–नियंत्रित पाया गया।

पोरी बेधक के संवर्धन में सुधार कर अंडे उत्पादन में वृद्धि करने पर लकड़ी के घरों के मुकाबले छोटे प्लास्टिक के डिब्बों में नरो और मादाओं को छोड़ने पर उत्पादन में उच्चतर निपुणता देखी गई।

डिम्भ परजीवी कोटेसिया फलेविपेस् को खेत में छोड़ने के स्टेशन को, अंड परजीवी टेलेनोमस डिग्नस के निगर्मन के लिये परीक्षित किया गया। यन्त्र को ढकने वाले पोलीथीन बैग में परजीवियों की संख्या के आधार पर, नौ परीक्षणों में परजीवियों के निगर्मन को 25.0 से 94.7% के बीच पाया गया। टेलेनोमस डिग्नस के 5,000 परजीवियों को प्रति हेक्टेयर की दर से दो सप्ताह की अवधि के दौरान 6 महीने पुरानी किसान के खेत में खड़ी फसल में आउगमेंटेटिव परीक्षण में छोड़ने पर पोरी बेधक के आक्रमण और तीव्रता को कन्ट्रोल में बढ़ते देखा गया जबकि परजीवियों को छोड़ने वाले प्लॉट में इन्हें घटते पाया गया।

विभिन्न कृषि–आधारित उपोत्पादों में से, जिन्हें बी.टी.–62 स्ट्रेन की बड़ी मात्रा में उत्पादन के लिये प्रयोग में लाया गया, गेहूँ का चोकर और गुड़ को सबसे उपयुक्त पाया गया, जब इन्हें ईस्ट निष्कर्षण और केल्शियम कलोराइड के साथ मिलकर प्रयोग में लाया गया। तरल संरूपण में जब विभिन्न परिरक्षक पदार्थों को बी.टी. संवर्धन किण्वक में मिला कर विभिन्न अन्तराल पर चैक किया गया तो डी.एम.एस.ओ.–0.5% को मिलाने पर 180 दिन के भंडारण पर उच्च बैक्टीरियल संख्या प्राप्त हुई। बी.टी.–62 के साथ जब खेत में परीक्षण किये गये, जिन्हें किण्वक में स्टैंडर्ड मीडिया पर बहुगुणित किया गया था, और 4.0 ग 1014 सी.एफ. यू./हे.दर से जब मृदा के जड़ क्षेत्र को भिगोया गया था तो इससे गिंडारों की संख्या में 60% कमी देखी गई। कर्नाटक के पश्चिमी घाटों, तमिलनाडू (वालपराय) और केरल (मल्लाकापारा जंगल) से 404 नमूने, त्रिपुरा से 259 और ओड़ीसा से 197 नमूनों से 31 बी.टी विलगनों को प्राप्त किया गया। पी.सी.आर. जाँच से कुछ विलगनों से क्राइ1 और क्राइ8 जीनों की उपस्थिती का पता चला।

बी.टी विलगन एस.बी.आइ.–के.के. 27, जिसमें 7 विषैले जीन हैं, 2 नवीन क्राइ1 जीनों, नामशः क्राइ1डी. और क्राइ1इ. को कलोन किया गया, एक्रिस्टेलिफैरस बी.टीएच.डी.73 विलगन में। इस पुनर्संयोजित बी.टी विलगन को पोरी बेधक के प्रथम इनस्टार, फाल आर्मी वॉर्म, कॉटन पिन्क बॉल वॉर्म के द्वितीय इनस्टार के विरुद्ध परखने पर इन्हें पैतृक विलगन एस.बी.आइ.–के.के. 27 से पोरी बेधक और फाल आर्मी वॉर्म के विरुद्ध कम प्रभावी पाया गया। यद्यपि खाने में मिलाकर देने से क्राइ1डी. ने पिन्क बॉल वॉर्म, जो बॉलगार्ड 2 कॉटन के प्रति प्रतिरोधी है, में 90% वृद्धि और विकास में कमी देखी गई। चीन की कृषि विज्ञानों की अकादमी से प्राप्त की गई क्राइ8 की 4 जीनों में से केवल क्राइ8एच.ए को ही सफेद गिंडार के प्रथम इनस्टार के विरुद्ध बी.टी 62 की तरह प्रभावी पाया गया।

एम. एनिसोपलि + बी. ब्रोंगनिआरटी और/या लासेंटा के प्रभाव का अध्ययन, सफेद गिंडार के विरुद्ध खेत में करने पर गिंडारों की संख्या में गिरावट बी. ब्रोंगनिआरटी के साथ 69.2% से लेकर एम. एनिसोपलि + बी. ब्रोंगनिआरटी या लासेंटा के साथ 92.3% तक देखी गई। एम. एनिसोपलि और बी. ब्रोंगनिआरटी को मृदा के नमूनों से पुनःप्राप्त किया जा सका।

एक नया गुड़ आधारित मीडिया (भा.कृ.अनु.प.–एस.बी.आइ. तरल मीडिया) विकसित किया गया जिसे किफायती और गन्ने की परिस्थितिकी के कई सारे कीट रोगजनक सूत्रकृमिओं (की.रो.सू.ओं) के उत्पादन के लिये उपयुक्त पाया गया, विशेषकर एम. एनिसोपलि के लिये।

एक 20 लिटर क्षमता वाली किण्वक (संकलित किया गया) प्रणाली से एम. एनिसोपलि (एस.बी.आइ.एम.ए.–16) का उत्पादन उच्च बिजाणु दर (108/मिलिलिटर) पर भा.कृ.अनु.प.–एस.बी. आइ. 0.5% तरल मीडिया में समय के बचत के साथ किया जा सका।

एक अन्य कवक एसचरसोनिया पलेसेंटा का उत्पादन बड़ी मात्रा में करने के लिये भा.कृ.अनु.प.–एस.बी.आइ. तरल मीडिया विकसित किया गया।

कीट रोगजनक सूत्रकृमिओं की गतिविधियों को मृदा की विभिन्न गहराइयों पर सफेद गिंडार के दूसरे इनस्टार के विरुद्ध अध्ययन किया गया। सभी की.रो.सू.ओं ने 10 सेंटीमीटर गहराई पर गिंडारों को मारा। एस. गलासेरी (एस.बी.आइ.एल.एन.1) के कारण गिंडारों की जल्द मुत्युशीलता देखी गई, जिसे 40 से 100% के बीच देखा गया। की.रो.सू.ओं को 25 सेंटीमीटर गहराई तक देखा गया जहाँ गिंडारों को मरते पाया गया। गिंडारों की मृत्यु होते 30 सेंटीमीटर गहराई पर नहीं देखी गई।

हैट्रोरहैब्डाइटिस बैक्टीरिओफोरा स्ट्रेन एस.बी.आइ.एल.एन.8 के संरूपण के भण्डार और उपयोग की अवधि 10 महीने पाई गई, जबकि स्टेइनरनेमा सिआमकायाइ स्ट्रेन एस.बी.आइ.टी.एन.टी.1 के भण्डार और उपयोग की अवधि 12 महीने पाई गई। इसी प्रकार स्टेइनरनेमा सुरखेटेंस स्ट्रेन एस.बी.आइ.पी.3 के भण्डार और उपयोग की अवधि भी 12 महीने पाई गई।

भा.कृ.अनु.प.–एस.बी.आइ. की.रो.सू. जैवकीटनाशी संरूपण प्रौद्योगिकी का व्यावसायिकरण किया गया, 5 कम्पनीयों को 10 लाख की लाइसेंस फीस के साथ देकर किया गया और जिसका समन्वय एग्रीइनोवेट इंडिया, नई दिल्ली द्वारा किया गया। अठतर की.रो.सू.ओं, जिनमें से 49 उष्णकटिबंधीय और 29 उपोष्णकटिबंधीय क्षेत्र से सम्बंधित हैं को कल्चर संग्रहण में अनुरक्षित किया जा रहा है। इसके अलावा 45 सहजीवी बैक्टीरिया में 26 फोटोरहैब्डस जाति और 19 जीनोरहैब्डस जाति

से हैं, को लगातार उपकल्चर कर गलिसरीन में भण्डारित किया जा रहा है।

तमिलनाडू के विभिन्न ज़िलों के मक्का और गन्ने के फाल आर्मी वॉर्म से ग्रस्त खेतों का सर्वेक्षण कर मक्का के खेतों से 14 की.रो.सू.ओं को विलगित किया गया। फाल आर्मी वॉर्म से ग्रस्त खेतों से विलगित किये गये 13 की.रो.सू.ओं, हैट्रोरहैब्डाइटिस और स्टेइनरनेमा जातियों से, के आन्तरिक लिखित अंतरक अनुक्रमों को जैन्बैंक में भेजा गया हैए जिनके अभिप्राप्तियों के नम्बर एम.जैड. 5075532 से एम.जैड. 5075544 तक हैं।

फाल आर्मी वॉर्म के तीसरे इनस्टार डिम्भ के विरुद्ध की.रो.सू. स्टेइनरनेमा सिआमकायाइ को विभिन्न जैव परख विधियों को परीक्षित किया गया ताकि उपयुक्त जैव परख विधि को विधिमान्य किया जा सके। पत्तियों के टुकड़ों को आइ.जे. इनाक्यूलेशन (भोजन 24 घंटे बाद) के साथ जैव परख विधि में फाल आर्मी वॉर्म के तीसरे इनस्टार डिम्भ के विरुद्ध 48 घंटे के इनक्यूबेशन के पश्चात 100% मृत्युशीलता देखे जाने के कारण इस विधि को उपयुक्त माना गया।

फाल आर्मी वॉर्म के दूसरे एवं तीसरे इनस्टार डिम्भ के विरुद्ध स्थानिक की.रो.सू. की मात्रा अनुसार प्रतिक्रिया का मूल्यांकन प्रयोगशाला में करने पर 100% मृत्युशीलता देखी गई – एच. इंडिका के 10 आइ.जे.ओं के कारण 36 घंटे पश्चात, एस. सिआमकायाइ के 10 आइ.जे.ओं के कारण 72 घंटे पश्चात, एस. गलासेरी के 40 आइ.जे.ओं के कारण 36 घंटे पश्चात और एच. बैक्टीरिओफोरा के 40 आइ.जे.ओं के कारण 48 घंटे पश्चात। गन्ने की को. 86032 प्रजाति के साथ गमलों में किये गये परीक्षण में एच. इंडिका, एच. बैक्टीरिओफोरा और एस. सिआमकायाइ की.रो.सू. ओं की जैविक क्षमता को परखा गया, फाल आर्मी वॉर्म के दूसरे इनस्टार डिम्भ के विरुद्ध। परिणामों में डिम्भों की मृत्युशीलता 40 से 50% के बीच देखी गई।

संख्यिकी, अर्थशास्त्र और कृषि ज्ञान प्रबंधन इकाई

चीनी परता, जो 2013–14 में 9% थी, उसने उत्तर प्रदेश में को. 0238 प्रजाति के किसानों द्वारा समय के साथ अधिक से अधिक अपनाये जाने के अनुपात में चीनी परता में वृद्धि दिखाई। चीनी परता ने 2019–20 में 11.5% का स्तर पार कर लिया है, जबकि गन्ने के अन्तरगत क्षेत्र के 85% हिस्से में को. 0238 को उगाया जा रहा है। चीनी परता के पैटर्न में आये बदलाव के कारण राज्यों के चीनी परता के आधार पर वर्गीकरण को बदलने की आवश्यकता पड़ी है, और जिसे तय कर लिया गया है। हमारे अध्ययन ने भारत के विभिन्न राज्यों के एतिहासिक चीनी परता पैटर्न, चीनी परता में सुधार, इसमें आये उतार चढ़ावों को प्रलेखित किया है। उष्णकटिबंधीय क्षेत्र में गन्ना खेती के अन्तरगत आये सार्थक गिरावट के बावजूद को. 0238 ने उत्तर प्रदेश, बिहार, हरियाणा, पंजाब और उत्तराखंड प्रदेशों में गन्ने की खेती के स्तर को बनाये रखा है। उपोष्णकटिबंधीय भारत में 2019–20 के दौरान 27.11 लाख हैक्टेयर में से 24.14 लाख हैक्टेयर में को. 0238 की खेती की जा रही थी। इसमें कोई शक नहीं की को. 0238 देश में गन्ने की खेती को दिशा प्रदान कर रही है, क्योंकि देश के कुल गन्ना खेती के 52.4% में को. 0238 की ही खेती की जा रही है।

विस्तार अनुभाग

दूर तक पहुँचने के कार्यक्रमों के अन्तरगत तमिलनाडू और पुद्दुचेरी की 51वीं गन्ना अनुसंधान एवं विकास कार्यशाला, किसानों के लिये एक दो दिवसीय प्रशिक्षण कार्यक्रम, किसानों और गन्ना कर्मचारियों के लिये 12 एक दिवसीय प्रशिक्षण कार्यक्रम, किसानों, गन्ना कर्मचारियों और विद्यार्थियों के लिये 14 अनावरण भ्रमण का आयोजन किया गया।

किसानों के खेत में ऑरगेनिक खेती के अन्तरगत को. 11015 प्रजाति पर अगली पंक्ति के प्रदर्शन में 82.65 टन/हे. गन्ना उत्पादन और 10.20 टन/हे. गुड़ उत्पादन प्राप्त हुआ।

गन्ना प्रौद्योगिकीयों के प्रदर्शन के बारे में प्रतिपुष्टि प्राप्त करने के लिये तमिलनाडू के विल्लुपुरम और कल्लाकुरुचि ज़िलों में सर्वेक्षण किया गया।

संस्थान में 1,249 आगन्तुकों, जिनमें 535 विद्यार्थी, 652 किसान और 62 गन्ना कर्मचारी शामिल थे, का स्वागत किया गया।

भा.कृ.अनु.प.–गन्ना प्रजनन संस्थान, क्षेत्रीय केन्द्र, करनाल

को. 15023 (करण 15), एक अगेती प्रजाति को गजेट अधिसूचना नम्बर एस.ओ. 500 इ. (दिनांक 29.011.2021.) द्वारा उत्तर पश्चिमी क्षेत्र – जिसमें दिल्ली, हरियाणा, पंजाब, राजस्थान, उत्तराखंड और उत्तर प्रदेश (केन्द्रीय और पश्चिमी भाग) शामिल हैं, में व्यावसायिक खेती के लिये अधिसूचित किया गया। पाँच प्रविष्टियों को को. गन्नों, नामशः को. 21012, को. 21013, को. 21014 और को. 21015 (अगेती प्रजातियां) एवं को. 21016 (मध्यम देरी से पकने वाली) के स्तर पर बढ़ाया गया। इनमें से को. 21012, को. 21013 और को. 21014 को, अ.भा.स. अनु.प. (गन्ना) की वार्षिक समूह बैठक में, उत्तर पश्चिमी क्षेत्र में क्षेत्रीय प्रजाति परीक्षणों में परीक्षित करने के लिये शामिल कर लिया गया। भूतल नर्सरी पेड़ी से 244 बेहतर प्रदर्शन करने वाली संततियों को चुनकर के. 19–01 से के. 19–244 नम्बर देकर सी.1 प्रवस्था में मूल्यांकन के लिये आगे बढ़ाया गया। सी.1 बहुगुणन प्रवस्था से के. 17 श्रंखला की 124 परीक्षण प्रविष्टियों में से 38 को शुरूआती परीक्षण के लिये आगे बढ़ाया गया। पूर्व क्षेत्रीय प्रजाति परीक्षण 2021–22 के 8वें महीने के मूल्यांकन से परीक्षत प्रविष्टि डब्लयू. एल.06–182 ने मानक को.सी. 671 के 17.64% से सार्थक रूप से अधिक 18.85% की शर्करा रस में दर्ज की, जबकि डब्लयू. एल.04–72 ने 17.86%, डब्लयू. एल.06–85 ने 17.66% और डब्लयू. एल.10–85 ने 17.27% के आंकड़े दर्ज किये, जो मानक के बराबर थे।

कुल 24 आइ.एस.एच. कृन्तकों को उनकी सूखा सहनशीलता के लिये मूल्यांकित किया गया। आइ.एस.एच. प्रविष्टियों, नामशः

14–131, 14–94, 14–38 और 14–34 ने 2% से भी कम, रोपण के 150 दिन बाद पौधे की ऊँचाई में गिरावट दर्ज की। फरवरी 2021 के महीने के दौरान 31 आइ.एस.एच. प्रविष्टियों की पेड़ी की शुरुआत की गई। एकल गन्ना भार में सूखे के हालातों में 14–147, 14–56, 14–144 14–188 और 14–49 को को. 0238 के बराबर पाया गया। आइ.एस.एच. 14–42, 14–49, 14–147, को. गन्ने को. 14034 ने 4, 8 और 10 डेसी.सीमन/मीटर लवणता के स्तरों पर 15.10, 19.72 और 22.0 : की क्रमशः गिरावट, जबकि को. 16030 ने 7.19, 16.45 और 29.23% की क्रमशः कम गिरावट दर्ज की।

अ.भा.स.अनु.प. (गन्ना) के 2020–21 के परीक्षणों में कटाई के समय, किसी भी शुरूआती प्रजाति परीक्षण (अगेती) की प्रविष्टि को आशाजनक नहीं पाया गया। उन्नत प्रजाति परीक्षण (अगेती) में को. 15025 को 18.69 टन/हे. सी.सी.एस. और 14.377 टन/हे. गन्ना उत्पादन के साथ इसे आशाजनक पाया गया, जबकि उन्नत प्रजाति परीक्षण (अगेती) द्वितीय पौधा फसल में को. 15023 को 135.87 टन/हे. गन्ना उत्पादन और 20.31 टन/हे. चीनी उत्पादन और को. 15027 को 147.29 टन/हे. गन्ना उत्पादन और 19.99 टन/हे. चीनी उत्पादन के साथ बेहतर प्रदर्शन दर्शाया। उन्नत प्रजाति परीक्षण (अगेती) पेड़ी फसल में को. 15023 को 139.92 टन/हे. गन्ना उत्पादन और 18.13 टन/हे. चीनी उत्पादन और को. 15027 को 133.16 टन/हे. गन्ना उत्पादन और 20.09 टन/हे. चीनी उत्पादन के साथ प्रविष्टियों में से सर्वोत्तम प्रदर्शन करने वाली थी।

लाल सड़न रोगप्रारूप सी.एफ.11 को सबसे विषैला पाया गया, जिसके बाद सी.एफ.07, सी.एफ.01, सी.एफ.08, सी.एफ.13, सी.एफ.02, सी.एफ.09 और सी.एफ.03 रोगप्रारूप थे। सी. एफ0238 के 4 विलगनों में से फरीदकोट विलगन को अधिक विषैला पाया गया, और इसने 10 संदर्भ मेज़बानों पर संवेदनशील प्रतिक्रियाऐं दर्शाई, जो क्षेत्र में इसके अलग उदगम का संकेतक है। पंजाब, हरियाणा और उत्तर प्रदेश के मिल क्षेत्रों में सर्वेक्षण करने पर को. 0238 में 50.0% तक लाल सड़न रोग की घटनायें देखी गई। कंडुआ रोग, पोक्काह बोइंग और विल्ट रोगों को कुछ लोकप्रिय गन्ना प्रजातियों में देखा गया।

टेरासटिस्कस पायरिल्ले को एक अंड परजीवी के रूप में पहचाना गया तथा इपिरिकाना मेलानोल्यूका को निम्फ के साथ साथ नवयुवा परजीवी के रूप में पायरिल्ला परपुसिल्ला में पाया गया। आइसोटिमा जावेंसिस और स्टेनोब्रेकोन डीसाए को चोटी बेधक के डिम्भ परजीवी के रूप में पहचाना गया। कोटेसिया फलेविपेस् को स्टॉक बेधक के डिम्भ के साथ साथ प्यूपल से पहले प्रवस्थाओं का परजीवी पाया गया। प्ररोह बेधक, चोटी बेधक, जड़ छेदक, स्टॉक बेधक, पायरिल्ला, काली कीड़ी और दीमक को हरियाणा में गन्ने के हानिकारक जीवों के रूप में लिस्ट किया गया, जबकि गुरदासपुर बेधक, गुलाबी बेधक और फफोला कीड़ी को हरियाणा, पंजाब और उत्तर प्रदेश में निमन्न दर्जे के हानिकारक जीवों के रूप में लिस्ट किया गया। चोटी बेधक के संक्रमण की घटनाओं को हरियाणा में 0.0 से 60.0% के बीच, पश्चिमी उत्तर प्रदेश में 0.0 से 40.0% के बीच और पंजाब में 0.0 से 43.0% के बीच दर्ज किया गया।

कुल 167 उपोष्णकटिबंधीय गन्ना संदर्भ प्रजातियों को 27 डस विवर्णकर्ताओं अनुसार लक्षण वर्णित किया गया। प्रत्याशी प्रजाति को. 12029 का दूसरे वर्ष का डस परीक्षण पूर्ण कर लिया गया और नई गन्ना प्रजाति को. 13035 के पंजीकरण का आवेदन पत्र पी.पी.वी. एण्ड एफ.आर. अधिकरण, नई दिल्ली को प्रस्तुत किया गया। जैव भार के विभाजन का रोपण के 120, 150 और 240 दिन बाद को. 15023 और को. 0124 में अध्ययन करने पर उनमें सार्थक अन्तर पाया गया। एम.डी.एस. प्लॉट का निर्माण किया गया, नमूने समूह के सेटों के बीच निकटता के पैटर्न ने संकेत दिये कि बैच त्रुटि के प्रभाव नहीं थे।

इस वर्ष 35,836.97 कविंटल गुणवत्तायुक्त प्रजनक बीज का रिकॉर्ड उच्च उत्पादन कर हरियाणा, पंजाब, उत्तर प्रदेश और बिहार के किसानों व चीनी मिलों को 2020–21 के दौरान वितरित (2,500 कविंटल लक्ष्य के मुकाबले) किया गया। समझौता ज्ञापन भा.कृ.अनु.प.–गन्ना प्रजनन संस्थान, कोयम्बत्तूर और फर्मों/चीनी मिलों, नामशः मैसर्स अवध शूगर एण्ड एनर्जी लिमिटेड, इकाई हरगाँव, उत्तर प्रदेश, मैसर्स अवध शूगर एण्ड एनर्जी लिमिटेड, इकाई सिओहारा, उत्तर प्रदेश, मैसर्स मवाना शूगर मिल्ल और नंगलमाल शूगर कम्पलैक्स, नंगलमाल, उत्तर प्रदेश, के साथ हस्ताक्षरित किया गया। कुल 23,160 कविंटल गन्ना बीज, करीब 7.0 लाख गन्ना बीज टुकड़े जनित पौधे और 3.0 लाख एकल कलिका गन्ना बीज टुकड़ों का उत्पादन आर.के.वी.वाइ. परियोजना के अन्तरगत बीज उद्यमी के फार्म पर किया गया। कुल 12,000 किवंटल प्रजनक बीज का उत्पादन किया गया और किसानों को स्वस्थ बीज की खरीद के लिये एन.एफ.एस.एम. (व्यावसायिक फसलें) बीज फार्म के बारे में बताया गया।

भा.कृ.अनु.प.–ग.प्र.सं. क्षेत्रीय केन्द्र, कन्नूर

दो कृन्तकों, डब्लयू.एल. 17–1804 और डब्लयू.एल. 17–1344 को सी.सी.एस. उत्पादन के लिये जल प्लावन के हालातों में आशाजनक पाया गया, और इन्हें पूर्व क्षेत्रीय प्रजाति परीक्षण के लिये प्रस्तावित किया गया। कोयम्बत्तूर में 2020–21 के पूर्व क्षेत्रीय प्रजाति परीक्षण में प्रदर्शन के आधार पर डब्लयू.एल. 13–711 (को. 99006 x डब्लयू.एल. 10–20) का चयन किया गया, को. 21010 के नाम से। तीन कृन्तकों लाल सड़न रोग प्रतिरोधिता के लिये डब्लयू.एल.10–85 और डब्लयू.एल. 10–102 को भा.कृ.अनु.प.–एन.बी.ए.जी.आर., नई दिल्ली में पंजीकरण के लिये पहचाना गया है।

जी.यू.के. 17–301 को सी.सी.एस. उत्पादन के लिये चैक प्रजाति से सार्थक रूप से बेहतर पाया गया, जो लाल सड़न रोग के प्रति मध्यम प्रतिरोधी है अतः इसे पूर्व क्षेत्रीय प्रजाति परीक्षण

के लिये प्रस्तावित किया गया है। द्वितीय कृन्तक परीक्षण में 25 कृन्तकों को 2 चैक के साथ मूल्यांकित किया गया, जिनमें से चार कृन्तकों को सी.सी.एस. उत्पादन के लिये आशाजनक पाया गया और इनमें से जी.यू.के. 18–413, जी.यू.के. 18–452 और जी.यू.के. 14–454 को विकसित किया गया, लाल छिलकों वाले एस. रोबस्टम से।

इस केन्द्र में संसार के सबसे बड़े गन्ना जर्मप्लास्म के संग्रहण (3,375 अभिप्राप्तियों) को खेत वाले जीन बैंक में वार्षिक पुनःरोपण द्वारा अनुरक्षित किया जाना एक मुख्य गतिविधि रही है। एस. बारबेरी से 42 और एस. साइनेन्स से 30 जातीय कृन्तकों को 31 शरीरिक लक्षणों, गन्ना उत्पादन और रस की गुणवत्ता मापकों के लिये वर्णित किया गया ताकि केटालॉग को संशोधित किया जा सके। एस. ऑफिश्नेरम, एस. बारबेरी और एस. रोबस्टम के 46 कृन्तकों को पिछले साल प्राकृतिक बाढ़ के हालातों में गन्ना उत्पादन और रस की गुणवत्ता के आधार पर मूल्यांकन करने पर जल प्लावन के हालातों के लिये 5 एस. ऑफिश्नेरम और 1 एस. बारबेरी को आशाजनक पाया गया। गन्ना जर्मप्लास्म के विभिन्न समूहों में ज़मीन के ऊपर पाये जाने वाले कीटों की विविधता का विस्तृत अध्ययन किया गया। कुल 523 अकशेरुकीयों, जो 10 वर्गीकरण विज्ञान सम्बंधी ऑरडरों से पहचाना गया।

करीब 100 एस. ऑफिश्नेरम कृन्तकों को प्रयोगशाला में शाखा के शिखर से सवंर्धित किया गया जिन्हें उप–संवर्धन द्वारा अनुरक्षित किया जा रहा है। सात एस. ऑफिश्नेरम (51 एन. जी. 131, आइ.जे. 76–314, आइ.जे. 76–559, एन.जी. 77–92, एन.जी. 77–63, एन.जी. 77–67 और एन.जी. 77–18) के घट्टों द्वारा पुनःप्राप्ति कर सजावटी मूल्य बढ़ाने के लिये और विविधता और चयन का कार्य किया गया। कृन्तक 51 एन.जी. 131 और एन.जी. 77–92 को घट्टों द्वारा पुनःप्राप्ति की कोशिश की गई।

पच्चास एस. ऑफिश्नेरम कृन्तकों की एस.एस.आर. मारकरों का प्रयोग कर डी.एन.ए. फिंगरप्रिंटिंग की गई। प्राइमरों से 73 परिवर्धित टुकड़ों को उत्पादित किया गया। कृन्तकों के बीच समानता गुणांक को 65 से 100 : तक पाया गया। आइ.जे. 76–314 और आइ.जे. 76–474 के एक समान पैटर्न थे, जिनके बीच इन प्राइमरों द्वारा भेदभाव न किया जा सका। इसी प्रकार फिजी 15 और फिजी 20 की जोड़ी और तामारिन पुनर्योग और तन्ना के बीच अन्तर न किया जा सका।

विल्ट, स्टॉक गलन और गन्ना बीज टुकड़ा गलन के विरुद्ध सर्वोत्तम प्रदर्शन करने वाले ट्राइकोडर्मा विलगनों का बड़ी मात्रा में बहुगुणन करने के लिये तरल गुड़–ईस्ट मीडियम और आलु डैक्सट्रोस ब्रोथ और टेल्क आधारित संरूपण बनाये गये। तीन कल्चरों (बी.सी. 36, पी.एफ. 4 और पी.एफ. 60) ने पौधों में बेहतर वृद्धि दर्शाई।

पायरिल्ला (पी. परपुसिल्ला) और इसके प्राकृतिक शत्रुओं की मौसमी गतिशीलता का अध्ययन किया गया तो पायरिल्ला के निम्फों और प्रौढ़ों की जनसंख्या के शिखर को अक्तूबर–नवम्बर में देखा गया। अंड परजीवी, पेराक्राइसोचेरिस जावेंसिस, की गतिशीलता फसल के सारे मौसम के दौरान देखी गई, जिसकी परजीवीकरण की औसत जनसंख्या 71.38% थी। जैवनियन्त्रक इ. मेलानोल्यूका, जिसे संस्थान के करनाल केन्द्र से व्यवहार में लाया गया था, ने कन्नूर केन्द्र में अपने आपको सफलतापूर्वक स्थापित कर लिया। की.रो.सू., मेटारहाइज़िअम जाति को खेत में सबसे अधिक पाया गया, जिसे आणविक स्तर पर लक्षणवर्णित (जेन्बैंक अभिप्राप्ति संख्या : ओ.के. 176688) कर मेटारहाइज़िअम फलेवोविरिडे गामस एण्ड रोज़ीपल के रूप में पहचाना गया, और इसे भारत में पहली बार पायरिल्ला जनसंख्या में रोगजनक्ता करते पाया गया है। कीटरोगजनक कवक का संवर्धी उपयोग पायरिल्ला के नियन्त्रण के लिये तीन दिशा, नामशः पत्तों की स्तह पर बीजाणुओं के लटकाव के स्परे और कवकग्रस्त प्रौढ़ शवों के वितरण, बीजाणुओं से भरे/दूषित प्रौढ़ों के निगर्मन, से किया गया। एम. फलेवोविरिडे का आलु डैक्सट्रोस ब्रोथ मीडिया पर प्रयोगशाला के हालातों में बहुत बड़े स्तर पर बहुगुणन सफलतापूर्वक किया गया, और इसके टैल्क आधारित संरूपण को भी तैयार कर लिया गया है।

ऑरगेनिक विशुद्धिकारक द्वारा शक्कर उत्पादन प्रक्रिया को विधिमान्य कर प्रौद्योगिकी के व्यावसायिकरण के लिये लाइसेंस दे दिया गया है। ताज़े रस को ठंड द्वारा भण्डारित करने की विधी को मानकीकृत कर इसकी चुस्की लगाकर पीने वाली 50 मिलिलिटर की पैकिंग बनाई गई है। इस विधी में इसके रंग, ताज़गी और गुणवत्ता को ध्यान में रखा गया है।

भा.कृ.अनु.प. – गन्ना प्रजनन संस्थान, अनुसंधान केन्द्र, अगली

वर्ष 2021 में 1,390 जर्मप्लास्म अभिप्राप्तियों में से 907, 62.25%, में पुष्पण देखा गया, जो 2020 के 46.01% से करीब 20% अधिक था। राष्ट्रीय सुदूर संकरण सुविधा, अगली में अनुरक्षित किये जा रहे 230 एस. ऑफिश्नेरम में से 76 कृन्तकों में पुष्पण देखा गया जो पिछले साल से 5% अधिक था। परागीकरण की शुरूआत 30 अगस्त 2021 से हुई और जिसका अन्त 30 नवम्बर 2021 को देखा गया। एस. ऑफिश्नेरम, नामशः 57 एन. जी. 174, मोंगेट गायम, नाज़, ओटाहेयटी, एल.एफ. 89–2064, सुफान–50 वाइट ट्रान्सपेरंट और शूगर डॉक्टर को अगस्त 2021 के आखिरी सप्ताह में जल्द पुष्पण करते देखा गया। कुल 220 क्रॉसेस 2021 के पुष्पण मौसम के दौरान अ.भा.स.अनु.प. (गन्ना) के भाग लेने वाले केन्द्रों और संस्थान द्वारा बनाये गये।

कुल 233 संदर्भ प्रजातियों को कोयम्बत्तूर व अगली के खेतों में रोग रहित वातावरण में अनुरक्षित किया जा रहा है। तीन नई प्रजातियों, नामशः को. 09004, को. 11015 और को. 10026 का डी.यू.एस. परीक्षण 2020–21 के फसल मौसम के दौरान अगली में किया गया, और इन तीनों को संदर्भ प्रजातियों से भिन्न पाया गया।

4. EXECUTIVE SUMMARY

Division of Crop Improvement

Co 14012 (Avani), a new variety, developed from and improved over the ruling tropical variety Co 86032 was identified for release in Peninsular zone. This variety has a clear improvement in sucrose content and has moderate resistance to red rot disease over Co 86032. Multilocation testing in Tamil Nadu showed the superiority of Co 18009 for release in Tamil Nadu. Among the genetic stocks registered with ICAR NBPGR during the period, Co 13003 (INGR 21068) was identified for its high fibre content combined with high sucrose content from the AICRP trials. Out of eleven 'Co' canes of 2021 series, eight 'Co' canes namely Co 21002, Co 21003, Co 21004, Co 21005, Co 21006, Co 21007, Co 21009 and Co 20010 were selected for testing in the AICRP trials of Peninsular zone. It was noteworthy that a few climate resilient parental clones figured in the parentage of the new Co canes.

Flowering intensity, observed to a tune of 68% in the Arrowing plot, facilitated in making 251 biparental crosses involving tropical and subtropical parents, interspecific and intergeneric hybrids and cytoplasmic diverse lines to facilitate more diverse populations to effect selection. From the crosses effected during 2020 season, 287 different populations adding to 19248 seedlings, were established in the field for screening. From the ratooned nursery of about 18000 seedlings, selection of desirable types were made and advanced to the first clonal trial and in the process, crosses with high selection intensity were identified for commercial breeding program. Trials in different stages of selection progressed and elite selections and successful combinations were identified. As sugarcane is emerging as a prominent energy crop, emphasis was made to select entries with early high sucrose accumulation and could identify eight clones with juice sucrose above 18.0% at 240 days and 26 clones above 20.0% at 300 days. A high proportion of red rot resistant clones were identified, indicating genetic improvement for red rot resistance through breeding. A total of 162 clones with good field stand, yield and quality parameters and red rot resistance were promoted to PZVT for further evaluation.

Fourteen 'Co' canes of 2020 (Co 20001-Co 20014) series developed at Coimbatore were botanically described based on DUS guidelines. The molecular fingerprints of the recently developed Co canes were also done. The molecular fingerprints of probable varieties for release *viz.,* Co 14012 and Co 15027 were also developed. Molecular analysis of 38 elite Co canes for population structure showed three sub populations and crossing of the second subpopulation individuals with the members of the other two clusters was suggested to ensure genetic variation and transgressive segregants.

In a trial for identifying short duration clones, one clone viz. RK2020-12 was better than the released short duration clone for sucrose content at 240 days (18.99%) and 300 days (21.09%). Adaptive trials were conducted at different southern states to facilitate identification of location specific varieties. Accordingly, two clones Co 17004 and Co 18009 were selected from KCP Sugars Ltd. Vuyyuru, Andhra Pradesh and were accepted for inclusion in the AICRP (sugarcane) of east coast zone. At S. Nijalingappa Sugar Institute (SNSI), Belagavi, 28 selected clones were under evaluation for identifying site specific varieties for North Karnataka. Breeding special varieties for high biomass and total sugars for cogeneration, ethanol and forage production was given importance for product diversification and SBIEC 14006 was registered as genetic stock (INGR 20112) with ICAR-NBPGR, New Delhi for high harvestable biomass. Nutritional evaluation, improvement and utilization of newer feed resources developed from *Saccharum* complex for livestock were under evaluation at ICAR-IGFRI, Jhansi.

All trials under AICRP of Peninsular zone were carried out at Coimbatore. In IVT, Co 17004 and Co 17001 for CCS yield and cane yield and Co 17003 for sucrose content were the best performers. In AVT I Plant crop Co 11015, Co 15017 and Co 15021 were the best, while in AVT-II Plant crop trial, Co 14027 combined both cane yield and quality. Three entries *viz.,* Co 14027, Co 14002 and MS 14082 were superior in ratoon

for cane yield. In the pooled analysis of two plant and one ratoon crops, MS 14082, Co 14027, Co 14016 and Co 14002 were superior for CCS yield compared to the best standard CoC 671. Co 14012 and Co 14002 were rated as tolerant to drought, while Co 14027 and Co 14032 were rated as moderately tolerant. Forty nine climate resilient clones comprising 18 water logging tolerant and eight drought tolerant clones, 20 ISH and three IGH genetic stocks were multiplied and supplied to the participating centres of AICRP(S) for screening in the natural stress prone regions. In Adaptive Research Trials conducted in different agro-climatic regions of Tamil Nadu in collaboration with TNAU, Co 14016 was superior to the best standard for yield. Among six test entries in Multi-location Trials four clones *viz.,* Co 14004, Co 14012, C 14516 and G 10045 were advanced to Adaptive Research Trial 2021-22.

Testing of 17 entries under Sweet Bloom project was completed during the year and Co 12009, Co 14027, Co 14002 and Co 18009 were found to be better than Co 86032 for cane yield and sugar yield at harvest, while Co 14027 and Co 17003 were grouped as high-quality clones. SISMA TN committee meeting recommended Co 14002, Co 14027 and Co 18009 for release in Tamil Nadu for the benefit of sugar factories and farming community. At six Cooperative sugar factories of Tamil Nadu, 21 entries were tested, of which Co 12009, Co 15018, Co 16018, Co 11015, Co 17012 and Co 18009 recorded more than 10 t/ha higher cane yield than Co 86032.

Standardization of accelerated flowering in sugarcane for speed breeding is an activity of important applications to commercial breeding programs and a pilot study was initiated to standardize light duration and intensity. Marker-assisted selection in sugarcane for drought tolerance and red rot resistance was also initiated and in the first year 51 drought specific markers were amplified in a panel of 52 resistant and susceptible genotypes and 28 were polymorphic, and more work is in progress.

Enhancement of sugarcane germplasm and development of pre-breeding material has always been a focus at the Institute. This year the long term project yielded encouraging results to develop climate smart varieties. An exploration conducted during October/November in the states of Tamil Nadu, Andhra Pradesh and Karnataka could collect 52 new germplasm including 49 *S. spontaneum* and three *E. arundinaceus* clones. The wild germplasm garden at Coimbatore maintained 2260 accessions of which majority were *S. spontaneum* (1709 Nos.), followed by *Erianthus arundinaceous* (230 Nos.), while 47 collections from Arunachal Pradesh were maintained at IARI Regional Station, Wellington. 'Co' cane maintenance plot with 2007 clones served desired parents in planned crossing programmes. National active germplasm bank maintained 271 notified and registered genetic stocks and 18 clones from the institute and other research stations were assigned index number.

Characterization of germplasm for yield related traits, flowering behavoiur, cytological and anatomical traits continued. Somatic chromosome number (2n) determined in 64 accessions of *S. spontaneum* collections from the western Ghats revealed different cytotypes like 2n= 48, 60, 62, 64, 68, 70, 72 and 78. Western Ghats collections were mainly of 2n=64, 72 and 80 cytotypes. *Erianthus arundinaceus* clones with 2n=30 cytotype were analysed with DELTA software. At the research centre at Agali, 1390 clones were maintained, which also included the core germplasm collections for use in genetic improvement by the scientists of National agricultural system. An unusually higher flowering intensity was noticed when 65.25% accessions flowered which was higher than that (46.01%) of the previous year (2020) and breeders were benefitted with the utilization of several hitherto nonflowering clones in crossing program, and 220 crosses were made.

Evaluation of sugarcane germplasm for biotic and abiotic stresses at Coimbatore was continued and among 170 wild *S. spontaneum* clones, three accessions *viz.,* Mondaley, IND 03-1318 and IND 03-1292 recorded < 20% reduction in biomass and high chlorophyll and carotenoid contents under drought condition. Among 96 *Erianthus arundinaceus* accessions 14 clones were found to be highly drought tolerant. Stem epidermal pattern of the drought and water logging resistant genetic stock 04-1687 showed male and

female specific anatomical modifications. These accessions will be used in trait enhancement program.

Development of Multiparent Advanced Generation Inter-Cross (MAGIC) population for drought tolerance in sugarcane has entered the last year of the trial and 8-way crosses were under evaluation in two locations. The two, 2-way intercross hybrids TWC 45 and TWC 23 were identified as Co canes *viz.* Co 21003 and Co 21007 respectively, of which Co 21003 recorded the highest cane yield in the trial with 152.66 t/ha compared to 110.75 t/ha in the standard Co 86032. Molecular cytogenetic characterization of 2-way hybrids showed 3-7 *Erianthus* chromosomes. PCR with 5s rDNA loci supported the GISH result and identified the *Erianthus* introgressed hybrids in five successive generations. Among the hybrids involving *E. procerus,* 15 BC_2 hybrids were identified to have a 370 bp fragment specific to the wild genus. Having established GISH analysis in monitoring chromosome transmission in intergeneric hybridization, its potential application to understand the genomic constitution of *Saccharum* hybrids using an intergeneric hybrid between *E. procerus* and *Saccharum* and its back cross hybrids using classical and Molecular cytogenetics.

A second generation hybrid CYM 08-922, a registered genetic stock, yielded progenies with significantly higher valuves for cane yield traits under drought and has become a preferred prebred material for climate resilience breeding. Another genetic stock GU 07-2276 (INGR21067; IC636676) was registered as genetic stock with NBPGR, New Delhi for its high cane yield (89.66 t/ha) and the lowest reduction for single cane weight under drought. A large number of interspecific hybrids already characterized for sugar yield parameters were under screening for stresses. Significant differences were observed for SPAD, relative water content and canopy temperature depression and selections were employed for drought and red rot. Among the novel hybrids involving *S. officinarum,* the crosses involving Uba white, Laukona, Manjuria, 28 NG 210, Baragua, Chapina, Oramboo and 51 NG 159 were better. Two new research areas involving targeted pre-breeding using different cytotypes of *S. spontaneum* characterized for abiotic stress tolerance being used as female parents and evaluation of multiratooning potential of selected interspecific and intergeneric hybrids of *Saccharum* spp. were started to strengthen climate resilience breeding. Studies on long term germplasm conservation (cryopreservation) commenced with the standardization of suitable media composition for regeneration in *S. spontaneum* and allied genera.

Transcriptome guided mining and validation of genes, miRNAs and their potential targets for water deficit stress continued. Differentially expressed novel miRNAs were identified, which included five novel miRNA in the drought-susceptible variety Co 8021 and nine in the tolerant variety Co 06022. The novel target genes mainly encoded drought-stress related genes involved in plant defense mechanisms. Network analysis of drought responsive miRNA in drought tolerant variety showed 144 conserved miRNAs belonging to 32 families encoding 28 genes for stress tolerance.

An analysis of transcript diversity and identification of isoforms / transcript variants of sucrose regulating genes in sugarcane revealed SWEETs to be highly differentially expressed and quantitative real time PCR analyses of high and low sugared clones revealed differential expression to prove that SWEETs played a regulatory role in sucrose accumulation during maturity. Full-length sequences of SWEET1, SWEET2a, SWEET3a and SWEET14 with over tenfold increase in expression in high sugar genotypes were obtained. The S-type anion channel gene (SLAC) associated with high water use efficiency retrieved from sugarcane monoploid genome database had 54% homology with the sugarcane variety CoM 0265. Suppression subtractive hybridization of *Saccharum spontaneum* exposed to salinity stress (8ds/m) revealed key genes and pathways activated during saline stress in *S. spontaneum.* The largest functional pathway identified was the starch and sucrose metabolism pathway. Deep sequencing of suppression subtractive libraries for prospecting differentially expressed genes/ transcription factors from the sugarcane hybrids exposed to drought and salinity stress was initiated. In order to under-

stand the molecular mechanism regulating tillering in sugarcane through functional genomics approach, expression profiles of strigolactone branching inhibitor gene (MAX) was studied and found significant variation between high tillering and low tillering genotypes, branching inhibitors were less expressed in high tillering genotypes.

Under genomic selection for important traits in sugarcane, and comparison of elite Indian and Australian germplasm, genomic prediction models BayesA, BayesB, BL, GBLUP, RKHS Single models showed significant SNPs for the sucrose and red rot trait, of which the RKHS Single & RKHS- averaging were more promising for sucrose, while Bayes A and Bayes B were better in prediction of red rot resistance.

For the first time in India, whole genome transcriptome of drought responsive genes generated both for root and leaf tissues with *Erianthus arundinaceus* and commercial sugarcane variety Co 86032. Many unigenes with specific functions and transcriptional factors responsive under water deficit stress conditions were identified. Important drought responsive genes *viz. EaALDH, EaEXPA1, EaGly I, EaGly II, EaGly III* and deeper rooting 1 *(DRO1)* genes, transcriptional factor *EaNFYB* were cloned and obtained full length sequence. More than 110 transgenic events with different abiotic stress tolerance genes *EaEXPA1, EaGLY III, EaNF-YB2, ALDH* and *DREB* genes were generated.

Validation of vacuolar targeting technology developed by ICAR-SBI for commercial recombinant protein production in sugarcane progressed with three genes *viz.*, Glucocerebrosidase *(GCS),* Insulin and Interferon *(Ifn2A).* The sequences were retrieved from GenBank, codon optimized and synthesised by TRANA Lab for better expression in sugarcane. Co 86032 was used for transformation and out of 89 events, 56 were positive and were advanced for further analysis. A novel laccase producing thermotolerant organism was identified and optimized culture conditions for effective delignification. Response surface methodology using Box-Behnken design was used to determine the optimum concentration of the selected variables and maximum enzyme production of 450U/µl was obtained after 120 hours of incubation, at 46 ^{0}C and pH 6.0.

Under NASF project, development of white grub *(Holotrichia serrata)* resistance in sugarcane was initiated by deploying novel cry toxin holotype genes. Whole genome sequencing of *Bacillus thuringiensis* isolate Bt 62 genome revealed the presence of two *cry* genes *viz. cry8Sa1* and *cry-8Ib.* Individual toxicity of the *Cry8Sa1* and *Cry-8Ib* and bioassay results indicated that *Cry8Sa1* toxin exhibited significantly higher mortality.

A new promoter isolated from *Erianthus* (EriPht) showing constitutive expression was subjected to deletion studies to develop tissue specific promoter. Three deletion constructs D2, D3 and D5 after transient GUS expression confirmation were mobilised through Agrobacterium mediated transformation and seeds from T_1 were harvested from putative transgenic plants to get T_2 seedlings for further expression analysis.

Sugarcane is challenging to genome editing due to polyploid genome. *Erianthus arundinaceus* cytotypes SES 153 (2n = 30) and SES 133 (2n = 60) and *Saccharum* commercial hybrid Co 86032 (2n=112) were used to target *Phytoene Desaturase* (PDS) gene to validate the genome editing through CRISPR/Cas9 mediated gene editing. Another gene, a eukaryotic translation initiation factor eIF4G isolated from a commercial sugarcane variety was also employed to study the functional interaction with the virus so as to use this strategy for controlling virus infections in sugarcane. Altering the flowering behavior of sugarcane progressed with the cloning the guide RNA to target the flowering gene.

Work on developing homozygous parental lines has been progressing through different approaches. Through repeated selfing, a large number of selfs up to eighth generations were developed. More homozygous and desirable selfs were screened in through molecular profiling and morphological screening and assessing yield, quality and disease resistance. Two relatively homozygous selfs of 6th generation were utilized in crossing with 1148-13-11-2-237-2-61 and selfed to raise two each of selfed and hybrid cross populations. Considerable improvement was observed in the hybrid populations compared to inbred populations for all the traits recorded except HR Brix. The lower CV values

for all traits in the hybrid populations compared to inbred populations indicated the homogeneity of hybrid populations and strengthened the concept to explore the possibility of using true seed as the propagule in sugarcane, which if realized would be a very significant achievement for improving productivity and to substantially reduce the cost of cultivation. Among the different biparental combinations involving inbreds the least morphological variability was observed in the combination 775-102 x ms68/47-27 (S1 x S1). Anther derived plants grown in the field needed further confirmation on their origin and ploidy levels. Five CENH3 mutant clones of Co 775 were used in crossing and the seedlings obtained would be checked for en bloc chromosome elimination. Similarly, four pools of *Erianthus* mutants were subjected for CENH3 amplification. Multiple bands in the amplification of the CENH3 region indicated probable mutants for further confirmation. Fungicide treated true seeds stored up to 11 months did not show any phytotoxic effect on germination.

Under fluff supply programme the institute took the responsibility of effecting crosses on account of Covid 19 situation during 2020 season and fluff from 401 bi-parental crosses, 342 general collections and 10 poly-crosses and fluff weighing 17.27 kg of crosses made at Coimbatore was supplied to the 21 centers. Apart, 25 bi-parental crosses were made in National Distant Hybridization facility at SBI Research Centre, Agali and 775.1g of fluff was supplied. Altogether 18.04 kg of fluff was sent to the 21 centers. During 2021-22, breeders of seven centres participated in hybridization and totally 424 bi-parental crosses were effected for the 24 centres.

DUS testing was pursued in accordance to the technical programme at the three testing centres of the Institute. The farmer's varieties Jeet Katari and Sugam Katari were distinct from the respective reference varieties but resembled each other.

Under ICAR Seed project, a total of 1335.71 tonnes of breeder seed of two varieties Co 86032 and Co 11015 was produced and supplied to the sugar factories of the TN state based on the indents received. Tissue culture plants numbering 1,13,555 were supplied to sugar factories and selected farmers and for breeder seed production. Based on demand, 42 mother culture flasks were supplied to various sugar factories.

Division of Crop Production

Bud chips and single buds of seven varieties of 12 months old sugarcane were treated with bioinoculants *viz., Frateuria aurantia* (FA), *Gluconoacetobacter diazotrophics* (GD-01), *Gluconoacetobacter xylinus* (GX-01), Pink Pigmented Facultative Methylobacteriam (PPFM-03), Beijerinckia (BE-03), *Azospirillum braziliense* (AB-01), and Control in sett treatment devise at 150 mm/Hg for 15 minutes. Among the bioinaculants, Beijerinckia has recorded higher germination per cent in bud chips (58 %) and single bud setts (80 %) at 30 days. Settling vigor is also high in Beijerinckia treated bud chips and single bud setts both on a fresh and dry weight basis. Treatment with bioinoculants *Beijernckia* at 0.5 ppm before planting improves the germination and vigor of sugarcane transplants.

Herbicide molecules like topramezone, tembotrione, halosulfuron methyl and ametryne were evaluated for their phytotoxic effect on sugarcane varieties Co 86032 and Co 0212. Among the varieties, Co 86032 showed no visual injury and was found tolerant to all the herbicides tested. Application of ametryne in combination with 2, 4-D also caused leaf scorching in the initial stage and significant yield reduction in Co 0212, indicating its susceptibility to ametryne.

Agronomic performance of 9 elite sugarcane genotypes Co 14002, Co 14004, Co 14012, Co 14016, Co 14027, Co 14030, Co 14032, Co 86032, and CoC 671 with two fertilizer levels (100% RDF and 125 % RDF) in wide row spacing was evaluated. Among the elite genotypes, Co 14016 (122.56 t ha^{-1}) and Co 14012 (117.98 t ha^{-1}) recorded significantly higher cane yield. Co 14012 was found promising in terms of higher CCS yield (18.26 t ha^{-1}) than the check entries CoC 671 (12.28 t ha^{-1}) and Co 86032 (14.46 t ha^{-1}). But the fertilizer levels did not significantly influence the cane yield and juice quality.

The sugarcane-based farming system model was established with livestock components like 2 milch cows + 4 calves (2 heifer and 2 bull calf), 22 Goats (12 female + 10 kids), duck-15 and a

composite of fishes (surface feeder-Catla, column feeder-Rohue, and bottom feeder- Mrigal) in the fish pond of 300 m^3 size.

Participatory on-farm research trials on sugarcane + blackgram intercropping system under National Food Security Mission (NFSM) project was carried out in 40 hectares of farmers' fields. Results found that sugarcane-based intercropping systems yielded significantly more cane yield (134.73 t ha^{-1}) than sugarcane alone (122.30 t ha^{-1}). The production efficiency of 369.13 kg cane per day, gross returns (353000.87 Rs ha^{-1}), net returns (146673.87 Rs ha^{-1}), and B:C ratio (1.71) also was higher than mono sugarcane cropping. Hence, intercropping black gram in sugarcane is viable for ensuring food security in tropical Indian conditions.

Licensed ICAR-SBI technologies *viz.,* Soil moisture indicator technology to five firms, EPN Biopesticide formulation to three firms, Cane jam technology to two firms, Liquid jaggery production to six firms, and Quatro sugarcane single bud cutter machine, Sugarcane de-trashing tool, Sugarcane dietary fibre food Products, ICAR-SBI-CIAE Sett treatment device, ICAR-CIAE-SBI sugarcane rind removing equipment, ICAR-CIAE-SBI Motorised double headed sugarcane single bud cutting machine and ICAR-IISR-SBI Deep furrow sugarcane cutter planter each to one firm. Totally Rs. 38,25,398 has been realized through licensing and commercialization of ICAR-SBI technologies.

Mini tractor operated EPN (Entomopathogenic nematode) applicator in collaboration with ICAR- CIAE, Regional Centre, Coimbatore has been developed. The applicator consisted of a 150 litre capacity tank with an agitator and two flexible tube outlets. The field capacity of the EPN applicator is 0.18 ha h^{-1} at the operating speed of 1 km h^{-1}. The cost of operation of the applicator is 2550 ha^{-1}.

The ratoon management operations *viz.,* stubble shaving and off-baring with IISR model disc type ratoon management device were evaluated against manual ratoon management operations in a wide row spaced crop of Co 86032 and found on par in yield. A mini tractor operated sugarcane harvester model has been developed and tested in ICAR-SBI and TNAU.

Chlorophyll SPAD index reduced by 5.8 and 11.4% (I1 & I2 respectively) in restricted irrigation treatments during formative phase and Co 15007, Co 15018, Co 12009 and Co 13014 had higher SPAD index for both the treatments (I1&I2). IWUE and WP improved in both the restricted irrigation treatments for Co hybrids. I2 was more detrimental for species clones.

SPAD chlorophyll index ranged from 11.2 (Lalri) to 41.37 (2019-75) among the genotypes with the mean of 29.95. Chlorophyll Fluorescence ranged from 0.584 (Fiji 55) to 0.774 (Co 17013) with a mean of 0.714, indicating more number of genotypes with high range of photochemical efficiency at early growth stage. Physiological traits *viz.,* SPAD index, total chlorophyll content, canopy temperature were positively correlated with cane yield, and canopy temperature had significant association with only CCS (t/ha) at early growth stage. However, all these traits had significant association with cane yield as well as CCS (t/ha) at grand growth phase.

Metabolic traits *viz.,* total chlorophyll content, NRase activity, soluble protein, total soluble sugars, sucrose synthesis and accumulating enzymes were high in tropical varieties than sub-tropical varieties. Soluble protein content was high in tropical varieties (55.38 mg g^{-1}) than the sub-tropical varieties (47.08 mg g^{-1}). The tropical groups are photosynthetically efficient for biomass production.

Narrow spaced sugarcane clones had better biomass accumulation and RUE in all growth stages than the wider row spaced sugarcane. Among the clones, Co 86032 and Co 99004 had more SPAD (>30) and chlorophyll content compared to other clones in all the row spacing. The sugarcane clones Fiji 55, Khakkai, ISH 107, ISH 111, Pathri showed better biomass production even under severe water deficit condition.

Low N stress significantly reduced total aboveground biomass (TBM) by 46%, while low P and low K caused 61% and 29% reduction in TBM, respectively as compared to control. Low P stress resulted in more than 50% reduction in TBM in all the tested varieties. Among the vari-

eties tested Co 10026 at low N, while Co 09004 was efficient in biomass production at low P and low K.

The sugarcane clones Co 8021, Co 10026 and Co 86032 were grown under hydroponic and subjected to dehydration and waterlogging stress. There was a significant increase in proline, phenolics, malonaldehyde, superoxide dismutase, peroxidase activity

Selected sugarcane germplasm clones were evaluated under drought and waterlogging stress at formative phase. Pansahi and Oshima recorded significantly higher RSA under drought as well as waterlogging stress. The clones IND 85-490, Putli Khajee and IK 76-166 recorded higher SCW values under drought, whereas Djantoer-1 recorded higher SCW under waterlogging stress.

In Ratoon III, the number of tillers, cane diameter, number of millable canes (NMC), cane yield and CCS yield did not differ significantly (p=0.05) due to intercropping residual effect. However it was significant in cane height, number of internode and single cane weight. The residual effect of intercropping was not significant for the juice quality, and the mean Brix, sucrose, purity and CCS. Soil organic carbon (SOC) was significantly higher in ridges (1.08%) than the furrows (0.91%). Two sugarcane genotypes *viz.*, Co 14027 and Co 11015 were evaluated under intercropping with black gram and coriander. The mean yield of leafy coriander was 2658 kg ha^{-1}, and black gram was 952 kg ha^{-1}.

In the study to standardize nutrient management package for sugarcane under calcareous soil the treatment, with 350:62.5:90 kg/ha $N:P_2O_5:K_2O$ + basal FYM @ 5 t/ha; entire P as basal, N and K in three splits) along with symptomatic foliar spray (5 sprays) of Urea, $FeSO_4$ and $ZnSO_4$ till 120 DAP recorded higher cane yield (147.77 t/ha) than other treatments. The differential flowering behaviour under nutrient treatments were recorded. The flowering intensity in absolute control (10.14%) was at par with the FYM only treatment (6.82%) and significantly higher than other treatments. The potassium content in trash of flowered cane (0.65%) was significantly lower than that of nonflowering cane (0.94%).

The TDD for flowering estimated using the date of ratoon initiation and flowering date of the clones flowered in the arrowing plot (Ratoon) during the flowering season in 2021 using the base temperature worked out in previous years (2019 and 2020). A total of 35 clones flowered in 2021. The base temperature ranged between 7 and 23 ^{0}C. The TDD for flowering ranged between 1065.5 and 5566 among the flowered clones. The TDD required for flowering in ratoon crop was compared with that of plant crop flowering in the previous seasons which showed that ratoon crop required lesser TDD (200-300) than the plant crop flowering. In the National Hybridization Garden (plant crop), out of flowered clones in 2021, 65 clones had base temperature worked out in previous years (2019 and 2020). TDD and base temperature for the season 2021 was estimated for these 65 clones which ranged between 786 and 7576 TDD and 3 and 24 ^{0}C, respectively. TDD required for flowering in the plant crop in 2021 was lower (200-300 TDD) than that of the previous two years. Hence, detailed investigation is required to elucidate the flowering behaviour in sugarcane.

200 liters of liquid jaggery was produced from about 1000 litres of sugarcane juice. Further improvement in the facility for the production was done with additional procurement of evaporating pans. Final certificate for the product was obtained on 18.09.2021 with the validity up to 17.09.2022. Gypsum and elemental sulphur were evaluated for soil calcareousness amendments in three sugarcane varieties Co 06022, Co 09004 and Co 86032. Number of tillers at 90 DAP and SPAD values at 120 DAP were not significantly affected by the amendments.

Division of Crop Protection

About 3036 clones comprising clonal trials, elite hybrids, parental clones, allied genera, inbreds, genetic stocks, germplasm and waterlogging tolerant clones, ISH and IGH clones, transgenic clones, PZVT-2021 series, Indo-Australian clones etc., were screened for red rot resistance under controlled conditions against CF06 (Cf671) pathotype and ~1543 clones were identified as R/MR to red rot. About 107 parental clones from NHG were evaluated against CF12 pathotype of

C. falcatum and 51 of them were identified as R/MR. About 103 parental clones were evaluated against sugarcane smut, wherein, 53 clones were identified as R and MR. Field tolerance to red rot in sugarcane varieties revealed that the new isolates exhibit a higher virulence than the designated pathotypes CF06 and CF12.

Pathogenic variation and gain of virulence in the new *C. falcatum* isolates from the tropical region on 29 sugarcane varieties varying in their disease reactions revealed that the isolates isolated from the cvs. Co 11015 and CoM 0265 during the season maintained a higher virulence over the other isolates. The Cf11015 isolates invariably caused susceptible reactions on the new varieties and the cvs. Co 86032 and CoV 09356 also exhibited reactions to a range of S to MS to these isolates.

Nano formulations of SAR inducer molecules *viz.,* Benzothiadiazole (BTH) and Salicylic acid (SA) were tested for their efficacy against red rot, smut and wilt diseases of sugarcane and the results reiterated that slow release of BTH from chitosan coated BTH nano formulation consistently induced host resistance and effectively protected the crop till harvest under pot culture conditions. A reduction of smut incidence to a tune of 62.5% to 90.0% in BTH nano formulation applied plants was recorded. Least incidences of red rot when applied with BTH nano formulation over control was recorded in the two test varieties *viz.,* CoC 671 and Co 11015.

Sett treatment with the combination of thiophanate methyl and *Paenibacillus alvei* at 50% concentration in the mechanized device was found to be significantly superior over other treatments. Further, mechanized sett treatment with both the biocontrol agents and fungicide individually or in combination were found to be not deleterious and were effective in reducing the disease incidence, improving plant growth and yield attributes. An improvised Sett treatment devise was fabricated with a provision of hot water treatment (HWT), with agitation and suitable sensors to ensure uniform treatment to manage SCGS phytoplasma, besides fungal diseases. Results indicated that the inactivation of the phytoplasma by the heat treatment was transient and the technology development process is continued to focus on the physical elimination of the target pathogens.

Standard operating protocol (SOP) was developed for the biogenesis of nanomaterials from effective *Trichoderma* spp. for the management of red rot disease in sugarcane.

Sett treatment of different varieties with STD-HWT at 52 and 54 ^{0}C individually or in combination with nutrients revealed that higher temperature 54 ^{0}C along with nutrients significantly improved germination, number of millable canes and the yield. Under field conditions also, significant reduction in GSD incidence (>80%) could be observed with increase in temperature level at 54 ^{0}C by vacuum- based treatment in STD-HWT unit.

Comparative analysis of the transcriptome data for virulence genes revealed the roles of carbohydrate-active enzymes (CAZymes - GH16, GH128, GH30, and GH45), transcriptional regulators, and membrane transporters, illuminating the transcriptional events occurring during the dimorphic transition of *S. scitamineum.* Whole transcriptome analysis of *S. scitamineum* isolates during its interaction with sugarcane revealed down-regulation of majority of genes at earlier infection stages in both high and low virulent isolates, presumably representing the host defense or invasion strategy against the fungus. Results highlighted the transcriptome alterations of *S. scitamineum* during its dynamic interaction with sugarcane.

Comparative proteomic analysis of apoplastic proteins of healthy and infected meristematic tissues (during compatible interaction) using iTRAQ labelled LC-MS/MS method resulted in identification of 1453 and 1601 peptides that accounted for 56 and 67 proteins, respectively. The expression of few significant and differentially expressed protein candidates were transcriptionally validated at different developmental stages of compatible and incompatible interactions.

In order to examine the defense inducibility of the candidate genes *viz.* Cf-EPL1 and Cf-PDIP1 in agroinfiltrated leaves of tobacco, expression of defense related genes was monitored through qPCR. Transcriptome analysis clearly depict-

ed the defense induction ability of these two proteins with the upregulation of SAR marker genes. Cf-EPL1 and Cf-PDIP1 mutants were developed by protoplast mediated transformation of *C. falcatum* 671 to delineate the functional role of these potential PAMPs/Effectors.

Studies conducted on simulation of wilt and pokkah boeng development from infected seed canes of 11 varieties under field conditions revealed that soil inoculum of *Fusarium sacchari* multiplied on sorghum grains and chopped canes of wilt affected canes caused a reduction in bud sprouting and crop stand in the plots.

The presence of rust resistant gene *Bru1* in our sugarcane parental clones was indicated by presence of an amplification by a product of 570 bp with the R12H16 marker and 200 bp with 9020-F4-PCR-Rsa1 marker. When ~ 100 parental clones from NHG tested with R12H16-PCR marker for the presence of Bru gene, about 20 clones showed presence of Bru gene. The results revealed that many clones, which are not carrying Bru gene, show resistance against rust pathogen indicating the availability of alternate rust resistant genes in our germplasm.

Impact of wilt on cane yield and juice quality parameters studied with five varieties Co 775, Co 7201, Co 87252, Co 2000-10 and Co 05010 revealed that wilt affected canes exhibit significant reductions in the range of 24 to 50% in cane height and respective losses for the parameters cane weight, juice volume and sucrose% were 16.1 to 57.5%, 17 to 66.6% and 5.1 to 33.6% respectively. Further, total wilted canes recorded drastic reductions in juice quality parameters including Brix, sucrose%, purity% and CCS % probably due to systemic damages to the tissues. The results further revealed that those plants, which suffer from nutrient deficiencies especially micronutrients, quickly succumb to wilt.

Yellow leaf severity on various germplasm and parental lines maintained at Coimbatore and Agali centre showed that most of the species clone entries *viz., S. officinarum, S. barberi, S. sinense,* and *S. robustum* were apparently free from yellow leaf. However, YL incidence was recorded to a tune of 24.36% in the parental clones at NHG. Detailed impact analyses of YLD on sugarcane (Co 86032) indicated that YLD-free crop maintained a healthy crop stand a better crop growth with moderate flowering, whereas the diseased plot had a poor crop stand of pale canopy with nutrient disorders. Estimation of yield parameters revealed that the healthy plots maintained significantly better values for cane height, cane diameter, cane weight and juice volume than the diseased plots.

Nested PCR assays with SCGS samples expressing various phenotypic symptoms using the universal P1/P7 primers revealed that more than 85% of the samples had shown the expected amplification of 1.8kb. qPCR diagnostic primers were standardized through gradient PCR assay from the CoC 671 samples.

The yeast expression vector *Pichia pastoris (pPICZ aB)* was used in order to maximize ScYLV coat protein gene expression, in which the recombinant proteins were expressed as fusions to a C-terminal peptide containing the c-myc epitope and a polyhistidine (6xHis) tag. The vector allows high-level methanol inducible expression of the gene of interest in *Pichia.* A similarity study on sugarcane viruses on its closely related host species showed highest nucleotide synteny between SCMV sequences from *Zea mays* to that of sugarcane.

SCBV-U, a novel genotype was considered as the most frequently occurring genotype in India, especially in case of isolates from *Saccharum* hybrids and interspecific hybrids, as part of the study on SCBV genetic variability. Characterization of recombination events and gene assortment within these genotypes of SCBV offers insight into the evolution of the species over the generation.

As part of the virus indexing service, about 106 tissue culture raised plants from different tissue culture production units *viz.,* M/s EID Parry, Pugalur 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 20,400/- was generated under virus indexing charges from the private tissue culture laboratories.

Yield loss assessment done at harvest indicated that repeated attacks of INB in different broods

did not result in significant loss in cane yield parameters.

The mealybug *Phenacoccus saccharifolii* was recorded in some sugarcane areas in the tillering stage, in association with Pokkah boeng, causing considerable damage. Internode borer (INB) incidence in 18 *Erianthus arundinaceus* derived intergeneric hybrids was in the range of 0-70%. Among the entries, nine genotypes were graded as least susceptible. Three clones (CYM 06-212, CYM 09-167 and CYM 07-981) were free from INB. Intensity of attack was minimum (0.39%) in CYM 09-565 and maximum (0.73%) in CYM 04-388.

Out of 22 progenies of *E. arundinaceus,* including 5 selfs, 2 BC_1 and 15 BC_2 and BC_1 progenies were free from INB attack. Incidence of the borer on BC_2 progenies ranged 0 – 80.0%, and 14, three and one progenies were graded as least susceptible, moderately susceptible and highly susceptible, respectively.

Silicon content, estimated in seven cultivated varieties and two *E. arundinaceus,* was higher in plant parts in the order of leaf > leaf sheath > midrib> rind. Silicon content was higher in selected *E. arundinaceus* clones than in cultivated varieties.

The transcripts associated with important molecular functions *viz.,* chitinase activity, chitin synthase activity, ecdysone activity, PTTH activity and voltage-gated sodium channel activity were identified in the INB transcriptome. Differential expression analysis of transcripts showed up-regulation of chitinases, juvenile hormone suppressible protein, P450 enzymes and glutathione-s-transferases in the advanced instars of INB.

Improvements made in INB culture to enhance egg production, release of males and females in small plastic boxes yielded higher fecundity than in wooden cages.

The field-release station standardized for the larval parasitoid *Cotesia flavipes* has been tested for egress of the egg parasitoid *Telenomus dignus.* Nine tests indicated 25.0-94.7% egress of parasitoids on the basis of number of parasitoids collected in a polyethylene bag covering the device.

In an augmentative field trial with *Telenomus dignus* released at 5000 parasitoids per ha over a two-week period in a 6-month old grower's farm, INB incidence and intensity showed a decline in release plots whereas they increased in control.

Among the different agro-based by-products used for mass production of *Bt*-62 strain, wheat bran and jaggery were most suitable when supplemented with yeast extract and calcium chloride. When different preservatives were added to liquid formulation of *Bt* cultured in fermentor and examined at different intervals, DMSO-0.5% added cultures produced higher bacterial output at 180 days of storage. In field trials with *Bt*-62, multiplied on standard media in fermentor, at 4.0×10^{14} CFUs/ha as soil drench near the root zone, 60% reduction in grub number was recorded. From 404 soil samples collected from Western ghats of Karnataka, Tamil Nadu (Valparai) and Kerala (Mallakapara forest), 259 from Tripura and 197 from Odissa, *31* Bt isolates were recovered. PCR screening revealed *cry*1 and *cry* 8 genes in some of the isolates.

From the *Bt* isolate SBI-KK 27, which has seven toxin genes, two novel *cry*1 genes *viz cry*1D and *cry*1E were cloned in acrystalliferous *Bt* HD73-isolate. Bioassay of this recombinant *Bt* isolate against first instar INB, fall army worm and second instar cotton pink boll worm indicated that both genes were less active than the parent isolate SBI-KK27 against INB borer and fall army worm. However, in diet incorporation method, *Cry*1D showed 90% growth and developmental retardation in pink boll worm resistant to Bollgaurd II cotton. Among four *cry*8 genes obtained from Chinese Academy of Agricultural Sciences, Beijing, China, under MTA, *cry*8Ha alone was active against first instar white grub, similar to *Bt* 62.

In field trial with *M. anisopliae* + *B. brongniartii* and/or Lesenta against white grub, the reduction of grub ranged from 69.2% *(B. brongniartii)* to 92.3% *(M. anisopliae* + *B. brongniartii* or Lesenta). *Beauveria brongniartii* and *M. anisopliae* could be recovered from the soil samples retrieved.

A new jaggery based media (ICAR-SBI liquid medium) was developed and found to be economical and suitable for production of several EPFs of sugarcane ecosystem, specifically *M. anisopliae.*

In a fermentor (assembled) system of 20 lit capacity, production of *M. anisopliae* (SBIMA-16) could be achieved with saving in time and high sporulation rates (10^8/ml) on ICAR-SBI-5% liquid medium.

The ICAR-SBI liquid media developed for other fungi was found suitable for *Aschersonia placenta* for large-scale production of the fungus.

Movement of EPN in different depth of soil and its efficacy against 2nd instar white grub was studied. All the EPNs caused mortality of the grubs at 10 cm soil depth and *S. glaseri* (SBILN1) recorded quicker mortality of the grubs. The mortality of the grubs ranged between 40%-100%. EPN movement was observed up to 25 cm depth and caused mortality of white grubs. There was no mortality of the grubs observed in 30 cm soil depth.

The formulation containing *Heterorhabditis bacteriophora* strain SBILN8 has a shelf life of ten months; *Steinernema siamkayai* strain SBITNT1 has a shelf life of 12 months and *Steinernema surkhetense* strain SBIP3 has a shelf life of 12 months.

The ICAR-SBI EPN biopesticide formulation technology has been commercialized to five companies (Coordinated by AGRINNOVATE INDIA, New Delhi) with a license fee of ₹ 10 lakhs. Seventy-eight EPN strains belonging to tropical (49) and subtropical (29) are being maintained in the culture collection and 45 symbiotic bacteria of *Photorhabdus* spp. (26 Nos.) and *Xenorhabdus* spp. (19 Nos.) are also being regularly sub cultured and stored in glycerine.

Survey was conducted in fall army worm (FAW) infested fields of maize and sugarcane from different districts of Tamil Nadu and 14 EPNs naturally occurring in maize fields were isolated. ITS sequences of 13 EPN *(Heterorhabditis and Steinernema* spp.) isolated from FAW infested fields have been submitted to GenBank with accession numbers from MZ507532-MZ507544.

Different bioassay methods were tested to standardise a suitable bioassay method for testing EPN *Steinernema siamkayai* against FAW 3rd instar larva. Leaf bit with IJ inoculation (Diet 24 h later) bio-assay method recorded 100% mortality of 3rd instar FAW larva at 48 h incubation and would be suitable bioassay method for *in vitro* evaluation of EPNs against FAW.

Dose response bioassay to evaluate the native EPN against 2nd and 3rd instar of FAW *Spodoptera frugiperda* under *in vitro* revealed 100% mortality of 2nd instar FAW in 10 IJs of *H. indica* at 36 h, 10 IJs of *S. siamkayai* at 72 h, 40 IJs of *S. glaseri* at 36 h and 40 IJs of *H. bacteriophora* at 48 h. Bio efficacy of three EPN (*H. indica, H. bacteriophora* and *S. siamkayai)* was tested against 2nd instar FAW under pot culture condition with sugarcane cv. Co 86032. It was revealed that, all EPN caused mortality of the FAW and it ranged between 40 to 50%.

Statistics and Economics

Sugar recovery which was 9% during 2013-14 has increased in correspondence with adoption of the new cane variety Co 0238 in Uttar Pradesh (UP). The sugar recovery has crossed more than 11.5% during 2019-20 due to more than 85% of the cane area being cultivated by Co 0238 in UP. The changed recovery pattern has necessitated to reclassify the states as per recovery pattern and new sugar recovery category was delineated. The study has documented historical sugar recovery pattern of different states, sugar recovery improvement, fluctuations and reductions in sugar recovery in different states and India.

Variety Co 0238 has sustained sugarcane cultivation in UP, Bihar, Haryana, Punjab and Uttarakhand despite significant reduction of cane area in the tropical states. During 2019-20, about 24.14 lakh ha out of 27.11 lakh ha in the sub-tropical India cultivated Co 0238 and it undoubtedly establishes that Co 0238 driving the sugarcane cultivation in the country with 52.4 % of the total area.

Extension

The outreach programs included 51st sugarcane research and development workshop of Tamil Nadu and Puducherry, a two-days training program for farmers, 12 one-day training programs for farmers and cane staff, 14 exposure visits for farmers, cane staff and students.

Frontline demonstration on the variety Co 11015 in farmers' field under organic cultivation gave 82.65 t/ha cane yield and 10.20 t/ha jaggery.

Survey based studies were conducted in Villu-

puram and Kallakurichi districts in Tamil Nadu to get feedback about the performance of sugarcane technologies.

We had entertained 1249 visitors to the Institute comprising students (535), farmers (652) and cane development staff (62).

ICAR- SBI, Regional Centre, Karnal

Co 15023 (Karan 15), an early maturing variety was notified wide gazette notification number SO 500 E (dt 29.01.2021) for commercial cultivation in NWZ comprising Delhi, Haryana, Punjab, Rajasthan, Uttrakhand and Uttar Pradesh (Central and Western parts). Five test entries were elevated to the status of 'Co' canes *viz.*, Co 21012, Co 21013, Co 21014 and Co 21015 (under early) and Co 21016 (under midlate). Among them, Co 21012, Co 21013, Co 21014 were accepted for inclusion in ZVT trials for NWZ in the annual group meet AICRP(S). From the ground nursery ratoon, 244 better performing progeny were selected and after assigning selection number K19-01 to K19-244 were advanced to C1 stage of evaluation. From the C1 multiplication stage out of 124 test entries of K 17 series, 38 were advanced to Preliminary trial. In PZVT 2021-22, at 8th month of evaluation, the test entry WL06-182 (18.85) recorded significantly higher sucrose% over the best standard CoJ 64 (17.64%), whereas three test entries; WL04-72 (17.86%), WL06-85 (17.66%) and WL 10-85 (17.27%) were equal performer with it.

A total of 24 ISH clones were evaluated for their drought tolerance potential. ISH entries *viz.*, 14-131, 14-94, 14-38 and 14-34 recorded least reduction (<2%) for plant height at 150 DAP. A total of 31 ISH entries were ratooned during the month of February 2021. For single cane weight, entries 14-147, 14-56, 14-144, 14-188 and 14-49 had at par performance with Co 0238 under drought. ISH clones 14-42, 14-49, 14-147, Co-canes, Co 14034 (15.10, 19.72 and 22.0%) and Co 16030 (7.19, 16.45 and 29.23%) showed less reduction in all the salinity treatments i.e. 4, 8 and 10 dS m^{-1} respectively.

In the AICRP trials 2020-21 crop season, at harvest, no test entry was promising in IVT (early) trial, Co 15025 (18.69 t/ha CCS yield, 142.37 t/ha cane yield, and 18.78% sucrose) was promising in AVT Early, Co 15023 (135.87 t/ha cane yield and 20.31 t/ha sugar yield) and Co 15027 (147.29 t/ha cane yield and 19.99 t/ha sugar yield) exhibited superior performance in AVT Early II Plant, and in AVT Early Ratoon Co 15027 (18.13 t/ha sugar yield and 139.92 t/ha cane yield) and Co 15023 (133.16 t/ha cane yield and 20.09% sucrose) were the best performing test entries.

Red rot pathotype CF11 was found to be the most virulent followed by CF07, CF01, CF08, CF13, CF02, CF09, and CF03. Among the four Cf0238 isolates, Faridpur isolate showed more virulence and exhibited susceptible reactions on ten host differentials indicating a different origin in the region. During survey, red rot incidence was recorded up to 50.0% in Co 0238 in Punjab, Haryana and UP sugar mills area. Smut, pokkah boeng and wilt diseases were also observed in some of the popular sugarcane varieties grown in the zone.

Tetrasticus pyrillae was identified as an egg parasitoid and *Epiricania melanoleuca* as nymph as well as adult parasitoid of *Pyrilla perpusilla*. *Isotima javensis* and *Stenobracon deesae* were recorded as larval parasitoids of top borer. *Cotesia flavipes* was found as larval cum pre - pupal parasitoid of stalk borer. Early shoot borer, top borer, root borer, stalk borer, pyrilla, black bug and termites were listed as key pests of sugarcane in Haryana, whereas, Gurdaspur borer, Pink borer and Blister mite were identified as minor pests of sugarcane in Haryana, UP and Punjab. Top borer incidence was recorded to be 0.0 to 60.0, 0.0 to 40.0 and 0.0 to 43.0 per cent in Haryana, western Uttar Pradesh and Punjab, respectively.

A total of 167 sub-tropical sugarcane reference varieties were characterized for 27 DUS descriptors. Second year DUS testing of candidate variety Co 12029 was completed and application for registration of new sugarcane variety Co 13035 submitted to PPV&FR authority, New Delhi. Biomass partitioning done in varieties Co 15023 and Co 0124 at 120, 150 and 240 DAP, indicated significant difference between them. MDS plot was constructed, the pattern of close proximity among the sets of samples group indicated that there was not batch effect error.

A record high 35836.97 quintals of quality breed-

er seed was produced and supplied (against the target of 2,500 quintal) to the farmers and sugar mills of Haryana, Punjab, Uttar Pradesh, Uttrakhand and Bihar during the year 2020-21. MoU's were signed between ICAR-SBI, Coimbatore and firms/sugar mills *viz.*, M/s Avadh Sugar & Energy Ltd unit Hargaon, UP, M/s Avadh Sugar & Energy Ltd unit Seohara, UP , M/s Mawana Sugar Mill and Nangalmal Sugar Complex Nangamal, UP. A total of 23160 quintals of seed cane, nearly 7.0 lakhs settlings and 3.0 lakhs single bud setts were produced at seed entrepreneur's farm under RKVY scheme. A total of 12,000 quintals of breeder seed was produced and the farmers were referred to the NFSM (CC) seed farms for purchasing healthy seed.

ICAR- SBI, Research Centre, Kannur

Two clones (WL 17-1804 and WL 17-1344) were identified as promising for CCS yield under waterlogging conditions and proposed for PZVT. Based on the performance in the pre-zonal varietal trial 2020-21 at Coimbatore, a waterlogging resistant clone WL 13-711 (Co 99006 X WL 10-20) was selected as Co 21010. Three clones with red rot resistance over years *viz.*, WL 10-85 and WL 10-102 were identified for registration with ICAR-NBPGR.

The clone GUK 17-301 was significantly superior for CCS yield over check varieties and was moderately resistant to red rot and identified for PZVT. In the second clonal trial, 25 clones were evaluated with two checks. Four clones were found promising for CCS yield, of which GUK 18-413, GUK 18-452 and GUK 14-454 were developed from the red-fleshed *S. robustum*.

Maintenance of the world collection of germplasm was one of the major activities of the centre and 3375 clones are maintained in field gene bank by annual re-planting. Forty-two clones of *S. barberi* and 30 clones of *S. sinense* were evaluated for yield and quality traits for revising the catalogue. Forty-six germplasm clones comprising *S. officinarum, S. barberi* and *S. robustum* clones that are identified as promising under natural flood conditions in the previous year were evaluated for yield and quality under waterlogged conditions and five *S. officinarum* clones and one *S. barberi* clone were found promising. The diversity and abundance of above-ground arthropods in different sugarcane germplasm crop assemblages were studied in detail. A total of 523 invertebrates belonging to ten taxonomic orders were identified.

Around 100 *S. officinarum* clones are *in vitro* cultured using shoot tip and are maintained through sub culturing. Indirect regeneration through callus was attempted in seven clones of *S. officinarum* (51 NG 131, IJ 76-314, IJ 76-559, NG 77-92, NG 77-63, NG 77-67, NG 77-18) with ornamental value for inducing further variation and selection. The clone 51 NG 131 and NG 77-92 were regenerated through callus culture.

DNA fingerprinting of 50 *S. officinarum* clones were done using SSR markers. The primers produced a total of 73 amplified fragments. The similarity coefficient among the clones ranged from 65 to 100%. IJ 76-314 and IJ 76-474 had similar patterns with these primers and could not be differentiated. Similar was the case with the following pairs Fiji 15 and Fiji 20; Tamarin reunion and Tanna.

Mass multiplication of the best performing *Trichoderma* isolates for wilt, stalk rot and sett rot was done using liquid jaggery-yeast medium and potato dextrose broth and talc based formulation was made. Three cultures (BC 36, PF 4 and PF 60) exhibited better plant growth.

Seasonal dynamics of *Pyrilla perpusilla* and its natural enemies were studied and the peak *Pyrilla* population comprising nymphs and adults were recorded during October-November. The activity of egg parasitoid, *Parachrysocharis javensis* was noticed throughout the cropping season with a mean parasitization of 71.38%. The biocontrol agent *E. melanoleuca* introduced from SBI Karnal Centre was successfully established at Kannur Centre. The field occurrence of EPF, *Metarhizium* sp. was abundant and was characterized at molecular level (GenBank accession: OK175688) and confirmed as *Metarhizium flavoviride* Gams & Rozsypal causing pathogenicity on pyrilla populations for the first time in India. The augmentative use of entomopathogenic fungi for pyrilla control was done by three pronged strategies *viz.*, spray of spore suspension on leaf surface and distribution of mycosed adult cadavers, release of spore-laden/contami-

nated adults. Mass culturing of *M. flavoviride* in potato dextrose broth (PDB) under laboratory conditions was successfully done and talc based formulation has also been made.

Powder jaggery production process with organic clarificant was standardized and licensed as technology for commercialization. The freeze preservation method of fresh juice was standardized in the form of sip-up packing (50ml) and blocks of 500ml/ 1L, without losing the colour, freshness and quality.

ICAR- SBI, Research Centre Agali

Of the 1390 germplasm lines, 907 accessions flowered (flowering intensity 65.25%), which is 20% higher than the previous year (46.01%). Among the 230 *S. officinarum* clones maintained at NDHF, Agali, 76 clones flowered, which is 5% higher when compared to that of the previous year (28.30%). Anthesis began from 30 August 2021 and lasted up to 30 November 2021. The *S. officinarum* clones *viz.*, 57 NG 174, Monget gayam, Naz, Otaheite, LF 89-2064, Suphan-50, Sugar doctor, White transparent, are the early flowering clones (flowered during last week of August 2021). A total of 220 crosses were made for the participating centres of AICRP(S) and the Institute.

A total of 233 reference varieties of tropical sugarcane varieties were maintained in field through clonal propagation. DUS test for three new sugarcane varieties namely, Co 09004, Co 11015 and Co 10026 were undertaken and results indicated that all were distinct from the resembling reference varieties.

5. RESEARCH ACHIEVEMENTS

5.1 CROP IMPROVEMENT

5.1.1 BREEDING

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

New Variety

Co 14012 (Avani), a midlate maturing sugarcane variety (Fig. 2) has been identified and the notification proposal is submitted to Central Varietal Release Committee for commercial release.

Fig. 2. Co 14012

Genetic stock registered with ICAR-NBPGR

Co 13003 (INGR 21068) is registered with ICAR-NBPGR for its high fibre content combined with high sucrose content.

'Co' canes identified

Eleven 'Co' canes from 2021 series were identified (Table 4).

'Co' canes promoted to AICRP(S)

Out of 11 'Co' canes of 2021 series, eight 'Co' canes namely Co 21002, Co 21003, Co 21004, Co 21005, Co 21006, Co 21007, Co 21009 and Co 20010 were selected for testing in the AICRP trials of Peninsular Zone.

a) Hybridization (2021 season)

Flower initiation occurred in the last week of October in ratooned hybridization block and flowering intensity was 60-68%. A total of 251 biparental crosses were effected, which included 171 crosses between tropical and tropical clones, 30 using tropical and subtropical clones and 20 crosses involving ISH, IGH and CYM clones, 40 polycrosses and 10 crosses using inbreds and genetic stocks. Crosses with short duration/ high sugar clones such as Agl 2018-24, RK 2020-12, RK 2020-17, SDC 2019-8, SDC 2019-15 as one of the parents were effected. Proven parents and recently identified superior clones as well as energy cane such as SBIEC 11001 and selected intergeneric and interspecific hybrids were used in hybridization. A large number of crosses were effected utilizing the parents *viz.*, Co 0209, Co 11015, Co 12009, CoTl 14111, CoVc 14061, CoC 671, Co 86032, Co 8347, Co 0238, Co 05011, Co 0327, Co 15027, CoPant 97222, CoS 92368 and CoLk 8102. Ten parents combining resistance to both red rot and smut, 20 parents with resistance to smut and 20 clones with resistance to red rot were utilized to effect crosses. A total of 150 general collections were also made.

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

Ground nursery (2021-2023)

Over 35000 seedlings were raised in beds from the fluff of 271 crosses made during 2020 crossing season, and 19248 seedlings from 202 biparental crosses, six proven crosses, and 80 general collections were transplanted in the ground nursery. It was ensured that sufficient parental diversity in the seedlings derived from combinations involving tropical and subtropical clones,

Table 4. Performance of 'Co' selections identified at Coimbatore

'Co' Numbers	Parentage	CCS yield (t/ha)	Cane yield (t/ha)	Sucrose (%)		CCS% 360 days	Red rot rating		Smut
				360 days	300 days		Plug	Nodal	
Co 21001	Co 11015 GC	17.63*	129.6*	19.66	19.39	13.61	MR	R	MS
Co 21002	CoM 0265 x Co 775	17.83*	142.8*	18.33	15.95	12.49	MS	R	R
Co 21003	CoM 0265 x Co 11015	20.58*	152.7*	19.47	17.53	13.48	MR	R	MR
Co 21004	Co 11015 GC	17.36	123.5	20.18*	20.14	14.16	MS	R	S
Co 21005	Co 11001 x Co 12014	17.38	132.6*	18.74	18.48	13.10	MS	R	R
Co 21006	Co 11015 PC (CoT 8201, Co 94005, Co 0311)	20.04*	144.7*	20.00*	20.14	13.80	MS	R	S
Co 21007	Co 95005 x CYMA 09-1369	19.83*	138.1*	20.71*	18.72	14.35*	MR	R	R
Co 21008	CoM 0265 PC (CoT 8201, CoC 671)	17.14	129.2*	19.15	18.65	13.27	MS	R	MS
Co 21009	Co 08016 GC	18.63*	130.4*	20.66*	20.43	14.31*	MR	R	MS
Co 21010	Co 99006 x WL 10-20	16.79	128.2*	18.68	17.51	13.10	MR	R	MS
Co 21011	Co 0403 x Co 99006	18.06*	131.8*	19.77	17.84	13.70	MR	R	S
Standards									
Co 86032		14.67	110.7	18.97	18.51	13.24			
Co 11015		16.06	111.7	20.63	21.89	14.37			
Co 09004		13.69	102.2	19.36	20.75	13.39			
Co 0212		16.82	128.2	19.06	17.76	13.14			
C.D.		2.64	17.3	1.12	1.55	0.87			

trait specific genetic stocks and elite intergeneric and interspecific hybrids. Genetic stocks for red rot, smut, drought and salinity tolerance and with high early sucrose accumulation potential, high fibre and biomass used in crosses resulted in progenies for screening in the nursery.

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

Ground nursery (Ratoon) (2020-2022)

A total of 18,000 seedlings were raised in December 2020 and ratooned in July 2021 for further evaluation. There was cross variation in the ratoon nursery. Crosses involving the parents Co 11015, Co 12009, Co 15027, CoVc 14061, Co 13018, Co 14020, Co 86032, Co 0238, Co 12029, CoT 8201, Co 8347 and CoPant 97222 gave better progenies. The trial will be screened in March 2022 to advance selections to first clonal trial.

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

First clonal trial

Two trials are in progress with 1907 and 3197 clones with four standards. Selection will be effected during January-February 2022 based on set criteria.

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

Second clonal Trial (2020-21)

Trial I

Five hundred and seventy two entries were evaluated along with the standards Co 86032 and CoC 671 in augmented RCBD. At 240 days, four clones recorded juice sucrose above 18.0%. At 300 days, 14 clones recorded more than 20.0% sucrose and were from the crosses *viz.*, 2017-187 x CoVc 14061, Co 10033 x CoPant 97222, Co 14002 x CoPant 97222 and 1148-13-11-2-251 x Co 62198. Maximum selections were obtained from 14 crosses. Five clones from the crosses, Co 10033 x CoPant 97222, 1148-13-11-2-251 x Co 62198 and Co 0118 x Co 11015 recorded > 22.0% sucrose at 360 days. Five clones recorded >300cm cane height. The crosses with Co 11015, CoVC 14061, Co 8353, Co 8347, CoPant 97222 and CoC 671 as one of the parents yielded more number of selections. Parents such as 2017-187, Co 11015 and CoC 671 produced progeny with high early sucrose accumulation. These parents together contributed more than 60% of selections. Among the 572 clones evaluated for red rot resistance through CCT, 34 clones combined high quality at 360 days and red rot resistance. Crosses Co 86032 x Co 94008, Co 86032 x Co 92008, Co 0238 x Co 12014, 2017-231 x Co 12014, 1148-13-11-2-251 x Co 62198, Co 11015 PC (Co 94008, Co 8371 and Co 12014), Co 0209 x (CoS 8436 and CoC 671), Co 14030 x (CoT 8201, Co 10033 x CoPant 97222) and Co 14002 x CoPant 97222 combined juice sucrose > 20.0% and red rot resistance. A total of 96 clones with good field stand, yield and quality parameters were promoted to PZVT for further evaluation.

II Clonal trial (2021-22)

Among 457 clones evaluated in second clonal trial for juice quality traits at 300 days, seven clones registered above 20.0% juice sucrose. Among them, one was R, three were MR, two were MS and one was S to red rot (Table 5).

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

Trial II

A total of 520 clones were evaluated along with three standards (Co 86032, CoC 671 and Co 09004) in an augmented design. Four clones were identified as early high sugar clones with more than 18.0% sucrose at 240 days. Twelve clones were identified as early maturing clones with more than 20.0% sucrose at 300 days. At harvest, nine clones from the crosses Co 99006 x Co 06015, CoC 671 x Co 16018, CoC 671 x Co 775, Co 86002 X Co 11012, Co 16018 PC recorded more than 21.0% sucrose. For NMC, 42 clones recorded a high stalk population of 1,20,000/ha. Nine clones were identified for high single cane weight (>2.0 kg), four each for high cane thickness (>3.4 cm) and cane height (>300 cm). Six clones from the crosses Co 0240 x Co 12014, 81V48 x Co 10015 were identified for high sucrose (>20.0%) combining red rot resistance. The trial comprised high proportion of red rot resistant clones (R, MR-37.8%), thus indicating genetic improvement for red rot resistance through breeding. A total of 66 clones with good agro-

Table 5. Selections with more than 20% sucrose at 10 months

Genotype	Parentage	Sucrose at 10 months (%)	Red rot reaction
19-139	Co 0240 x CP 62-23	22.11	R
19-227	1148-13-11-2-251 x Co 62198	22.07	S
19-30	Co 0238 x Co 12014	21.55	MS
19-417	2007-231 x Co 10015	20.65	MR
19-242	Co 11001 x CoPant 97222	20.43	MS
19-006	Co 16001 x Co 10033	20.37	MR
19-029	2017-135 GC	20.14	MR

nomic performance combining red rot resistance were advanced for further evaluation in PZVT.

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

New trials: 2021-22

Second Clonal Trial

A total of 610 clones were evaluated for yield and quality traits with four standards *viz.*, Co 86032, Co 09004, CoC 671 and Co 11015 in an augmented RCB design. Twenty-nine clones recorded more than 20.0% sucrose at 10th month compared to 19.99% recorded in the best standard Co 11015. The highest sucrose of 22.17% was recorded by the entry 2020-168. The crosses *viz.*, Co 11015 x CoVc 14061, Co 11015 x Co 13014, Co 14020 x Co 11015, Co 11015 x CoH 119, Co 0240 x Co 12014, Co 10033 x CoC 671 and Co 11015 PC contributed to more number of selections. More than 75% of the high sucrose clones had Co 11015 as one of the parents which clearly emphasised the potential of Co 11015 in developing high sucrose varieties in breeding programmes. Sixteen clones possessed high early sucrose accumulating potential with red rot resistance, which is a notable achievement considering the need of such clones for bioethanol production (Table 6).

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

b) Pre-Zonal Varietal Trial Location: Coimbatore

i) Cane yield and quality: PZVT (2020-21)

In PZVT (2020-21) 43 test clones and four standards *viz.*, Co 86032, Co 0212, Co 09004 and Co 11015 were evaluated in a randomised block design with two replications. Overall, 11 Co canes (Co 21001 to Co 21011) were identified based on quality and yield traits from the trial. Among the Co canes identified, Co 21003 (20.58 t/ha) recorded the highest CCS yield, followed by Co 21006 (20.04 t/ha), Co 21007 (19.83 t/ha) and Co 21009 (18.63 t/ha) showed significantly superior commercial sugar yield over the best standard Co 11015 (16.06 t/ha) in the trial. For cane yield, Co 21003 (152.66 t/ha), Co 21006 (144.69 t/ha), Co 21002 (142.80 t/ha) and Co 21007 (138.07 t/ha) were significantly superior to the standards Co 86032 (110.75 t/ha), Co 11015 (111.73 t/ha), and Co 09004 (102.20 t/ha). For juice quality (sucrose % & CCS %) at 360 days, Co 21004 (20.18% &14.16%), Co 21007 (20.71% & 14.35%) and Co 21009 (20.66% & 14.31%) recorded significantly superior values at harvest over the popular standard Co 86032 (18.92% &13.24%).

Table 6. Selections combining more than 20% sucrose at 10th month and red rot resistance

Clone No.	Parentage	Sucrose (%) at 10 months	Red rot reaction
2020-169	Co 17003 x Co 11015	21.32	MR
2020-90	Co 11015 x Co 13014	20.68	MR
2020-123	Co 14020 x Co 11015	20.29	MR
2020-158	Co 16009 x Co 11015	20.23	MR
2020-108	Co 11015 x Co 13014	20.22	MR
2020-3	Co 11015 x Co 12009	20.02	MR
2020-51	Co 11015 PC	21.69	MR
2020-91-12	Co 11015 x CoH 119	21.02	R
2020-202	Co 0240 x Co 12014	20.42	R
2020-91-5	Co 11015 x CoH 119	20.26	MR
2020-65	Co 11015 PC	20.11	MR
2020-209	Co 0240 x Co 12014	20.08	R
2020-10	Co 0209 x CoH 70	20.22	MR
2020-248	Co 10033 x CoC 671	20.39	MR
2020-250	Co 10033 x CoC 671	20.24	MS
2020-255	Co 86002x Co 12014	20.58	MR

At 300 days Co 21004 (20.14%), Co 21006 (20.14%) and Co 21009 (20.43%) recorded significantly superior sucrose content over the zonal standard, Co 86032 (18.51%). Among the entries screened, 18 were R/MR, 20 were MS and four were S to red rot by nodal method of inoculation, while 40 were R and three were S to red rot by plug method. For smut ratings, nine were R/MR, nine were MS, 17 were HS and eight were S. The short duration variety, Co 11015 was involved in the development of four Co canes as a parent among the 11 'Co' canes.

(G. Hemaprabha and V. Sreenivasa)

PZVT: (2021-22)

In PZVT trial, 80 entries along with four standards *viz.*, Co 86032, Co 09004, Co 11015 and CoC 671 were evaluated for cane and juice quality at 10th month. Thirty-eight clones recorded higher sucrose than the standard Co 86032 (17.40%). Three clones 2020-67, 2020-117 and 2019-69 recorded more than 20% sucrose at 10th month. Among the 80 entries, 44 were resistant to red rot and 27 were resistant to smut.

(K. Mohanraj and H.K.Mahadevaswamy)

PZVT Multiplication (2021-22)

In PZVT multiplication, 184 clones were planted along with three checks (Co 86032, Co 11015, CoC 671) at Coimbatore. The clones were periodically observed for field performance and natural disease incidence, and selected clones will be taken forward to the PZVT (2022-23) trial in February, 2022.

(C. Appunu and V. Vinu)

Screening for disease resistance

Red rot

Among the 77 PZVT clones of 2020 series screened under field conditions with Cf671 by plug and nodal methods, 54 were identified as R by nodal method and 45 as R/ MR by plug method.

(P. Malathi)

Smut

Totally, 79 PZVT entries were evaluated against sugarcane smut during the crop season 2021-22. Among the 79 entries, eleven entries *viz.*, PZVT 2020-42, 84, 85, 86, 92, 96, 118, 141, 147, 157 and Co 15023 were identified as resistant, whereas 18 and 24 entries were identified as moderately resistant and moderately susceptible, respectively.

(A. Ramesh Sundar)

c) Botanical characterization and DNA fingerprinting of elite selections and varieties

Fourteen 'Co' canes of 2020 (Co 20001-Co 20014) series developed at Coimbatore were botanically described based on DUS guidelines. The molecular fingerprints of the recently developed 'Co' canes were also completed. Molecular fingerprints of probable varieties for release *viz.*, Co 14012 and Co 15027 were also developed (Fig. 3).

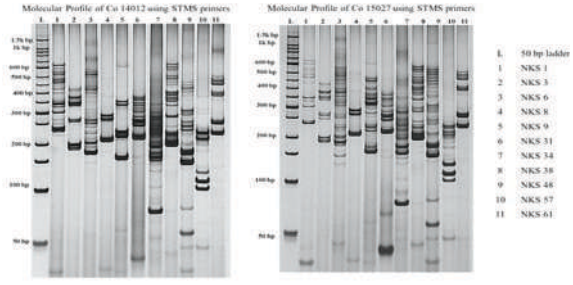


Fig. 3. Molecular profiles of Co 14012 and Co 15027 using 11 sugarcane specific STMS pimers

Molecular analysis of 38 clones for population structure was done (Fig. 4). These genotypes were grouped into three sub populations; SP1, SP2 and SP3 comprised 27, 2 and 9 clones, respectively. The mean fixation index (Fst) of SP1 and SP3 was comparatively low (0.34 and 0.35) with good gene flow (Nm) of 0.48 and 0.46, while the SP2 was with high fixation index (0.71) with very meagre gene flow of 0.1. The SP3 included the clones Co 16001 and Co 16002, which are of diverse origin from the rest, but exhibited high similarity between them and hence less gains are expected from their combination. However, the crossing of SP2 individuals with SP1 and SP3 would ensure genetic variation and trans-

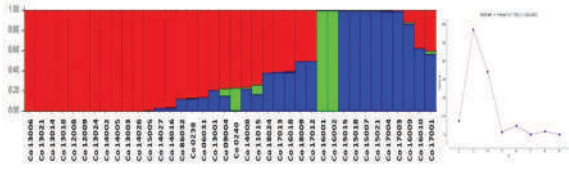


Fig. 4. Population structure of 38 accessions (K = 3) and graph of estimated membership fraction for K = 3

gressive segregants, likely to be generated in the progeny population.

(G. Hemaprabha and H.K. Mahadevaswamy)

d) Identification and testing of short duration sugarcane clones

Eighteen short duration clones were evaluated in replicated trial (2R x 6m x 0.9m) Based on juice analysis done at 8 and 10 month, the highest sucrose content was recorded by the clone RK 2020-12 (18.99 and 21.09% at 8 and 10 month) in comparison to 17.58 and 19.29% at 8 and 10 month, respectively of the registered genetic stock, Co 16001. However, this clone had relatively thin canes resulting in less yield over grand mean. Agl 2018-24 was the second best in the trial for sucrose content (18.24 and 19.84% at 8 and 10 month respectively). The cane yield of this clone at 8 month was 86.11 t/ha in comparison to 90.46 t/ha and 123.01 t/ha in the standards Co 8338 and CoC 671, respectively. Agl 2018-24 is a high sucrose clone with moderate cane yield. Both these clones gave 'S' reaction to red rot. Another noteworthy clone with good field stand and moderate quality is SDC 2019-15 with 17.42% and 19.19% sucrose at 8 and 10 months respectively as against 18.88 and 19.37% sucrose in the recently released short duration variety Co 11015. Cane yield of SDC 2019-15 is the highest (129.31 t/ha at 8 month) in the trial, above the best standard CoC 671 with 123.01 t/ha (Table 7).

(R.Karuppaiyan and G.Hemaprabha)

Evaluation of elite clones for identifying promising location specific sugarcane varieties

Andhra Pradesh

Six elite 'Co' canes along with the standard CoV 09356 were evaluated in RBD with three replications for cane and juice quality traits at KCP Sugars, Vuyyuru, Andhra Pradesh. The highest cane yield was recorded in the clone Co 17004 (156.06 t/ha) followed by Co 06031(139.9 t/ha) and Co 18009 (135.9 t/ha). The entry, Co 18009 recorded the highest sucrose of 19.88% compared to the standard CoV 09356 (19.03%).

Entries accepted for AICRP (S)

Based on performance of the clones in the trial conducted at KCP Sugars, Vuyyuru, Andhra Pradesh during 2020-21, two clones, Co 17004 and Co 18009 were proposed and accepted for inclusion in the AICRP (sugarcane) of East Coast Zone.

Seed supply

Seed material of 15 elite 'Co' canes were supplied to the factory for multiplication.

(K. Mohanraj and T. Lakshmi Pathy)

Karnataka

Twenty eight clones of 2018 series were supplied to S. Nijalingappa Sugar Institute (SNSI), Belagavi in March 2020 as part of identification of loca-

Table 7. Juice quality traits and cane yield of selected short duration clones

Clone	Brix (%) at 8 months	Sucrose (%) at 8 months	Brix (%) at 10 months	Sucrose (%) at 10 months	Cane yield at 8 months (t/ha)	CCS yield at 8months (t/ha)
RK 2020-12	20.83	18.99	22.65	21.09	84.07	11.41
Agl 2018-24	20.47	18.24	21.54	19.84	86.11	10.69
SDC 2019-15	19.29	17.42	20.77	19.19	129.31	15.92
GS: Co 13001	19.84	17.19	21.58	19.23	96.99	11.06
GS: Co 16001	20.11	17.58	21.70	19.29	83.52	10.32
Std Co 11015	20.08	18.88	21.07	19.37	108.07	13.51
Std Co 8338	18.40	16.64	20.27	17.91	90.46	10.65
Std CoC 671	19.06	16.87	21.75	19.24	123.01	14.56
General Mean	18.50	16.26	20.95	18.97	102.55	11.84
CD	1.65	1.84	1.31	2.10	20.84	3.42
CV	5.22	6.58	2.91	5.16	9.44	13.44

tion specific high yielding varieties for Northern Karnataka. The above clones along with standards Co 86032 and CoC 671 were planted in RBD with two replications at SNSI in April 2021.

(V. Sreenivasa and H.K. Mahadevaswamy)

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

Cogeneration and ethanol production

Biomass production potentials of SBIEC 14006 in different environments were estimated under suboptimal management condition with limited irrigation and fertigation in both plant and ratoon crops and compared with the high biomass registered genetic stock, INGR 12017. SBIEC 14006 recorded the highest mean harvestable biomass of 265.28 t/ha compared to the INGR 12017 (219.22) across four environments and showed 21.01% improvement. Percent improvement was more in ratoon crop (28.98%) compared to plant crop (24.17%) under normal irrigation. Under limited irrigation condition also, it recorded 14.96% improvement over INGR 12017. The mean harvestable biomass yield under limited irrigation condition was 241.41 t/ha while under normal irrigation condition the yield was 289.08 t/ha. For fibre % cane also, SBIEC 14006 recorded the highest value of 27.54% compared to INGR 12017 (20.90%) and showed an improvement of 31.77% compared to the INGR 12017.

Registration of genetic stock

SBIEC 14006 was registered as genetic stock (INGR 20112) with ICAR-NBPGR, New Delhi for high harvestable biomass.

Fodder quality of the energy canes tops were compared with the sugarcane varieties (Co 0238 and CoS 767). Average crude protein content in sugarcane varieties was 7.32% while SBIEC 11002 and SBIEC 13002 recorded the highest of 6.66% and SBIEC 14007 showed 6.40%. Ash % was low in SBIEC 14006 (2.09%) compared to sugarcane (2.25%). While SBIEC 14006 recorded 32.43% and 36.98%, sugarcane varieties showed 30.02% and 34.49% for hemicellulose and cellulose respectively. Energy canes were comparable to sugarcane varieties for organic matter %, dry matter intake %, dry matter digestibility and total carbohydrates. SBIEC 14006 had low net energy lactation (MJ/kg) and relative feed values with 1.99 and 72.17 respectively compared to sugarcane varieties with 2.27 and 77.80 respectively. Considering all the parameters energy cane tops have acceptable fodder quality but were found to be slightly inferior compared to sugarcane tops.

(P. Govindaraj and Mintu Ram Meena)

Nutritional evaluation, improvement and utilization of newer feed resources for livestock production

In 2020, 72 fodder type clones derived from the backcrosses (sugarcane x *S. halepense*) x (sugarcane, maize, bajra, *Sorghum, Erianthus arundinaceus*) were ratooned in microplots to assess their suitability for multi-cuts as well as to estimate green fodder yield. Four harvests (cuts) per year was made, with the duration between two cuts varied from 66 days (during monsoon seasons) to 118 days (during post monsoon / winter season) with an average of 91 days between harvests. Three elite clones (Agl2019-51, Agl2019-82 and Agl2019-56) recorded 154.62 t/ha/year to 202.73 t/ha/year of green fodder yield hence a farmer can harvest 4 crops in a year at a harvest interval of 91 days and in each harvest, 40.92 t/ha of green fodder. These clones also recorded >50 shoots (tillers) per clump, shoot length at harvest (at flowering stage) >200 cm, and broad leaves with leaf length >45 cm were adjudged as suitable fodder clones. Preliminary results showed that the Erianthus derived fodder type clone was better in terms of leaf to shoot ratio (0.47), although its total biomass yield was relatively lower (154.62 t/ha/year). Higher proportion of leaf to shoot is a desired fodder quality trait to increase animal digestibility.

From the F_1 seeds of the cross Bajra x *Erianthus arundinaceus,* four purple coloured fodder type plants resembling *Pennisetum purpureum* were obtained. The chromosome number of F_2 was 2n=28 as against 2n=21 in Cumbu-Napier hybrid and 2n= 28 in *Pennisetum purpureum.*

(ICAR-SBI, Coimbatore: P. Govindaraj and R. Karuppaiyan,

ICAR-IGFRI, Jhansi: A.K. Misra, S. B. Maity, K. K. Singh, Sultan Singh, Vijay Kumar Yadav and P. Koli)

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

Adaptive Research Trial (2020-21)

Four test entries (Co 14016, Co 15007, C 30010 and Si 10-12) and five standards (Co 86032, Co 11015, CoC 25, CoG 6, TNAU (SC) Si 8) were evaluated at six locations *viz.*, Sathyamangalam, Appakudal, Odapalley, Udumalpet, Theni and Pugalur. The trial at Pugalur was vitiated due to severe incidence of wilt. For cane yield, Co 14016 was found superior to the respective best standard at three locations *viz.*, Bannariamman Sugars, Sathyamangalam, Ponni Sugars, Erode and Amaravathi Co-operative Sugar Mills Ltd., Udumalpet while C 30010 was superior to Co 86032 at Sakthi Sugars, Appakudal. Co 14016 was better than the best standard for CCS yield at Sathyamangalam and Appakudal and C 30010 was better at Appakudal. For juice sucrose content, Co 11015 was the best standard in all the five locations and none of test entries was superior to Co 11015 for juice sucrose content (Table 8).

Multi-location Trial (2020-21)

Six test entries *viz.*, Co 14004, Co 14012, Co 18023, C 14516, C 14436, and G 10045 along with three standards *viz.*, Co 86032, Co 11015 and CoG 6 were evaluated under MLT at ICAR- SBI. For juice quality traits at 270 days the highest juice sucrose content was recorded in Co 11015 (20.39%) followed by CoG 6 (17.51%) and Co 86032 (17.16%). Among the test entries, none of them was found superior to the best standard Co 11015. Two entries *viz.*, Co 18023 (18.22%) and Co 14012 (17.98%) were found superior to the ruling variety Co 86032 for juice sucrose content at 270 days. With respect to NMC at 240 days, Co 11015 was superior with 94350 canes per hectare followed by Co 14012 (92410/ha). Two test entries C 14516 and Co 14004 were superior to Co 86032 for sucrose content at 360 days. Co 14012 (131.44 t/ha) was on par with Co 86032 (131.17 t/ha) for cane yield (Table 9). Based on the performance, the entries in MLT at Coimbatore and other test locations, Co 14004, Co 14012, C 14516 and G 10045 were advanced to Adaptive Research Trial 2021-22 to be conducted in Tamil Nadu. Among the entries C 14436 and G 10045 exhibited heavy flowering.

Adaptive Research Trial (2021-22)

Trial with four test entries *viz.*, Co 14004, Co 14012, C 14516, G 10045 and five standards *viz.*,

Table 8. Performance of test entries at factory locations in ART

	Ponni Sugars, Erode			BAS, Sathyamangalam			Sakthi Sugars, Appakudal		
	CCS (t/ha)	Cane yield (t/ha)	Sucrose (%)	CCS (t/ha)	Cane yield (t/ha)	Sucrose (%)	CCS (t/ha)	Cane yield (t/ha)	Sucrose (%)
C 30010	11.22	88.69	18.34	16.32	136.57	17.31	17.14	140.52	17.85
SI 10-12	13.53	111.07	17.37	17.65	142.56	17.77	17.42	159.25	16.06
Co 14016	14.55	132.52	15.95	17.75	142.55	17.70	15.01	124.24	17.36
Co 15007	10.00	84.94	17.09	18.01	135.75	18.88	17.27	130.80	18.59
Standards									
Co 86032	13.20	106.66	17.75	17.71	139.61	18.19	17.08	146.00	16.92
Co 11015	15.31	115.41	19.07	20.31	140.44	20.64	15.55	115.73	19.45
CoC 25	11.34	117.60	14.24	13.77	134.67	14.93	14.39	133.43	16.1
CoG 6	9.99	85.50	17.02	16.09	132.48	17.35	16.83	137.75	17.15
TNAU (SC) Si 8	11.00	107.72	15.15	14.83	124.45	17.06	14.97	132.45	16.31
CD	2.42	12.98	1.91	2.30	10.68	1.79	2.06	16.77	1.59
CV	11.46	7.16	6.52	7.77	4.48	5.78	7.3	7.09	5.25

Table 9. Performance of MLT entries

Entries	CCS (t/ha)	Cane yield (t/ha)	Sucrose (%)		CCS (%)	NMC ('000/ ha)	SCW (kg)	Red rot reaction
			360 d	270d				
C 14436	11.98	87.03	19.16	16.61	13.52	84.26	0.93	S
C 14516	16.51	111.18	20.74	15.77	14.79	88.42	1.10	MR
G 10045	11.12	89.72	18.24	16.85	12.73	88.33	1.01	MR
Co 14004	16.75	116.28	20.35	17.54	14.33	90.00	1.25	R
Co 14012	18.38	131.44	19.94	17.98	14.14	92.41	1.31	MR
Co 18023	14.01	106.14	18.47	18.22	12.99	84.24	1.26	R
Co 86032	18.89	131.17	20.32	17.16	14.39	88.98	1.53	MS
Co 11015	19.43	127.86	22.11	20.39	15.48	94.35	1.29	MS
CoG 6	16.24	117.09	19.66	17.51	13.98	79.45	1.47	MS
Mean	15.92	113.01	19.89	17.56	14.04	87.83	1.24	
CD	2.75	12.25	1.43	1.18	1.12	NS	0.18	
CV	10.26	6.22	4.12	3.85	4.59	5.59	8.42	

Co 86032, Co 11015, CoC 26, CoG 6 and TNAU (SC) Si 8 are in progress at all the six test location in Coimbatore region.

Multi-location Trial(2021-22)

Planted seven test entries *viz.*, Co 15020, Co 18023, C 2015-006, C 2015-021, C 2015-0095, G 11035 and Si 2013-032 along with five standards *viz.*, Co 86032, Co 11015, CoC 26, CoG 6 and TNAU (SC) Si 8 at ICAR-SBI, Coimbatore.

Nomination of entries for Multi-location Trial (2022-23)

Three entries *viz.*, Co 13003, Co 15003 and Co 17001 were nominated for MLT 2022-23.

(A. Anna Durai and K. Mohanraj)

Marker assisted selection in sugarcane for drought tolerance and red rot resistance

Fifty one drought specific markers reported earlier were amplified in resistant and susceptible genotypes. The 28 markers found polymorphic were run in a panel of 52 genotypes (Fig. 5). The 52 genotypes were planted in RBD with two replications in two sets. One was imposed with drought after 90 days of planting, by withholding irrigation up to 150 days and other was irrigated normally. The 28 markers obtained will be validated in these 52 genotypes panel. For red rot, the gene sequences of identified candidate genes were retrieved from NCBI and primers were designed using primer 3. From the ground

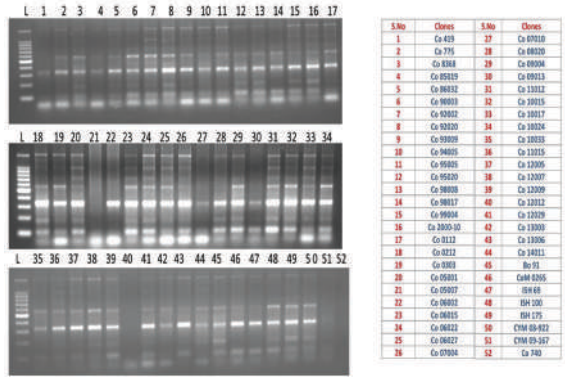


Fig. 5. Amplification patterns of candidate gene marker DERBM in 52 genotypes

nursery from different crosses the progenies were selected, and advanced. From this 176 clones were given for red rot testing, based on results, resistant and susceptible bulks will be constituted and the newly designed primers will be analysed to tag the resistance gene with its phenotypic variance for red rot resistance.

(G. Hemaprabha, H.K. Mahadevaswamy, K. Mohanraj, C. Appunu, R. Viswanathan and R. Manimekalai)

Standardization of accelerated flowering in sugarcane for speed breeding

Preliminary trials were conducted to study the effect of extended photoperiod on growth in sugarcane with two clones with regular flowering habit *viz.*, Co 0238 and Co 16001. The single bud setts were planted in pots on 9 November 2020. One month after the establishment, the settlings

were subjected to an extended photoperiod of 16 hrs with 50000 lux for 90 days. The results showed that the clone Co 0238 produced mean tiller of 5 under treatment and 2.5 under control, indicating the strong influence of extended light on tiller production. Similarly, there were significant differences in the total biomass as well as dry root biomass production between control and treatment. The total dry matter was 257.0g per plant under treatment compared to 192.2g per plant under control. The dry root weight was 88.5g per plant under treatment compared to 56.0g per plant under control.

The side shoots were removed during 90 DAP leaving only one main shoot for photoperiodic treatment. A decrease in the daily photoperiod of 60S was started from 12 h 30 min for 40 days. After completion of the photoperiodic cycle, the plants were observed for symptoms of flowering and no canes in both the varieties showed flower induction.

The induction was tried in an unusual time when the natural photoperiod was increasing. It is well known that each and every clone requires different climatic conditions for flower induction. Single treatment is not enough to decide the factors required for flowering and needs more factors/combination of factors to induce flowering in sugarcane clones.

(K. Mohanraj and R. Arun Kumar)

Enhancement of sugarcane germplasm and development of pre-breeding material

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

Identification of 'Co' canes

Two-way inter-cross hybrids, TWC 45 and TWC 23 were identified as 'Co' canes *viz.*, Co 21003 and Co 21007, respectively. Co 21003 recorded the highest cane yield in the trial with 152.66 t/ha compared to the standard Co 86032 which recorded 110.75 t/ha.

Evaluation of four-way inter-cross population for drought tolerance

Forty FWC clones were evaluated along with drought tolerant commercial varieties (Co 86032, Co 06022 and CoM 0265) and drought susceptible commercial clone Co 775. Eleven clones recorded higher Fv/Fm than the drought tolerant commercial varieties (0.734) under drought condition. The four-way inter-cross hybrids recorded higher mean cane yield of 80.09 t/ha under drought compared to drought tolerant commercial varieties (71.49 t/ha). Among the four-way inter-cross hybrids, FWC-17, FWC-2, FWC-14, FWC-16, FWC-23, FWC-29, FWC-42 and FWC 7 were identified as drought tolerant.

Screening for red rot

Sixty four-way inter-cross clones were screened for red rot resistance in CCT using CF671 inoculum and 61.6% clones were identified as resistant.

Planting of eight-way/second inter-cross population and evaluating for drought tolerance

A final population of 1550 seedlings from 55 eight way/inter-crosses were screened for NMC, cane diameter and HR brix at 10th month. The population had a mean of 16.27 for HR brix, 2.34 cm for cane diameter and 14.12 per clump for NMC per plant. Fifty-seven clones were selected and planted in a split plot design along with standards, Co 86032, Co 06022 and Co 775. Another set of 45 clones were planted at SBIRC, Agali for evaluation and identification of drought tolerant clones.

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

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

Collection

An exploration was conducted for the collection of late flowering (during October/November) types in Tamil Nadu, Andhra Pradesh and Karnataka. A total of 52 germplasm including 49 *S. spontaneum* and three *E. arundinaceus* were collected from these states. Widespread distribution of *S. spontaneum* was observed throughout these states but most of them had flowered already and were with matured fluff. Hence only the clones which were in active flowering and short blade stages were collected as they were

late in flowering. *S. spontaneum* collections exhibited high variation for different traits like plant height (121 to 392 cm), leaf length (40 to 132 cm), leaf width (0.1 to 1.3 cm), peduncle length (18 to 88 cm), arrow length (16 to 72 cm), internode length (4 to 24 cm) and cane diameter (0.2 to 0.9 cm). Three *E. arundinaceus* accessions were collected including two from Tamil Nadu and one from Karnataka. All the three accessions had huge biomass with tall canes and heavy tillering. The first *E. arundinaceus* (IND 21-2061) was spotted in low altitude (33m AMSL) at Thirunelveli district and it was a tall (347 cm) type with medium thick canes (1.9 cm diameter). The leaves were longer (117 cm) and wider (3.8 cm). IND 21-2068 was another *E. arundinaceus* accession collected from the river bed of Thamirabarani River had long internodes (14 cm). The other E. arundinaceus accession, IND 21-2087 was located in the Mysuru district which had the tallest cane (412 cm) with long (162 cm) and broader (2 cm) leaves. The late flowering collections are expected to synchronize in flowering with the commonly used sugarcane parents, hence can be used for diversifying the genetic base of the commercial varieties.

(P. Govindaraj and H.K. Mahadevaswamy)

Maintenance at Coimbatore and Wellington

The 2260 accessions *viz., S. spontaneum* (1709), *Erianthus arundinaceus* (230), *Erianthus* spp. (176), Allied genera (63), improved *Erianthus* for fibre (48) and *Saccharum* (34) were maintained at Coimbatore and 47 accessions from Arunachal Pradesh were maintained at IARI Regional Station, Wellington. The new 52 collections from Tamil Nadu, Karnataka and Andhra Pradesh regions *viz., S. spontaneum* (49) and *E. arundinaceus*(3) were maintained in glasshouse for quarantine.

(S. Karthigeyan and S. Sheelamary)

Maintenance of commercial hybrids and genetic stocks

A total of 2007 clones were maintained including 1361 'Co' canes, 284 ISH clones, 38 IGH clones, 52 foreign hybrids, 18 Co allied clones and other genetic stocks developed at the Institute.

(H.K. Mahadevaswamy and V. Vinu)

National active germplasm maintenance

Assigning Index Number

The seed materials received from different centres were submitted to quarantine process and monitored periodically. Eighteen clones namely CoH 13263, CoH 14261, CoH 06266, CoA 16321, CoC 13339, Co 13003, CoSnk 14102, CoSnk 15101, CoSnk 15102, CoSnk 15103, CoSnk 15104, Co 14012, Co 15027, Co 18009, CoVSI 18121, CoLk 15201, CoLk 15207, CoLk 15466 were assigned index number. Another 24 clones (CoM 11082, CoLk 12207, CoLk 12209, CoH 17261, CoH 17262, CoH 19261, CoSnk 14102, CoSnk 15101, CoSnk 15102, CoSnk 15103, CoSnk 15104, CoSe 11453, CoPb 14181, MS 14082, CoP 11438, CoP 18437, CoS 14233, CoLk 15201, CoLk 15207, CoLk 15466, CoN 15071, CoPant 12226, CoPant 12221, CoPant 13224) were monitored and maintaining under quarantine.

Field maintenance of National Active Germplasm

A total of 271 notified and registered genetic stocks were maintained. Flowering was observed in nine 'Co' and Co-allied varieties.

(C. Jayabose and S. Alarmelu)

Characterisation, Evaluation and Cataloguing

Out of 1709 *S. spontaneum* planted in 2020 in Coimbatore, 926 accessions flowered during 1 July to 31 December 2020.

(S. Karthigeyan and S. Sheelamary)

Characterization of germplasm

Flowering behaviour of allied genera

Flowering behaviour was observed for 12 allied genera consisting of 410 clones and were maintained in the germplasm field. Among them, 14 clones flowered in the 3rd week of July, 29 clones in the first week of August, 27 clones in the 3rd week of August, 33 clones in the 2nd week of September, 18 clones in the 2nd week of October, 28 clones in the 3rd week of November and 3 clones in the 2nd week of December. Totally 152 clones flowered in 2021.

(C. Jayabose)

Cytological studies in *Saccharum* and allied genera

Somatic chromosome number (2n) determined in 64 clones of *S. spontaneum* collected from Tamil Nadu and Andhra Pradesh states (IND 03-collection). Out of these, 33 clones were collected from Southern Tamil Nadu and 31 clones were collected from Andhra Pradesh. This collection showed different cytotypes like 2n=48, 60, 62, 64, 68, 70, 72 and 78.

Clone	2n
IND 03-1218, 1264	60
IND 03-1216, 1220,	62
IND 03- 1266, 1282, 1285	48
IND 03-1252	68
IND 03-1243, 1265	70
IND 03-1231, 1295	72
IND 03-1242	78
IND 03-1215, 1219, 1292, 1217, 1221, 1222, 1223, 1224, 1226, 1227, 1229, 1232, 1233, 1235, 1236, 1237, 1238, 1239, 1240, 1241, 1245, 1246, 1247, 1248, 1249, 1250, 1251, 1268, 1283, 1284, 1291, 1293, 1294, 1296, 1297, 1298, 1299, 1300, 1301, 1302, 1304, 1305, 1306, 1307, 1308, 1310, 1311, 1312, 1313, 1316, 1317, 1318	64

The 36 *S. spontaneum* clones of IND 19 collection (collected from Western Ghats of Tamil Nadu, Karnataka, Goa and Maharashtra) were studied cytologically. The cytotypes of 2n=64, 72 and 80 were detected (Fig. 6).

Clone	2n
IND 19-2002, 2004, 2016, 2017, 2018, 2019, 2023, 2025, 2027, 2029, 2030, 2031, 2037, 2038, 2039, 2040, 2041, 2043, 2044, 2046, 2051, 2052, 2053, 2054	64
IND 19- 2021, 2022, 2026, 2042, 2045, 2047, 2048, 2049, 2050	72
IND 19-2024, 2028, 2035	80

(V.P. Sobhakumari)

Floral biology and cytological characterization of *Erianthus*

The data on 40 descriptors of 42 *E. arundinaceus clones* has been recorded and entered in DELTA software after comparing with the available data. Digitals of descriptors of 52 clones were taken. The clones with 2n=30 cytotype were analysed with DELTA. Automated descriptions were generated as depicted for SES 288.

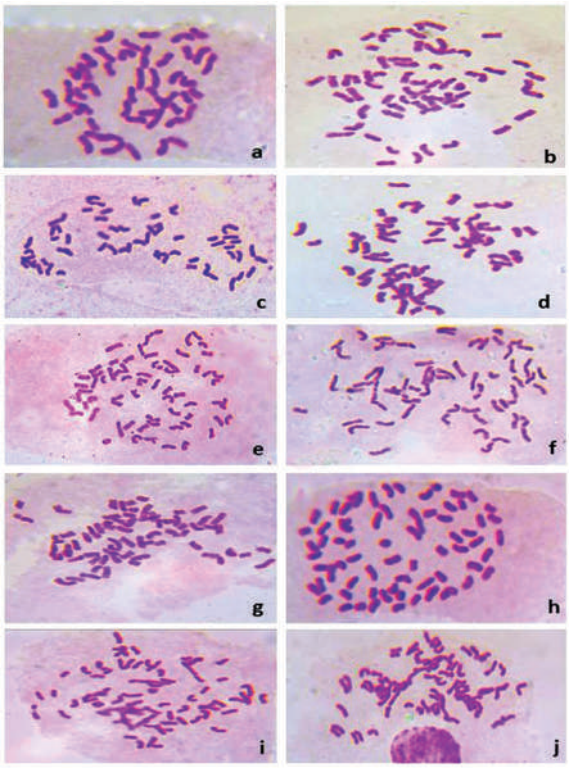


Fig. 6 (a) – (j) Somatic chromosomes in different cytotypes of* S. spontaneum *a) IND 03-1266 (2n=48), b) IND 03-1218 (2n=60), c) IND 03-1216 (2n=62), d) IND 19-2043 (2n=64), e) IND 03-1252 (2n=68), f) IND 03-1243 (2n=70), g) IND 03-1231 (2n=72), h) IND 03-1242 (2n=78), i) IND 19-2035 (2n=80), j) IND 19-2038

SES 288

Growth habit semi erect. Chromosome no 30. Year 1950. Country India. Plant height 495 cm. Vegetative stalk present. Stalk length 285cm. Ivory marks absent. Corky patches absent. Internode shape cylindrical. Number of internodes 30. Internode length 7.9 cm. Internode colour Light yellow. Diameter 11.5 mm. Pithiness present. Alignment straight. Node colour light or pale green. Internode C.S Oval solid. Waxiness absent. Node swelling present. Root eyes present. Number of root eyes rows one. Bud nature 2. Bud size small, or medium. Cushion absent. Shape Deltoid, or ovate. Bud extension 2. Leaf sheath hairs 0. Leaf sheath length 25.7 cm. Leaf blade length 109 cm. Leaf midrib width 2.9 cm. Waxiness very light. Spines absent. Clasping tight. Ligule hairs 1. Ligule shape Crescent.

Flowering was noticed in the clones *viz.*, SES 153,133,189, 288, 293, IND 84-478, Tewlong, Mythan A, C, Mindana, Fiji 10, IND 84-478, EA sarkender, EA Munja, EA Layalpur, IK76-8, 55, 62, 75, 76, 80, 81, 88, 90, 91, 92, 93, 94, 99, 105, IJ 76-357, 64, 365, 376, 394, 400, IM 76-247 and IMP 1536.

(A. Suganya)

Evaluation of sugarcane germplasm for biotic and abiotic stresses at Coimbatore

Drought tolerance in *Saccharum spontaneum*

One hundred and seventy *S. spontaneum* accessions were evaluated for drought tolerance along with two standards (*S. spontaneum* Coimbatore and Ponape 1) in augmented design. Different morphological and physiological observations were recorded periodically. The highest total chlorophyll and carotenoid content during drought period was recorded in IND 03-1318. The highest growth rate during drought period for plant height was recorded in IND 05-1411 and number of tillers was the highest in IND 00-1070. Three accessions *viz.*, Mandalay, IND 03-1318 and IND 03-1292 recorded < 20% reduction in biomass and high chlorophyll and carotenoid contents under drought condition.

Drought tolerance in *E. arundinaceus*

Ninety-six *E. arundinaceus* accessions were evaluated for drought tolerance along with four checks (SES 288, SES 293, IS 76 215 and IS 76 218). Different morphological and physiological observations were recorded periodically. For the first time non-destructive methodology was developed to measure leaf area in *Erianthus clones.* Two-year (2019-20 & 2020-21) data were pooled and analysed to identify the tolerant and susceptible clones of *E. arundinaceus.* Fourteen clones were found to be highly drought tolerant (IND 01- 1105, IND 04- 1335, IND 01- 1091, SES 347, IND 10- 1591, SES 206, SES 288, SES 133, SES 181, IND 02- 1208, SES 293, SES 149, SES 136, SES 159) with < 10% biomass reduction, higher chlorophyll fluorescence and RWC under drought conditions. These clones along with the tolerant checks were also found to possess higher leaf area under drought.

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

Anatomical characterization of *Saccharum* complex and core collections

The stem epidermal pattern of the drought and water logging resistant genetic stock 04-1687 (BO 102 x *S. spontaneum*) indicated presence of elongated sinuous long cells as in male parent. Short cells occurred in single to multiple pairs with a frequency of 40.2-47.6% (Fig. 7). Solitary

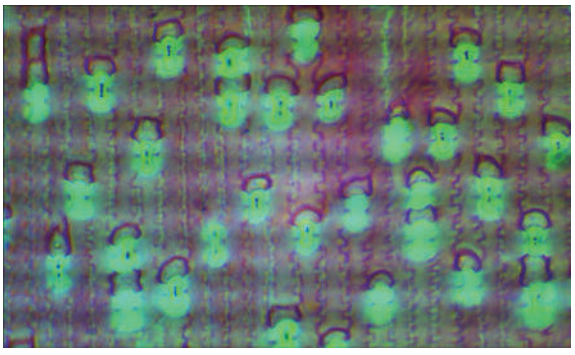


Fig.7. Stem epidermis of the drought and water logging resistant genetic stock 04-1687

cork cells were rare. Pointed cork cells were observed in the female parent BO 102. In the hybrid with 2n+n transmission (04-244, 2n=166), multiple pairs of short cells with solitary cork cells were observed. The female clone, Co 89029 had multiple pairs of short cells with few pairs of pointed cork cells. The male parent had single pairs of short cells and solitary cork cells.

(A. Suganya)

Molecular cytogenetic characterization of interspecific and intergeneric hybrids of Saccharum

For the preparation of probes, genomic DNA has been isolated from *Erianthus* (IK 76-62). The quality and quantity of the DNA was checked and it was fragmented to 500-1000bp size by sonication. The fragmented DNA was labelled with biotin and the probe efficiency was tested in the mitotic slides of respective species. For GISH analysis the mitotic slides were prepared and slides having cells with division were freeze dried in liquid nitrogen.

The backcross progenies of the hybrid between *E. arundinaceus* (IK 76–78, 2n=60) x *S. spontane-*

um (Iritty-2, 2n=64) which has been developed as an intermediate hybrid to transfer the characters from *E. arundinaceus* to sugarcane cultivars were subjected to GISH analysis. Four BC_4 progenies (FWC 2, FWC 28, FWC 29 and FWC 39) were obtained as a result of cross between a BC_3 progeny TWC-82 (with seven *Erianthus* chromosomes) with an interspecific hybrid, MG17-101. The GISH analysis revealed that four *Erianthus* chromosomes were present in FWC 2 and FWC 28, three *Erianthus* chromosomes in FWC 29 and five *Erianthus* chromosomes in FWC 39 (Fig. 8). The somatic chromosome numbers were also determined in these BC_4 progenies, FWC 2 (2n=102), FWC 28 (2n=108), FWC 29 (2n=102) and FWC 39 (2n=110).

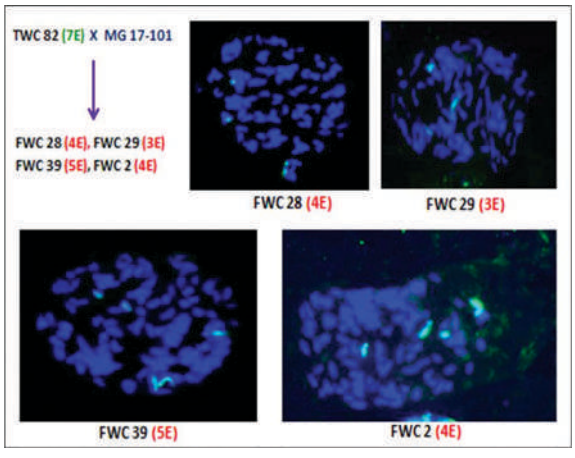


***Fig. 8. Introgression of* Erianthus *chromosomes in the fifth generation of* Erianthus x Saccharum**

PCR identification of true hybrid progeny was conducted with *Erianthus* specific 5S rDNA sequences. It was found that no amplification was obtained beyond BC_2 generation. As 5S rDNA had one locus per set of chromosomes. It is present only on a few chromosomes in each genome. Due to unequal segregation of *Erianthus* chromosomes and also its elimination, the advances back cross progenies may not inherit the chromosomes that carry the 5S rDNA loci. Hence amplification of *Erianthus* specific 5S rDNA sequences could not be reliable for identification of true hybrid progeny. Another set of primer designed with *E. arundinaceus* tandem repeat satellite DNA sequences (ESTR) which are present in all *Erianthus* chromosomes. PCR with this primer supported the GISH result and identified the *Erianthus* introgressed hybrids in five generations (Fig. 9 & 10).

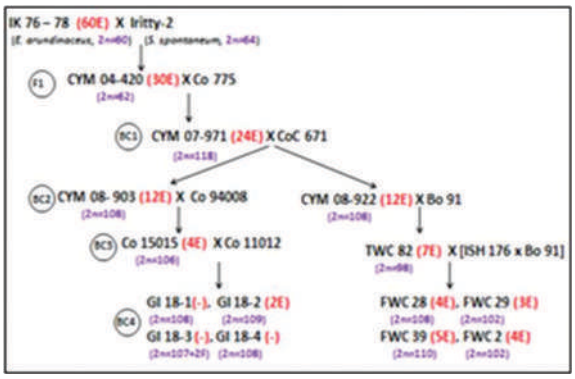


***Fig. 9. Erianthus introgression in five generations of* Erianthus x Saccharum**

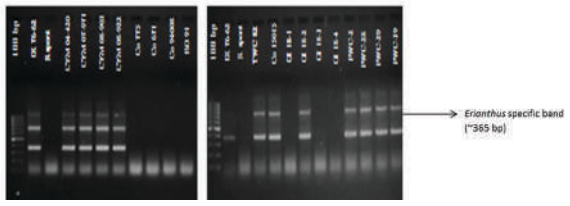


Fig. 10. Confirmation of* Erianthus *introgression using ESTR primer amplification

GISH analysis has been done in CYM 08-903 and CYM 08-883 (BC_2 progenies of *Erianthus* x *S. spontaneum*) with biotin labelled IK 76-62 probe. In both progenies, 12 *Erianthus* chromosomes were identified.

While analyzing the agronomical characters, it was found that the second generation progeny, CYM 08-922, which is having 12 *Erianthus* chromosomes, was showing significantly higher performance in terms of number of millable canes, cane diameter, single cane weight and yield under drought condition while comparing with the performance of Co 775, Co 86032 and CoM 0265. These progenies are potential source for diversifying the genetic base of sugarcane varieties as introgression of *Erianthus* genome, and also in view of yield potential and drought tolerance.

(V. P. Sobhakumari and K. Mohanraj)

Developing trait specific genetic stocks with biotic and abiotic stress tolerance, quality and yield traits in sugarcane through pre-breeding

Identifying multi trait genetic stocks with improved *Saccharum* genetic base

Evaluation of inter-specific hybrid clones for drought tolerance

Ninety five entries were evaluated under drought stress and normal condition along with

three standards (Co 10026, Co 85019 and CoM 0265). Drought stress was imposed at formative phase of the crop by withholding irrigations, and data on physiological and morphological traits along with yield and quality parameters were recorded in normal and drought stress conditions. Among the clones assessed for NMC at 10 and 12 months, 33 clones registered NMC of 20.14 / 10ft row. At eleven months, HR Brix ranged from 18.24 to 22.12% and 25 clones recorded HR Brix above 20.10%. Forty five clones registered juice sucrose in the range of 18.0 to 19.20% and 25 clones in the range of 18.50 to 19.78% at 360 days.

Visual observation under drought indicated that 10 clones were drought tolerant and four clones *viz.*, 14-001, 04-174 14-198 and 04-353 were highly susceptible. The overall mean reduction under the drought for cane height was 26.13% and clone 03-14 was best clone with 1.10% reduction and among the standards Co 10026 showed least reduction of 15.91%. Nine clones *viz.*, 07-132, 03-572, 07-776, 14-27, 003-14, 07-1016, 01-803, 14-161 and 04-533 recorded less reduction for cane height. Reduction was high in the clone 20-304 (Co 7201 x 96-104) for single cane weight and cane yield. The overall mean reduction under the drought for NMC was 23.99% and the clone 99-19 was the best with least reduction of 6.17% for NMC under drought. For juice sucrose, the highest reduction was recorded in 14-51 (17.21%) and the lowest in 99-43 (8.44%). The clones Co 10026, 14-161, 07-1016, 20-191 01-807, 14-189 and 04-395 had minimum reduction under drought condition. Thirty clones recorded good cane population at 240,300 and 360 days under both conditions. A reduction in number of millable canes was observed due to severe drought stress. Cane yield was most affected by drought (61.49%) followed by single cane weight (52.57%) and cane height (25.30%). Cane height showed a positive and significant correlation with cane yield (r =0.585) under both normal and water deficit conditions.

During the stress period, physiological data on chlorophyll content, leaf area and tiller number were recorded. At the time of harvest, biomass, leaf area index, stalk number and stalk weight were recorded under both control and drought conditions. High genetic variability was observed among the accessions for biomass at harvest, leaf area index, stalk number and stalk weight under drought condition.

Among the parents RWC ranged from 52.5% (PIO 88-79) to the highest 83.2% (PIO 14-100) with a mean of 72.58%. RWC ranged from 38.51 to 59.66% in the hybrids of improved *S. robustum* x improved *S. officinarum* under drought conditions. Under normal conditions it ranged from 57.62 to 79.11%. A decrease in cane height (17.96%) and stalk diameter (9.64%) was observed in drought affected canes of mating group involving improved *S. robustum* and improved *S. officinarum*. Under drought, nine clones *viz.*, 03-14, 07-435, 20-538, 14-198, 01-807, 07-776, 06-028 and 07-1100 had high RWC and remained green up to maturity stage (360 days). Two clones 07-50 and 07-520 recovered after drought. Eight clones had high leaf area and recorded high total dry matter in comparison with CoM 0265 and Co 10026. These clones form a new genetic source for use in breeding to develop climate resilient sugarcane clones.

Significant differences were observed for SPAD, relative water content (RWC), canopy temperature depression (CTD) among the genotypes and between treatments. CTD, an important trait in selection for drought tolerance had significant and positive correlation with cane yield under both normal (r = 0.416) and drought situations (r = 0.246). Mean STI (stress tolerance index) was 0.34 with 60% of the genotypes having an above average STI. Drought tolerance of BC_1 hybrids was found stronger than that of BC_2.

Cane height, number of millable canes, CTD and RWC showed significant positive associations with cane yield under both normal and drought conditions indicating their importance in identifying drought tolerant genotypes. The genotypic differences observed among the traits studied indicated that this new pre-breeding gene pool with high genetic diversity can be utilized in breeding climate resilient types of sugarcane.

Screening for red rot

The hybrid derivatives were screened for red rot reaction through CCT and among the clones tested, 20 were MR, seven MS and nine R types.

(S.Alarmelu, S. Vasantha and S. Sheelamary)

Developing trait specific genetic stocks for biotic and abiotic stress tolerance utilizing novel Saccharum germplasm

Development of prebreeding material

Thirty crosses involving rare flowering *Saccharum* species clones (21 NG 31, 57 NG 197, 28 NG 15, 28NG 210 Stir, 28NG 288 Stir, 55/22, 21 NG 036, 51 NG 156, 51 NG 077, Baragaua, Fiji 40, Fiji 62, IJ 76-364, IJ 76-060, IJ 76-564, IK 76-060, Keong, Laukona 15, NG 77-102, NG 77-142, NG 77-154, S. hybrid, Selri Bali, Ubawhite and Vespertina) and commercial canes (Co 86002, Co 0327, Co 8347, Co 89003, Co 62198, Co 775, Co 8371, Co 11015, Co 15018, Co 453, Co 0209, HR 83-65, CoA 13182, CoA 13325, CoS 8436, CoSe 01434, Co 92102, CoVC 14061, CoH 70, CoPant 97222, CoT 8201, CP 52-1 and CP 62-23) were effected at SBI RC Agali. Nine back crosses *viz.,* TSGS 20-39 (Laukona 15 x Co 0235) x Co 11015, TSGS 20-41 (Laukana 15 x Co 0235) x Co 11015,TSGS 20-59 (Uba white x Co 88028) x Co 11015, TSGS 20-79 (Chapina general collection) x Co 12014, TSGS 20-126 (*S. officinarum* hybrid general collection) x Co 12009, 24-5 (Otaheite x 11-1686, 15-1712) x Co 0209, TSGS 58-1 (Ubawhite x Co 88028) x Co 11015, TSGS 67-1 (Laukona 15 x Co 0212) x Co 11015, TSGS 69-1 (*S. officinarum* Unknown x IJ 76-564) x Co 11015), TSGS 69-2 (*S. officinarum* Unknown x IJ 76-564) x Co 11015, and TSGS 69-3 (*S. officinarum* Unknown x IJ 76-564) x Co 11015 were effected at Coimbatore. A total of 1550 seedlings were transplanted including 1272 backcross derived progenies of 15 crosses *viz.,* TSGS 113 (Manjuria x Co 13001) x Co 0209, , TSGS 155 (51 NG 159 GC) x Co 775, TSGS 157 (51 NG 159 GC) x Co 0209, TSGS 159(51 NG 159 GC) x Co 11015, TSGS 173(51 NG 159 GC) x Co 12009,TSGS 174(51 NG 159 GC) x Co 775, TSGS 178 (S.o Hybrid x Co 12009) x Co 8353, TSGS 188 (57 NG 184 GC) x Co 11015, TSGS 191 (57 NG 184 GC) x Co 8347, TSGS 201 (57 NG 184 GC) x Co 12014, TSGS 217(57 NG 184 GC) x Co 15027, TSGS 244 (Baragua GC) x Co 15027, TSGS 33 (IJ 76-316 GC) x Co 12014, TSGS 79 (Chapina GC) x Co 775 and TSGS 96 (IJ 76-545 GC) x Co 15027. Seventy-one F_1 progenies of the crosses involving *S. officinarum* (White transparent, Manjuria, Keong, Laukona) and *S. spontaneum* (Irity 2, IND 99 -881, IND 89-151, SES 93, IND 99-915) and 207 F_1 of the cross having Co canes as female and *S. spontaneum* (IND 99-904, IND 99-882, IND 99-905) as male. The fluff of the four crosses involving stable red rot resistant *S. officinarum* clone Baragua failed to germinate.

Evaluation of clones for drought tolerance

A total of 39 clones (tested 'R' for red rot) were evaluated under drought along with standards Co 86032, Co 775, Co 10026 and CoM 0265. Drought was imposed by withdrawing regular irrigation during formative phase. Under drought conditions, the clones 97 GUK 119, 92 GUK 220, GUK 11-870 and 84 GUK 352 recorded least reduction (<5%) for cane traits like cane diameter, cane height, SCW, NMC and cane yield, The clones *viz.,* GUK 02-100, 90 GUK 300, 97 GUK 94 and 88 GUK 3203 recorded more than 50% reduction for cane parameters. For quality traits, there was not much difference under drought and normal conditions.

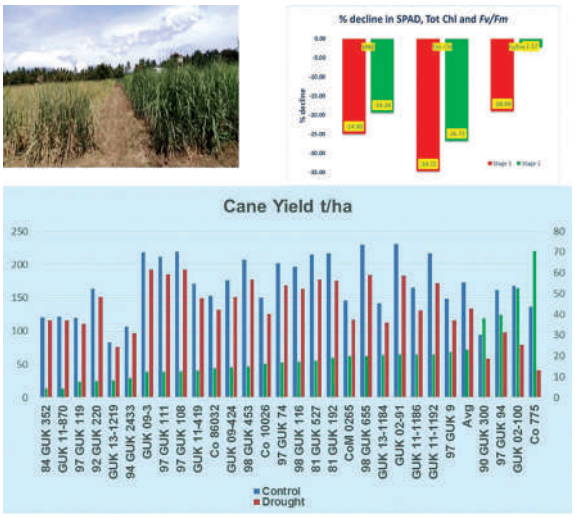


Fig. 11. Effect of drought stress on cane yield, SPAD, total chlorophyll and chlorophyll fluorescence

Morphological (plant height, number of leaves, leaf length, leaf width, leaf area, stalk number, NMC, leaf angle, biomass partitioning (leaf, sheath and stem) and physiological traits (SPAD index, chlorophyll content, chlorophyll fluorescence, canopy temperature, canopy coverage, epicuticular wax) were recorded in two phases in 43 sugarcane clones grown under both control and drought condition. The mean physiological traits *viz.,* SPAD-31.24, Chlorophyll

content-0.026 mg/cm^2, chlorophyll fluorescence- 0.698 were observed during phase 1 and during phase 2 the mean SPAD- 36.09, Chlorophyll. content - 0.033mg/cm^2, chlorophyll fluorescence- 0.781 under control condition. The mean physiological traits *viz.,* SPAD-23.46, Chlorophyll content-0.017mg/cm^2, chlorophyll fluorescence-0.566 were observed during phase 1 and during phase 2 the mean SPAD-29.11, Chlorophyll content-0.024, chlorophyll fluorescence-0.764 under control condition (Fig. 11). Significant reduction in morphological and physiological traits was observed. Reduction in physiological traits indicates the impact of drought on sugarcane clones. Decline in leaf, sheath and stem dry matter was also observed under drought condition compared to control. Significant correlation was observed between canopy temperature depression, leaf dry weight, leaf area, leaf length, cane height and cane volume under drought condition. Canopy coverage also recorded positive correlation with total dry matter production. Several GUK clones recorded better physiological traits under drought stress compared to the control condition.

Screening for red rot

A total of 255 progenies developed from 20 cross combinations involving *Saccharum* spp. clones and commercial hybrids were evaluated for yield components and quality characters in first clonal trial. The 187 progenies of seven bi-parental crosses *viz.,* Laukona 15 x Co 0233, Awela Green Sport x CoSe 92423, 28 NG 210 x Co 89003, 51 NG 159 x CP 62-23, Manjuria x Co 13007, Pathri x Co 62175 and POJ 2878 x Co 15007 and Co 88025, and nine general collections *viz.,* Monget Gayam GC, 51 NG 159 GC , 57 NG 184 GC, Baragua GC, Chapina GC, IJ 76-316 GC, IJ 76-545 GC, Oramboo GC and S. o hybrid GC having more number of shoots were selected for testing for their reaction against CF 06 isolate of red rot pathogen. The progenies of Baragua exhibited all kinds of reactions i.e. MR, MS, S and HS reactions against red rot pathogen. Most of the clones showing reaction towards resistance (MR and MS) are produced by progenies of *S. officinarum* hybrid.

Among the 255 progenies developed from a new genetic background and 43 clones having acceptable cane characters were selected for their reaction against other stresses. Most of the selections were from the crosses, Ubawhite x Co 88028 (13), Laukona x Co 0233 (8), Manjuria x Co 13007 (6), and 28 NG 210 x Co 89003 (3). Other crosses giving selections are Baragua GC (9), Chapina (4), 57 NG 199 GC (2), *S. officinarum* hybrid (2), Oramboo GC (2) and 51 NG 159 x CP 62-23 (1) and being studied for their drought tolerance potential.

(A. Anna Durai, A.J. Prabakaran, V. Sreenivasa, H.K. Mahadevaswamy, C. Mahadevaiah, K. Mohanraj, R. Viswanathan, K. Chandran and R. Arun Kumar)

Developing trait specific genetic stocks with *Erianthus* genetic base

Registration of genetic stock: The clone GU 07-2276 (INGR21067; IC IC636676) was registered as genetic stock with NBPGR, New Delhi for its high cane yield (89.66 t/ha) and the lowest single cane weight reduction under drought. It also recorded high nitrogen use efficiency among the IG hybrids (77.92 kg of dry biomass/kg of nitrogen). It was developed by crossing two wild species *viz., Saccharum robustum* 'PIR 00-1188' and *E. arundinaceus* IK 76-91 and backcrossing the resultant F_1 'GU 04 (50) RE-9' with CoH 70.

Evaluation of BC_2 *progenies using E. procerus:* The fluff from 35 BCs was sown and raised 658 BC_2 progenies involving *E. procerus.* Maximum of 114 seedlings were obtained in the cross GU 12-33 x Co 11015, 112 seedlings from GU 12-25 x Co 12009 and 108 seedlings from GU 12-33 x Co 12014. The clones were evaluated for HR Brix and it ranged from 9.0 to 22.6% and 26 clones recorded more than 20% brix at 10th month.

Hybridization: Thirty-one back crosses were made using BC_2 progenies as female parents.

Cytological characterization of BC_2 progenies involving *E. procerus*

Clone	Parentage	Somatic chromosome number (2n)	Probable chromosome transmission
2019-1	GU 12-33 x Co 11015	140	2n+n

2019-2	GU 12-33 x Co 11015	92	n+n
2019-3	GU 12-33 x Co 11015	102	n+n
2019-4	GU 12-33 x Co 11015	102	n+n
2019-5	GU 12-33 x Co 11015	102	n+n
2019-11	GU 12-33 x Co 11015	108	n+n
2019-13	GU 12-33 x Co 12014	140	2n+n
2019-14	GU 12-33 x Co 12014	140	2n+n
2019-15	GU 12-33 x Co 12014	140	2n+n
2019-15	GU 12-33 x Co 12014	97	n+n

Molecular characterization: The fifteen BC_2 hybrids were characterized using genus-specific 5S rDNA markers. A 370 bp 5S rDNA fragment was distinctly amplified in three BC_2 hybrids along with the Saccharum-specific fragments.

(K. Mohanraj, H.K. Mahadevaswamy and A. Suganya)

Improvement of elite interspecific hybrids derived from different cytotypes of *S. spontaneum* through nobilisation with typical clones of *S. officinarum* (2n=80)

Hybridisation: As flowering occurred at Coimbatore in Laukona 15 (typical) and Baragua (atypical) (female), they were utilized in 16 backcrosses with cytotype 2n=40, 64, 72 and 80 derived hybrids (male). Thirty backcrosses were made with elite hybrids and 'Co' varieties. About 630 seedlings of crosses made were transplanted in field. At Agali, five clones of *S. officinarum* (Fiji B, NG 77-018, IJ 76-214, IJ 76-317) have been utilized for backcrosses.

Meristem tip culture: About 762 meristem tips from 20 clones (*S. officinarum* clones with 2n=80 and Indian clones) were inoculated and subcultured. Regeneration was obtained in IND 04-1377, NG 77-154, IJ 76-314 Saipan G and NG 77-142 in MS media supplemented with GA3 (0.5 mg/L) and BAP (0.25 mg/L). About 120 Plantlets of IND 04-1377, 402 of NG 77-154, 60 of IJ 76-314 and 155 of Saipan G were hardened in plastic tumblers. About 134 plantlets of IND 04-1377, NG 77-154, IJ 76-314 and Saipan G were transplanted in field.

Biochemical analysis indicated increase in total sugars at 30th day and it ranged from 2.567 (Laukona 15) to 6.927 µg/200 mg tissue (IND 04-1377). IND 04- 1377 showed 3.559 µg increase of reducing sugars while NG 77-154 with 4.814 µg increase of reducing sugars. The mean increase in protein content at 30th day ranged from 0.560 µg (Laukona 15) to 0.817 µg (IND 01-1116). HPLC analysis indicated increase in GA level during in vitro elongation and it declined in the regenerated shoots. IAA level showed 13.8 µg per 10 g of tissue during regeneration phase in NG 77-134.

Molecular studies: In order to analyse the segregation ratio of alleles in interspecific hybrids with n+n, 2n+n and n+2n transmission with the SSR markers, 30 clones comprising three female parents (Co 89029, BO 102 and BO 130), five male parents (*S. spontaneum,* 2n=40, 64, 72, 88 and 112) and 22 interspecific hybrids including three hybrids with 2n+n transmission (04-244, 04-2153, 04-1492), six hybrids with n+2n transmission (04-815, 04-817, 04-1912, 04-488, 04-479, 04-1791) and thirteen hybrids (04-1478, 04-1491, 04-1114, 04-1117, 04-2092, 04-2097, 04-245, 04-1875B, 04-1892, 04-249, 04-1831 and 04-1819) with n+n transmissions were subjected for molecular analysis.

Among 60 primer pairs used, 18 primers showed clear amplifications. A total of 563 fragments have been amplified of which 463 were ploypmorphic. The primer SOMS 11 produced maximum of nine male specific and 17 female specific fragments. All hybrids amplified male and female specific fragments which indicated the contribution of alleles from both the parents and thus confirmed their hybridity. Analysis of allelic frequency and their ratio differed with different chromosome transmission pattern (Table 10). In n+n transmitted progenies, segregation of alleles occurred almost equally with male and female specific fragments in the ratio of 1:1.05. Whereas increased contribution of 16 female specific fragments were noticed in 2n+n transmission with a ratio 1.0:1.2 of male and female

Table 10. Segregation of male and female fragments in different chromosome transmission

Chromosome transmission	Cytotype	Fragments			
		Male	Female	Ratio (Male and Female)	Difference
n+n	2n=64, 72, 88, 112	71.0	75.0	**1:1.05**	4.0
2n+n	2n=64, 88, 112	62.0	78.0	**1:1.2**	16.0
n+2n	2n=40	89.0	79.0	**1.12:1.0**	10.0

specific fragments. Allelic segregation ratio was 1.0:0.88 with an increase of 10 male fragments of *S. spontaneum* with 2n=40.

The clustering pattern obtained with the SSR data also reflected the origin of interspecific hybrids. Three clusters obtained with hybrids and the respective female parents. The 2n=40 derived hybrids with n+2n closely clustered with the male parents indicating the 2n male gamete transmission.

(A. Suganya, A. Selvi, P. Govindaraj, and V. Sreenivasa)

Targeted prebreeding with different cytotypes of *S. spontaneum* L. characterized for abiotic stress tolerance

The germination potential of fluff from 46 crosses made during last season indicated that the cross IND 03-1294 x Co 11015 recorded the highest number of germinants in three days. Other crosses *viz.*, SES 106B x Co 1148, *S. spontaneum* x Co 14016, IND 03-1307 x CoSe 92423, IND 03-1256 x Co 11015, *S. spontaneum* (CBE) x Co 12009 also recorded the highest germination. Pollen grains of Co 14016, Co 12009 and CoC 671 were stored at -20o C for two weeks and utilized for making crosses. Good seed germination was recorded when *S. spontaneum* (CBE) was used as pistil parent and stored pollens of Co 14016 and Co 12009 were utilized in crosses. Poor germination was recorded when SES collections were used as a pistil parent. Somatic chromosome number (2n) was determined for 41 clones of *S. spontaneum* and twelve cytotypes were identified. IND 01-1142 x Co 11015, IND 03- 1292 x Co 11015, IND 99-980 x Co 11015, IND 08- 1500 x Co 1148, IND 03-1323 x Co 11015 and IND 03-1278 x Co 11015 have recorded more number of seedlings (>300 seedlings). During the crossing season 2021, 44 crosses were made utilizing 42 female parents and 7 male parents.

(S. Sheelamary, S. Karthigeyan and V.P. Sobhakumari)

Identification of multiratooning potential of selected interspecific and intergeneric hybrids of Saccharum spp.

Forty two clones comprising seven clones each from ISH and IGH hybrids involving *S. officinarum, S. spontaneum, S. robustum, S. barberi/sinense,* IGH/CYM and PIO/PIR clones were planted along with three standards *viz.*, Co 86032, CoC 671 and Co 14016 for evaluation. Tiller count at 90 days indicated that, *S. spontaneum* involved clones recorded the highest tiller number of 101.72 ('000/ha) followed by *S. barberi/sinense* with 93.90 ('000/ha) and CYM/IGH clones had tiller count of 78.41('000/ha) which was higher than the standards (76.64 '000/ha). Tiller counts at 120 days also showed similar trend and recorded the highest tiller number ('000/ha) in *S. spontaneum* involved clones (172.71 '000/ha) followed by *S. barberi/sinense* (167.26 '000/ha), CYM/IGH clones (143.26 '000/ha) and *S. officinarum* involved clones (135.09 '000/ha) in comparison with the standards (132.44 '000/ha).

(K. Elayaraja)

Cryopreservation of sugarcane genetic resources for long term storage and future utilization

Standardization of suitable media composition for regeneration of S. spontaneum: Standardized the protocol for apical meristem culture in *S. spontaneum* for in vitro conservation for conserving germplasm using cryopreservation technique. Growth and development was observed in of five clones of *S. spontaneum* under different hormonal concentrations. Shoot initiation and multiplication was observed when MS media is sup-

plemented with BAP 0.1mg/L, Kinetin 0.03g/l and NAA 0.5g/l. After 75 days, the overall growth and development of *S. spontaneum* clones *viz.,* SES 250and SES 180B, shows very good response. This optimized protocol was also used in other clones such as IND 99-150, SES 69, IND 99-849, IND 05-1400 and IND 05-1405. Good response was observed in the clones IND 99-150, SES 69 and IND 99-849 and they were sub-cultured to M2 media.

Standardization of suitable media composition for regeneration of allied genera: Standardized the protocol for apical meristem culture in *Phragmites* for in vitro conservation especially for conserving germplasm using cryopreservation technique. Observed the growth and development of five clones of *Phragmites* under different hormonal concentrations. Shoot initiation and multiplication was observed when MS media is supplemented with BAP 0.1mg/L, Kinetin 0.03g/l and NAA 0.5g/l. After 75 days, the overall growth and development of *Phragmites* clones *viz.,* IND 89-711and IND05-1423 shows very good response. Rooting and multiplication of these clones shows better response. This optimized protocol would also be used to explore in other allied genera in future prebreeding programme and conservation studies.

(C. Jayabose and R. Valarmathi)

Strengthening *S. spontaneum* L. genetic resources for productivity enhancement and utilization through core development

A total of 1709 *S. spontaneum* accessions collected through exploration from all over India were utilised to establish a core collection of wild *S. spontaneum* germplasm using 34 agro-morphological traits using a PPVFRA descriptor. Initially 1070 accessions were characterised for 12 quantitative traits. To identify the genetic divergence among these *S. spontaneum* accessions, about 100 germplasm accessions were analysed using STMS molecular markers to differentiate accessions, to identify redundancies and to select genotypes with characters of interest.

(S. Sheelamary, S. Karthigeyan, C. Jayabose, V. Vinu, T. Lakshmi Pathy and M. Nisha)

Sugarcane genomics and molecular markers

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

CRISPR- CAS construct and transformation – Cloning the guide RNA to target the flowering gene: Designed and synthesized the oligos for selected spacers regions. Prepared the oligo duplex with phosphorylation. The BSA restricted oligo duplex was cloned and ligated with digested vector. Ligated products were transformed into competent DH5α cells. The positive colonies were selected for the plasmid isolation and further cloning into sgRNA vector. The binary vector pRGEB31 (15.0 kb) was selected to generate stable transformation through *Agrobacterium.* Transformed colonies were selected based on antibiotic kanamycin resistance. Plasmids were isolated from the transformed colonies. Restriction digestion with *Bsa1* and *Sac1* enzyme was done for transformation confirmation. Confirmed the gRNA sequence further by Sanger sequencing using M13R (-48) primer. The sequence revealed cloned target region in the pRGEB31.

Revalidation of expression of miRNA genes: Validation of expression levels of miR397-3p in non-flowering clones showed insignificant expression and high expression in flowering clones was recorded for miR169e-5P (Fig. 12). The miRNA169 family genes regulate the stress-induced flowering by repressing the AtNF-YA transcription factor, allowing for the expression of FLC target genes FLOWERING LOCUS T (FT) and LEAFY (LFY) to promote flowering. Hence CRISPR- Cas cloned target genes for FT provide the reduction in available gene transcripts.

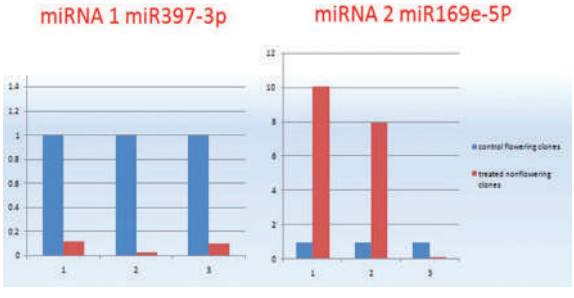


Fig. 12. Interaction of mRNA – MiRNAs related to flowering

Cross species conservation of flowering genes: The phylogenetic tree of full length gene and protein sequence of the flowering gene (FL) showed more conservation of *S. officinarum* genes with maize than that of sorghum, sugarcane hybrid and wheat sequences (Fig. 13).

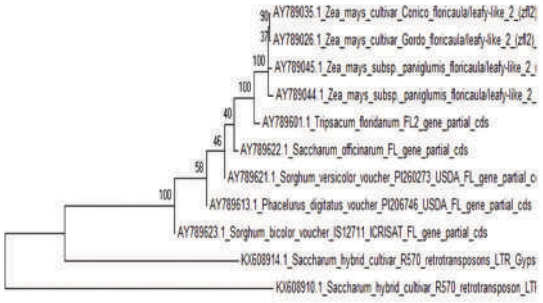


Fig. 13. Phylogenetic relationship of flowering genes among different species.

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

Transcriptome guided mining and validation of genes, miRNAs and their potential targets for water deficit stress

Identification of novel miRNAs and their expression under drought stress

The novel miRNAs were detected using MIREAP software (http://sourceforge.net/projects/mireap/; Li et al. 2012). In the drought susceptible variety Co 8021, 94 and 111 novel miRNAs were discovered in control and drought stressed libraries and in the drought tolerant variety Co 06022, 112 and 118 novel miRNAs were discovered. The 17 miRNAs were common among the different libraries. Differentially expressed novel miRNAs (log2 ratio ≥ 1 up and ≤ 1 down, $p \leq 0.05$) were identified in this study. In the drought-susceptible variety Co 8021, five novel miRNAs were found to be differentially expressed between V1-11 and V1-31, of them, four were upregulated *(mireap-m0095-5p, mireap-m0049-5p, mireap-m0099-3p, mireap-m0024-3p)* and one was downregulated *(mireap-m0045-5p)*. In the drought-tolerant variety Co 06022, nine novel miRNAs were found to be differentially expressed between V2-11 and V2-31, of them, three*(mireap-m0017-3p, mireap-m0087-5p, mireap-m0082-3p)* were upregulated while six-*(mireap-m0021-3p, mireap-m0016-5p, mireap-m0086-5p, mireap-m0049-5p, mireap-m0104-3p, mireap-m0061-3p)* were downregulated.

Functional analysis of target genes of the drought induced conserved and novel miRNAs in sugarcane

A total of 10312 target genes were found to be regulated by the 145 known miRNAs expressed in the susceptible variety, Co 8021 and 11357 target genes were regulated by 143 known miRNAs expressed in the tolerant variety, Co 06022. The predicted target genes mainly encoded transcription factors, proteins, phosphatase and kinases involved in signal transduction pathways, integral component of membrane and inorganic ion transport metabolism, enzymes involved in carbohydrate transport and metabolism, drought-stress related proteins involved in defense mechanisms, and cell wall/membrane biogenesis. Similarly a total of 5308 targets were identified by 50 novel miRNAs expressed upon drought stress in susceptible variety, Co 8021 and 5979 targets were identified for 49 novel miRNAs in the tolerant variety, Co 06022. The novel target genes mainly encoded drought-stress related genes involved in plant defense mechanisms.

Network analysis of drought responsive miRNA and their targets

The network analysis of drought responsive miRNA and their targets upon stress in sugarcane indicated that drought tolerant variety had 144 conserved miRNAs belonging to 32 families encoding 28 genes and 89 novel miRNAs belonging to 14 families encoding 19 genes for stress tolerance. Drought susceptible variety had 128 conserved miRNAs belonging to 34 families encoding 27 genes and 89 novel miRNAs belonging to 17 families encoding 20 genes involved in stress tolerance. The genes were mostly encoding stress responsive transcription factors, plant hormone signal transduction and phenylpropanoid biosynthesis. Combined network analysis of most abundant miRNAs revealed that nine novel miRNAs and 19 known miRNAs interacted with 36 genes in drought stressed Co 8021 (Fig. 14a), and in Co 06022 (Fig. 14b) 10 novel miRNAs and 20 known miRNAs

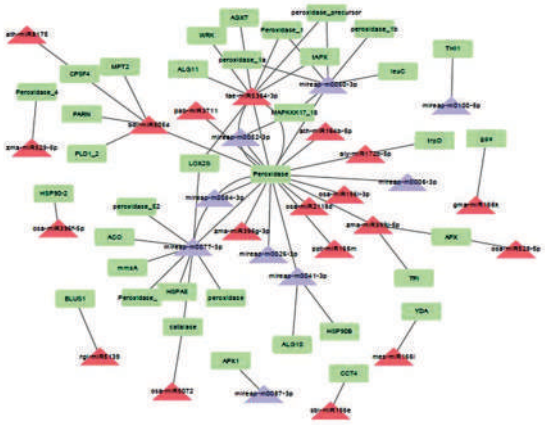


Fig. 14a. Network analysis of abundant miRNAs and predicted target genes of Co 8021

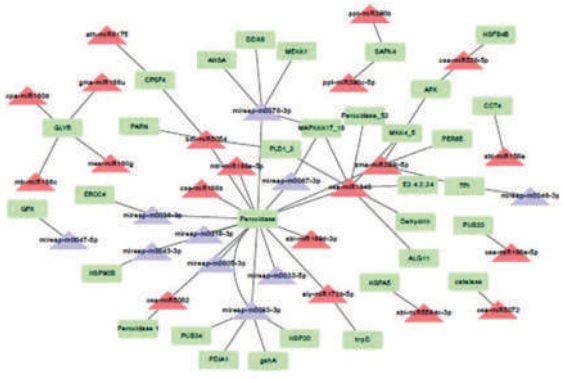


Fig. 14b. Network analysis of abundant miRNAs and predicted target genes of Co 06022

interacted with 32 genes. It was found that different miRNAs targeted different number of stress-responsive genes. For instance, the conserved miRNA *osa-miR396f-5p* targeted only one gene (heat shock protein 90), while *bdi-miR5054* targeted five genes (peroxidase, phospholipase D1/2, poly(A)-specific ribonuclease, mitochondrial phosphate carrier protein 3 and cleavage and polyadenylation specificity factor subunit 4). Similarly, the novel *mireap-m0100-5p* targeted only one gene (thiazole biosynthetic enzyme), *mireap-m0087-3p* targeted two genes (L-ascorbate peroxidase and WRKY transcription factor 26) but *mireap-m0077-3p* targeted seven genes (aconitatehydratase, catalase, peroxidase, WRKY, heat shock 70kDa protein 5, lipoxygenase and malonate-semialdehyde dehydrogenase). Among the different targets, peroxidase gene was targeted by most of the known and novel miRNAs.

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

Sucrose regulating genes in sugarcane – analysis of transcript diversity and identification of isoforms / transcript variants

RNA for Iso-Seq sequencing was collected from *S. spontaneum*, *S. officinarum* and sugarcane hybrid genotype, Co 11015 at 12th month of planting. For *S. spontaneum,* accession Coimbatore was taken while for *S. officinarum,* Black Cheribbon accession was selected and the sample was taken from ICAR SBIRC Kannur. The samples were sent to Nucleome Informatics lab facility for long read sequencing. The Iso-seq reads were obtained and sequence analyses is in progress. Meanwhile, from the previous transcriptome studies carried out with eight high sugar and eight low sugar Australian genotypes, SWEETs were found to be highly differentially expressed. In order to find the isoform specific expression of SWEETs in our hybrid genotypes, 114 SWEET transporter sequences from published sugarcane long read transcriptome were retrieved. Bioinformatics analyses for protein properties, full length coding sequences, motif distribution, allelic variations, conserved domain prediction, structure, and evolutionary relationship among the SWEETs from related genera like *Zea mays* and *Sorghum* were performed (Fig. 15). The phylogenetic tree of SWEET proteins was constructed by neighbour-joining method with a bootstrap of 1000 replicates. The enrichment analyses and network were constructed using STRING available in ExPaSy database. Structure of the SWEET protein with seven transmebrane domain was confirmed by using SWISS-MODEL with Arabidopsis SWEET1 template, unique SWEET isoforms were selected out of the 114 and also from NCBI from other reported crops and primers were designed for carrying out expression studies. Quantitative real time PCR analyses were performed with a set of sugarcane genotypes consisting of two high sugar (Co 11015, Co 86032) and two low sugar genotypes (Co 62175, MS 68/47) at 10th month of planting (Fig. 16). The results revealed very clear differential expression between the two sets proving that SWEETs play a regulatory role in sucrose accumulation during maturity. Full-length sequences of SWEET1, SWEET2a, SWEET3a and SWEET14 that were differentially expressed were cloned and sequenced and functional char-

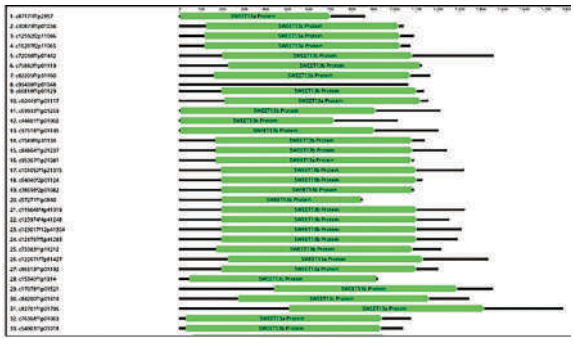


Fig. 15. SWEET gene transcripts identified and characterized for coding region using Geneious version 2021.1 from the sugarcane long read reference transcriptome

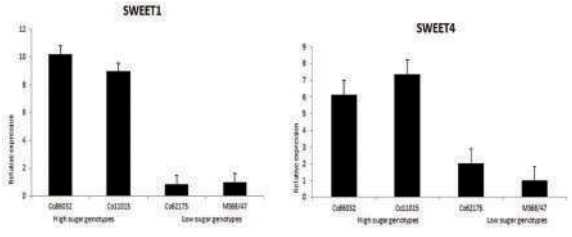


Fig. 16. Expression profiling of SWEET genes using qRT-PCR showing relative expression of SWEET1 and SWEET4 in high sugar and low sugar genotypes

acterization is in progress. These genes were highly differentially expressed showing more than 10 fold expression difference in high sugar genotypes.

(P.T. Prathima and T. Lakshmipathy)

Isolation and characterization of genes associated with high Water Use Efficiency (WUE) in sugarcane cultivars

Retrieved gene sequence, the S-type anion channel gene (SLAC) from the sugarcane monoploid genome database and primers were designed to amplify the 1.26 kb coding regions of the gene. The PCR reaction was carried out using the template DNAs of the sugarcane variety, CoM 0265. A 1329 kb sequence data was obtained by sequencing the PCR products in both the forward and reverse direction. The sequences were found to correctly match with the SLAC genes of the sugarcane monoploid genome database. The sequence was found to have 54% similarity with the SLAC gene from the sugarcane monoploid genome (R570 cultivar genome). The NCBI blast results showed that the sequence had 92% similarity with the *Sorghum bicolor* SLAH2 gene, 89% similarity with the *Zea mays* SLAH3 gene, 84% similarity with the *Setaria italica* gene, 77% similarity with the japonica rice SLAH2 gene. A dendrogram was constructed with the sequences of the matching sequences using the fast minimum evolution method with the maximum sequence difference setting at 0.75 (Fig. 17). The low similarity between the sugarcane varieties could be due to the variable levels of introgression of SLAC genes in these varieties or due to the environmental or selection pressure operating in the field conditions. Among the monocots, the maximum similarity was found with the sorghum SLAH2 gene and the lowest similarity was observed with the *Oryza brachyanda* SLAH2 gene. Cloning of SLAC gene was carried out for two of the high WUE varieties (Co 10026 and Co 85019) and one low WUE(Co 86032) variety of sugarcane as per published literature and yet to be sequenced.

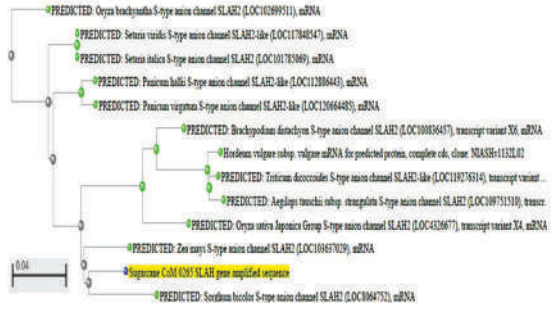


Fig.17. Phylogenetic Tree of the SLAC gene from Sugarcane CoM 0265 showing close evolutionary relationship with Sorghum and Maize

PCR amplification and sequencing was carried out for the variety (CoV 92102) for the SLAC gene and no match was found. Out of the 683bp sequence from the variety 302bp matched with the SLAC gene from sugarcane monoploid genome. NCBI search showed no significant matches.

PCR amplification and sequencing was carried out in two varieties (CoM 0265 and CoV 92102) for the SLAC 100 gene. No match was found with any of the sequences in the database.

PCR amplification and sequencing was carried out in six varieties (Co 62175, CoV 92102, Co 85019, Co 94008, BO 91 and Co 8021) for the GTL1 A (Trihelix transcription factor) gene. All sequences matched with the maize and Sorghum GTL 1 gene in the database.

The PCR amplification and sequencing was carried out in two varieties (CoM 0265 and CoV 92102) for the GTL 1C (Trihelix transcription factor 2) gene. Both the sequences matched with the GTL 1 gene of Sorghum and maize in the database (Fig. 18)

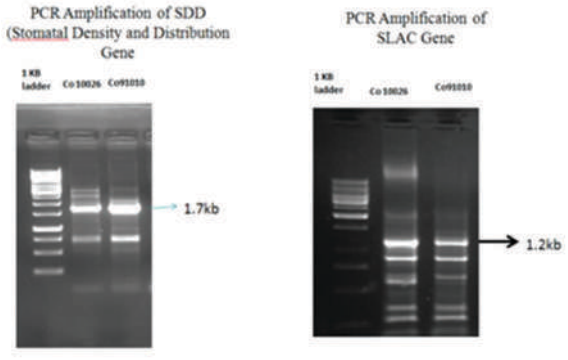


Fig. 18. PCR amplification of SDD and SLAC gene

The PCR amplification and sequencing was carried out in two varieties (CoM 0265 and CoV 92102) for the Stomatal Density and Distribution gene (SDD). Both the sequences didn't match with the gene in the database.

Stomatal density studies were carried out for midrib lower, midrib upper, epidermis lower and epidermis upper in 31 sugarcane varieties. Microscopic observations were completed for 19 varieties. The stomatal count, epidermal cell count and stomatal index were calculated from the abaxial and adaxial side of the lamina (Average of 4 regions). The distinct morphology of some leaf lamina cells was also recorded. The varieties, Co 99004 and CoLk 8102 recorded a maximum of 26 stomata in the lower lamina and the varieties, Co 2001-08 and Co 0212 recorded a maximum of 16 stomata in the upper lamina (per field of view at 20X). The stomatal index

Table 11. Stomatal Density, Stomatal Index and epidermal cell count of sugarcane varieties in upper and lower leaf

Sugarcane Varieties	Laminar (Stomatal Density, Stomatal Index (%) and epidermal cell count)		Midrib (Stomatal Density and Stomatal Index (%) and epidermal cell count)	
	Lower	Upper	Lower	Upper
CoV 92102	7/14.2/42	-	-	-
Co 0238	9/12.8/61	-	12/21.8/43	-
Co 740	8/16.6/40	11/14.8/63	12/19.6/49	10/9.1/99
Co 62175	13/23.2/43	-	8/17.3/38	-
Co 94008	9/11/65	8/6.6/112	12/15.7/64	7/17/34
Co 85019	14/19.7/57	-	13/14.6/76	9/8.1/112
Co 1148	13/6.6/78	11/11.6/84	13/13.3/86	8/13.1/53
Co 86249	12/10/108	9/8.5/96	18/15.3/72	13/12.4/92
Co 2001-8	16/12.7/110	16/17.5/75	11/12.8/80	-
Co 0212	13/14.6/76	16/14/98	17/14.4/101	6/8.8/62
Co 99004	28/18.91/120	12/16.6/66	18/21.42/72	12/14.28/60
CoLk 8102	28/21.05/105	14/16.7/70	27/21.95/96	15/18.07/68
BO 91	25/14.28/150	15/10/100	26/20.47/101	11/10/99
Co 8021	27/14.43/160	8/8.16/90	15/10.34/130	7/7.2/90
Co 86010	30/21.42/110	17/12.40/120	26/18.43/115	-
Co 86032	22/14.47/130	18/10.40/155	30/19.35/125	13/9.1/129
Co 13006	13/8.87/135	14/9.09/140	30/21.42/110	16/12.69/110
Co 15007	31/19.87/125	22/14.01/135	-	16/10.25/140
Co 10026	16/16.3/160	16/9.3/155	31/15.73/166	9/5.4/155

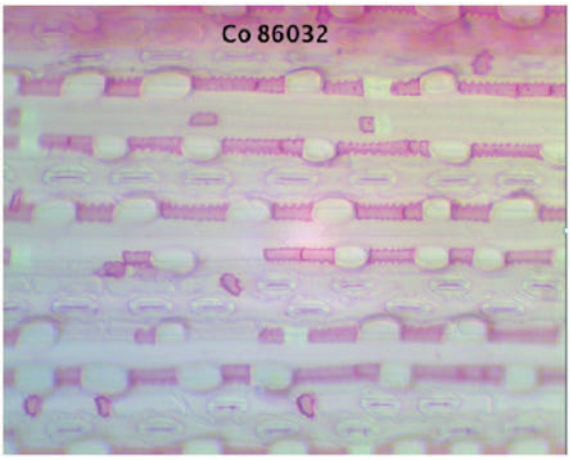


Fig. 19a. Stomata of Co 86032

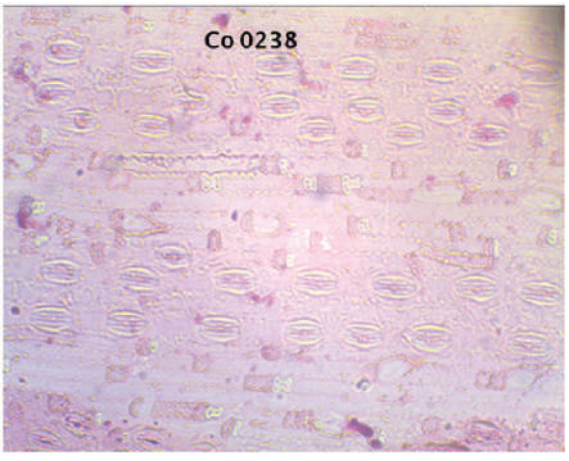


Fig 19b. Stomata of Co 0238

was the highest in lower lamina for the variety, Co 62175 followed by CoLk 8102 at 23.2 and 21, respectively. In upper lamina the stomatal index is the highest for Co 2001-08 at 17.5 followed by CoLk 8102 at 16.7 (Fig. 19a and 19b; Table 11).

(K. Deva Kumar and P.T. Prathima)

Deep sequencing of suppression subtractive libraries for prospecting differentially expressed genes / transcription factors from the sugarcane hybrids exposed to drought and salinity stress

The project work has been initiated with the identification of differentialy expressed genes / transcription factors in 20 clones varying in drought and salinity tolerance. A field experiment has been designed for drought and salinity tolerance experiments. Isolated total RNA from different tissues (leaves, stem, root and pollen) of three clones Co11015, Co 12009 and IND 16-1762. The isolated total RNA was quantified through NanoDrop and converted into cDNA. Then the cDNA was normalized with 25S rRNA. Real time primers were designed for certain lipid signalling genes and performed absolute quantification of these genes.

(K. Lakshmi, A. Selvi, R. Gomathi, A. Suganya and K. Deva Kumar)

Gene discovery and genetic transformation in sugarcane

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

The promoter isolated from *Erianthus* (EriPht) showed constitutive expression. To identify the core region of the EriPht promoter that control the expression pattern in different tissues and organs at various developmental stages, five deletion construct were generated. Among them, three deletion constructs D2, D3 and D5 were mobilised to *E. coli* DH5α. After transient GUS expression confirmation, these constructs were mobilised into *Agrobacterium* LBA4404 and confirmed by colony PCR, plasmid PCR and restriction digestion. The tobacco leaf discs infected with *Agrobacterium* having deletion constructs were co-cultured on plant transformation medium. The putative transformed leaf discs were transferred into selection medium containing hygromycin. After four rounds of selection, the callus was transferred to plant regeneration medium. The transformed plants were kept for hardening in glass house conditions and hardened plants were planted in pots for seed production. The seeds from T1 were harvested from putative transgenic plants, and were sown to get T2 seedlings.

(C. Appunu and H.K. Mahadevaswamy)

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

Identification of DETs associated with saline response in S. spontaneum clone: The secondary PCR products obtained were sequenced. A total of 5.5

million raw reads were obtained, of which about 5.1 million clean reads were retained and used for mapping to the reference transcriptome. By mapping the clean reads of SSH library to the sugarcane reference transcriptome, we were able to identify 314 DETs in the salinity treated samples after subtraction. These transcripts were first annotated against the GO database to reveal the enriched biological functions associated with the DETs. BlastX analysis of the DETs from salinity treated samples showed "top hit species distribution" with *Sorghum bicolor, Zea mays, Saccharum* hybrid cultivar R570, *S. officinarum, Panicum virgatum* and *S. spontaneum.* Functional annotation categorized the DETs into three principle GO groups as biological process, molecular function and cellular component. Among the DETs assigned to the biological process group, the highest proportions of transcripts were involved in biosynthetic process (31 transcripts, 23%), nucleobase-containing compound metabolic process (26 transcripts, 19%), response to stress (18 transcripts, 13 %), cellular component organization (17 transcripts, 13%) and transport (16 transcripts, 12%). In the molecular function group, nucleotide binding was prominent (75 transcripts, 33%), followed by protein binding (55 transcripts, 44%) and hydrolase activity (40 transcripts, 17%). In cellular component, most of the transcripts were assigned to cytoskeleton (27 transcripts, 34%), nucleus (22 transcripts, 27%), endoplasmic reticulum and plasma membrane (8 and 7 transcripts, 10 and 9%, respectively) (Fig. 20).

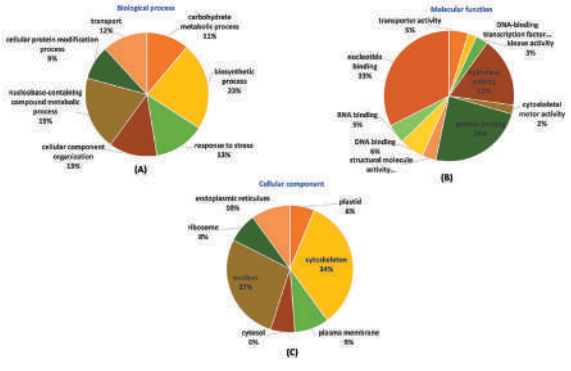


Fig. 20. Gene ontology distribution of upregulated transcripts identified in* S. spontaneum *clones exposed to salinity stress

Key genes and pathways activated during saline stress in S. spontaneum: Important functional groups of the 314 DETs activated during salinity stress in *S. spontaneum* were identified using Mercator automated sequence annotation pipeline. Result suggested that a large proportion of the DETs were attributed to bins 29 (protein), 31 (cell), 20 (stress), 27 (RNA/TFs), 34 (transport), 30 (signalling), 33 (development), 17 (hormone metabolism) and 26 (miscellaneous enzyme families), 10 (cell-wall), 21 (reduction-oxidation regulation) and 13 (amino acid metabolism).

Among these, the most significant functional bin 29 (protein) was composed of 58 transcripts involved in protein glycosylation, protein folding, heat shock protein 70 and protein degradation through ubiquitin E2 and E3. In addition, the transcripts coding for ubiquitin-dependent protein catabolic processes, protein degradation through serine protease and cysteine protease, protein post-translational modification, chloroplast-localized thylakoid formation were identified. Notably, functional bin 31 'cell' comprised 34 transcripts coding for vesicle transport, cell division, organization and cytoskeleton myosin (Class 9, 7) which encodes an alpha-tubulin isoform involved in response to salt stress, protein binding and structural constituent of cytoskeleton. The bin 20 'stress' represented transcripts coding for wound-responsive protein which functions in DNA binding and nuclease activity, heat shock protein 70 involved in protein folding, response to cadmium ion, response to salt stress, response to virus, response to heat, and heat shock protein 90.

Functional bin 27 'RNA/TFs' comprised 27 transcripts encoding for TFs for RNA regulation such as Acyl-CoA N-acyltransferase with RING/FYVE/PHD-type zinc finger protein, RNA binding protein with nuclease activity that are essential for stress response. These TFs are involved in mechanisms acting on mRNAs entering the secretory pathway. Among the transcription regulators, identified the prominent transcripts were Nascent polypeptide-associated complex (NAC) which is involved in response to salt stress, MYB domain protein 59 TF (MYB59) which is induced in response to cadmium ion, regulation of tran-

scription, DNA-dependent, response to chitin, and response to salicylic acid stimulus. Other TFs induced during salinity stress were homeobox TF family, a member of the class III HD-ZIP protein family which contain homeodomain and leucine zipper domain that are critical for vascular development and negative regulation of vascular cell differentiation. Additionally, C2H2 zinc finger family TFs, basic helix-loop-helix family and A- type response regulator (RR3) involved in cytokinin-mediated signaling were also induced in *S. spontaneum* clones due to salinity stress (Fig. 21).

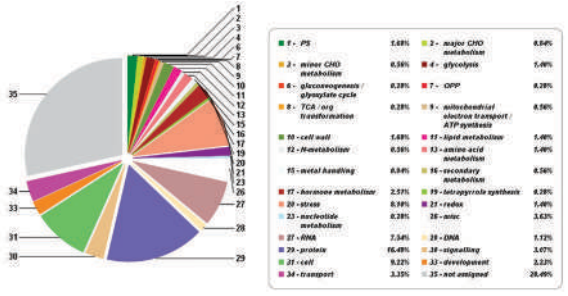


Fig. 21. Functional annotation of upregulated transcripts identified in this study. Map-man analysis of the upregulated transcripts identified in* S. spontaneum *clones exposed to salinity stress

Functional bin 34 "transport" comprised 12 transcripts, coding for putative secretory carrier membrane protein (SC3) involved in transmembrane transporter activity, type II H+-PPases that localizeing function as a proton pump of the golgi apparatus. Aquaporin PIP1.1 (plasma membrane intrinsic protein 1a, PIP1a) functions in water channel activity and plays a vital role in response to salt stress. ABC transporters involved in ethylene signal transduction, acts downstream of CTR1, positively regulates ORE1 and negatively regulates miRNA, mir164A, B, C to regulate leaf senescence. ETHYLENE INSENSITIVE 2 (EIN2), sugar transporters sugar transport proteins (AtSTPs) are involved in monosaccharide transport. KEGG metabolic pathway analysis provided additional information on the pathways that the DETs are involved. The largest functional pathway identified was the starch and sucrose metabolism pathway followed by pyruvate metabolism, methane metabolism, oxidative phosphorylation, arginine biosynthesis and glycolysis/gluconeogenesis pathways (Fig. 22).

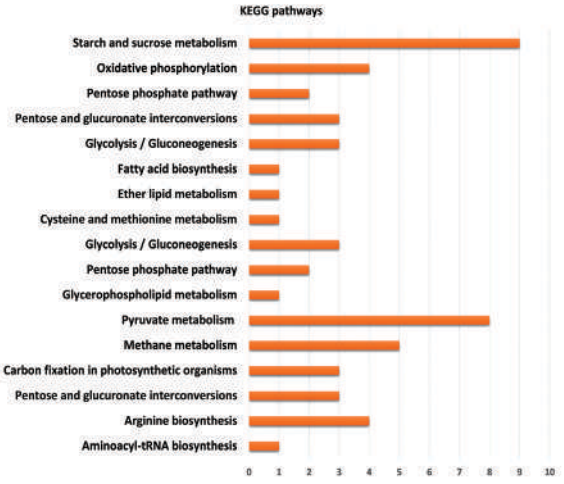


Fig. 22. KEGG pathway analysis of the upregulated transcripts identified in* S. spontaneum *clones exposed to salinity stress.

(K. Lakshmi and S. Vasantha)

CRISPR/Cas9-mediated targeted mutagenesis in sugarcane

This initiative began with the goal of establishing gene editing in sugarcane. Clones with varied chromosomal numbers were used to examine gene editing efficiency. This study focused on *Erianthus arundinaceus* clone SES 153 (2n=30), *E. arundinaceus* clone SES 133 (2n=60), and *Saccharum commercial* hybrid Co 86032 (2n=112). *Phytoene Desaturase* (PDS) gene was targeted to validate the genome editing in these clones through CRISPR/Cas9 mediated gene editing. *Erianthus* clones chromosome numbers were confirmed through cytology studies (Fig. 23). The PDS gene was cloned from commercial sugarcane variety, Co 86032 and *Erianthus arundinaceus* with a size of 1713bp. The genetic transformation of four guide RNA constructs was carried out. Calli are in selection stage.

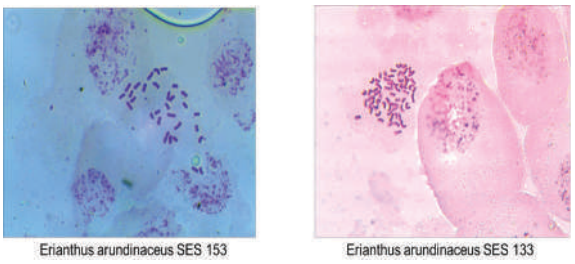


Fig. 23. Cytology study of chromosome numbers of* Erianthus arundinaceus *SES 153 (2n=30) and SES 133 (2n=60)

(C. Appunu and R. Valarmathi)

Deciphering the molecular mechanism regulating tillering in sugarcane through functional genomics approach

The study was initiated to understand the molecular mechanism regulating tillering in sugarcane through functional genomics approach. Sugarcane genotypes (Co 14016, Co 86032, CoC 671 and Co 99004) contrasting for tillering behaviour were selected and screened for both tiller bud initiation and bud outgrowth at different developmental stages. High tillering genotypes showed early bud emergence as well as early establishment of tillers compared to the low tillering genotypes. To understand the molecular role of genes in tillering, relative expression of strigolactone branching inhibitor gene (MAX) was studied in the genotypes contrasting for tillering behaviour. The study showed significant variation in expression profiles of (MAX) among high tillering and low tillering genotypes. Branching inhibitors were less expressed in high tillering genotypes compared to the high transcript abundance in low tillering genotypes. To develop mutant population of Co 99004, callus was generated from young leaf whorls and established calli were exposed to different concentration of EMS and LD50 was standardized.

(R. Valarmathi, K. Mohanraj and C. Appunu)

MULTI-DISCIPLINARY PROJECTS

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

Inbreeding

Molecular genotyping of inbreds: Twenty eight advanced generation inbreds of Co 1148 along with parent were genotyped with 11 STMS markers, and genotypic data were run in STRUCTURE to identify the subpopulations with larger genetic differentiation from the parent (Fig. 24). Accordingly, the selfs, 1148-13-11-2-242-3-272, 1148-13-11-2-237-2-61 and 1148-13-11-2-237-6-328 were identified as relatively homozygous and were utilised in crossing with 1148-13-11-2-237-2-61 as female parent to develop hybrid populations.

Crossing season 2021: A total of 33 selfs and 23 crosses among inbreds of different selfing generations were effected. Majority of selfs from S7

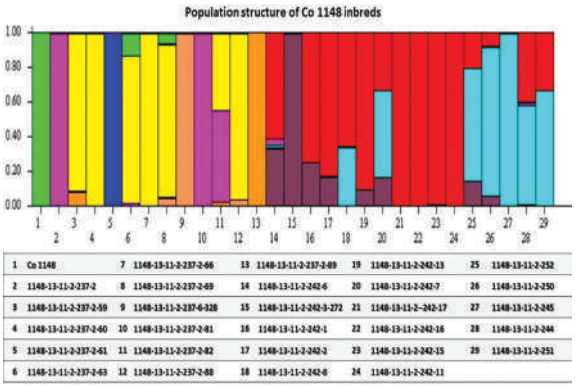


Fig. 24. Population structure of Co 1148 inbreds

generation of Co 1148 were selfed for further advancement and new clones were also selfed to derive selfed progenies.

Phenotypic evaluation of inbred and hybrid populations: Out of 82 selfs tested for reaction to red rot, six were found to be resistant and 25 were moderately resistant. Juice analysis was conducted in hybrid progeny from two crosses *viz.*, 1148-13-11-2-237-2-61 x 1148-S4-242-3-272 (Hybrid 1), 1148-13-11-2-237-2-61 x 1148-13-11-2-237-6-328 (Hybrid 2) involving advanced selfs of Co 1148. The progenies of these two crosses did not differ significantly from each other for cane diameter, juice brix, sucrose and purity, but Hybrid 1 recorded significantly higher mean values for cane height and single cane weight than other cross as inferred by two sample t-test. Out of newly developed selfs, 1148-13-11-2-252-250-30 recorded 18.66% sucrose, which was on par with standard Co 86032. Among hybrids, three clones recorded sucrose content greater than 19%.

Forty progenies each of four advanced generation (6^{th} & 7^{th}) selfs of Co 1148 and two hybrid populations derived by crossing the sixth generation inbreds of Co 1148 were evaluated for HR brix (%), stalk length (cm), stalk diameter (cm) and single cane weight (SCW) (kg) at 11^{th} month of crop growth. On comparing the four inbred families, it was found that there were no significant differences for cane diameter over the populations while the 1148-13-11-2-252-170 family was significantly different from other populations for stalk length and single cane weight. For HR brix, no significant differences were observed between 1148-13-11-2-252-170, 1148-13-11-2-237-2-61 and 1148-13-11-2-242-1-46 fam-

ilies. Considerable improvement was observed in hybrid populations compared to inbred populations for all the traits recorded except HR brix. The lower CV for all traits in the hybrid populations compared to inbred populations indicated the homogeneity of hybrid populations (Fig. 25).

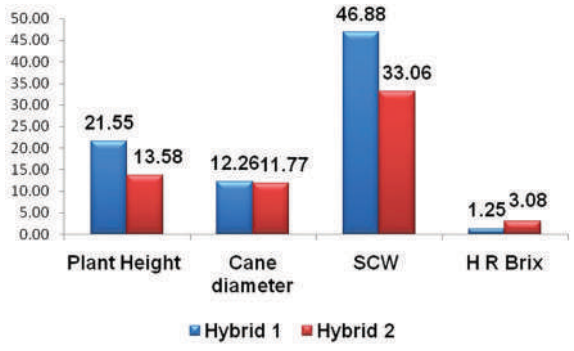


Fig. 25. Hybrid vigour of different traits in hybrid populations

New selfed and hybrid populations developed in 2019 flowering season were planted in November 2020, nearly 400 selfed and crossed progenies were evaluated for HR brix at 10th month. Both selfed, and hybrid progeny from 0112-65 recorded lower variance for the trait. The selfed progeny of 1148-13-11-2-252-170 recorded high mean value of 20.87 with less variance. These parental selfs and derived populations will be focussed to derive and identify more homozygous lines subsequently. At Kannur 26 selfings were attempted on third, fourth and fifth generation selfs and fluffs were sown to advance generation.

(G. Hemaprabha, A. Annadurai, T. Lakshmi Pathy, V. Vinu, K. Chandran)

Anther culture

Total of 27 calli or plants developed from anther culture (2019 series) and explant Co 86032 were evaluated for morphological variations as per the DUS descriptors (age of the plants: 200 days). Among them, three calli were differing for morphological variations (Fig. 26) as compared to Co 86032. Buds are ovate in shape, but most of them germinated and placed above the growth rings. Bud grooves are prominent and extended up to next nodes. Overall, these three calli/plants lost their vigour and clearly visible in terms of their plant height (100.33 – 113.33 cm), thin stem (1.75-2.04 cm), narrow leaves (3.3-4.1

Fig. 26 Anther derived plants growing under field conditions

cm), reduced internode diameter (1.75-2.04 cm), root band width (0.64-0.89 cm) and high number of shoots or canes per clump (12.67-16.67/clump). This shows that these plants might have developed from a microspore. Molecular characterization of these plants using NKS markers did not show any polymorphism. Further molecular characterization using rice SSR markers and genome size estimation using flow cytometry analysis is in progress at ICAR-NRRI, Cuttack and cytological characterization at ICAR-SBI, Coimbatore. Remaining 24 plants resembled exactly as Co 86032 and these plants are likely to be developed from the somatic cells of anthers. Co 86032, Co 0238, Co 0212, Co 11012, CoVc 14061 and Co 12009 were used for anther culture studies during the flowering season 2020-21 and cultured around 3000 test tubes. All these genotypes were symptomatic, but did not respond to androgenesis except Co 86032. Total of 97 calli were derived from Co 86032 and among them, 32 regenerated into green plants. These plants are transplanted into field for further evaluation.

(C. Mahadevaiah, Sanghamitra Samantaray (ICAR-NRRI, Cuttack), H.K. Mahadevaswamy and A. Suganya)

Chromosome elimination

The identified CENH3 mutants of Co 775 has been subjected for CENH3 amplification (650 bp fragment) and it has been cloned into a T/A cloning vector. This PCR product was sequenced. Induced point mutations were found in the five clones of Co 775 across the sets of chemically mutagenized populations. EMS normally converts GC to AT due to recurrent alkylation of guanine remnants. As reported in ma-

jor plant model species, including arabidopsis, wheat, maize, and pea, we also detected point mutations that led to GC: AT base conversions.

Five CENH3 mutant clones of Co 775 (E2, E5, E6, E10 and E11) were planted in the field during 2019-20. Out of five, only one clone, E11, flowered during last flowering season. As two arrows were obtained were used as female as well as male parent and crossed with CoC 671. Seeds were collected and sowing has been done. Germination was very poor, only few seedlings were obtained.

In order to use *Erianthus* as a haploid inducer for uniparental genome elimination, mutant population has been developed from an *Erianthus* clone, SES 153, by treating the embryonic calli with different concentrations of EMS. Isolated genomic DNA was purified from 56 samples of *Erianthus* clone SES 153 mutants which were quantified through gel electrophoresis and NanoDrop. All the *Erianthus* samples were diluted proportionately to make the 4X and 8X pools in such a way that equal amount of genomic DNA has been represented from every individual. Prepared 14 pools of *Erianthus* mutants and these pools were subjected for CENH3 amplification. Multiple bands were observed in the amplification of the CENH3 region and standardized the PCR programme for *Erianthus* clones. The PCR programme standardized earlier was for Co 775 mutants and the primers were from maize. Hence new fresh primers were designed also for *Erianthus* CENH3 amplification.

(V.P. Sobhakumari and K. Lakshmi)

Wide hybridization

Seven wide crosses were made using gamma ray irradiated pollens to generate haploid sugarcane. The crosses effected were, (i) ISH 100 x Maize (UV irradiated), (ii) CoOr 03152 x Sorghum (UV irradiated), (iii) CoPb 09181 x CoJ 64, Co 11015, CoPt 97222 (UV irradiated), (iv) Co 98010 x Agl2018-24, Co 11015 (UV irradiated), (v) Co 06022 x *S. spontaneum* (UV irradiated), (vi) CoC 671 x Bajra (UV irradiated) and (vii) Co 0118 x *E. arundinaceus* (UV irradiated). The fluffs were harvested and yet to be sown.

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

Evaluation of hybrids

Tropical (Coimbatore)

Assessing variability in the intermated inbred progenies

Hybrid seedling progenies from six combinations between inbreds at different stages of selfing were screened for cane yield traits and HR brix at 240 days. Four combinations had more than 100 seedlings for screening. Out of six crosses evaluated, the combination, 775-102 x MS68/47-27 (S1 x S1) recorded the least variability for cane diameter (CV= 10.75%), cane height (18.76%), single cane weight (19.78%), number of millable canes (49.51%) and HR Brix (14.33%). Among the traits, cane diameter was the least variable while NMC per clump registered the highest variation (Table 12). For stalk colour, the seedling progenies of this cross exhibited only yellow green colour. High frequency of transgressive segregants (TS) was observed for cane height (58.51%) and HR Brix (62.64%). Also this cross comprised of large number of recombinants performing above cross mean (CM) for cane yield traits and HR brix (Fig. 27).

Table 12. Percent variation for cane yield traits and HR Brix in the cross with least variability

	S1 x S1 (775-102 x MS68/47-27)				
	NMC/clump	Cane diameter (cm)	Cane height (cm)	Single cane weight (kg)	HR Brix(%)
Mean	5.00	2.53	164.41	0.70	16.38
MIN	2.00	2.08	70.00	0.45	12.00
MAX	16.00	3.56	255.00	1.45	21.20
SD	3.20	0.45	25.22	0.27	2.35
CV (%)	49.51	10.75	18.76	19.78	14.33

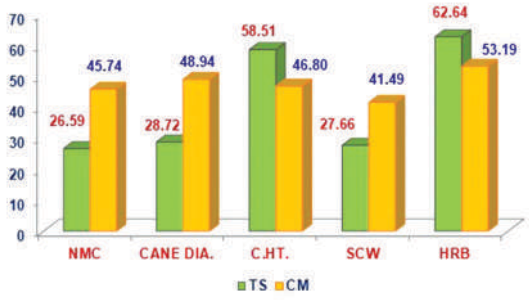


Fig. 27. Percent transgressive segregants for cane yield and juice quality traits

Biparental crosses to study stalk colour variation

To study the pattern of segregation for stalk colour, 12 combinations were effected between contrasting stalk colours. Three crosses between yellow green and dark purple (CoTl 14111 x Co 0209, CoM 0265 x Co 0209, Co 97009 x Co 94008) were effected. Crosses between yellow green and greyed purple (CoM 0265 x Co 11015), purple and ash green (87A 380 x Co 12009), purplish red and green (Co 14020 x Co 93009) were also attempted.

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

Evaluation for diseases

Effect of fungicide treatment on germination of true seed

The fuzzed and defuzzed seeds of Co 09004 were treated with fungicide Taqat 0.1% (Captan 70% + Hexaconazole 5% WP), shade dried and stored at -20 ^{0}C and assessed for germination at 9 and 11 months after storage. The true seeds without fungicide treatment were also stored at -20 ^{0}C and used as control. The initial germination of defuzzed seeds was 85% and fuzzed seeds were in the range of 75 to 78%. Germination of fungicide treated defuzzed seeds and its control were 27% and 23%, respectively while germination of fungicide treated fuzzed seeds and their respective controls were 18% and 15%, respectively at 9 months after storage. Similarly, at 11 months after storage, germination of fungicide treated defuzzed seeds and its control were 15%, and germination of fungicide treated fuzzed seeds and their respective controls were 13% and 11.5%, respectively. The results clearly showed that fungicide treated seeds stored up to 11 months had no phytotoxic effect on germination.

(V. Jayakumar and K. Nithya)

Seed processing, packaging and storage

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

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

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

From defuzzed seed, mean 100-seed weight of defuzzed seed has been 76.32 mg and 100-seed weight among 161 clones ranged from 32 mg (Co 62422) to 126 mg(Co 97004). The mean germination percent of defuzzed seed was 2.93% and it ranged from 0% (54 Clones) to 56% (Co 8311) among 161 clones.

Defuzzing by hammer mill was successful to generate high proportion of viable seeds.

(N. Rajendra Prasad)

All India Coordinated Research Project (Sugarcane)

(I) Peninsular Zone

Initial Varietal Trial

Among the 18 entries evaluated, Co 17004 recorded the maximum CCS yield of 22.16 t/ha followed by Co 17001 (21.42 t/ha) and Co 17005 (19.25 t/ha) compared to the standards Co 09004 (19.41 t/ha), CoC 671 (18.12 t/ha) and Co 86032 (16.65 t/ha). For cane yield, the entry Co 17004 recorded the highest cane yield of 157.67 t/ha

followed by Co 17001 (147.68 t/ha) and CoN 17072 (139.69 t/ha). Among the standards, Co 09004 recorded 125.43 t/ha followed by Co 86032 (121.75 t/ha) and CoC 671 (115.95). The highest sucrose content at 12th month was recorded by CoC 671 (22.05%) followed by Co 09004 (21.92%) and at 10th month also CoC 671 recorded the highest sucrose content of 21.40% followed by Co 09004 (21.03%) and Co 86032 (17.77%). Among the test entries, Co 17003 recorded the highest sucrose content of 22.42% and 19.88% at 12th and 10th months respectively. For CCS, Co 17003 recorded the highest value of 15.93 % followed by Co 17013 (14.53%) at 12th month compared to the standards CoC 671 (15.62%) and Co 09004 (15.44%).

(P. Govindaraj and C. Appunu)

Multiplication and exchange of seed material

The 23 clones of 2019 Co series approved for testing under AICRP(S) were multiplied at ICAR-SBI, Coimbatore and supplied to six centres (Mandya, Pugalur, Thiruvalla, Rudrur, Sameerwadi and Powarkheda) for conducting IVT (Initial Varietal Trial) in the respective centers. The 14 clones of 2016 series and the 13 genotypes of 2018 series along with three zonal standards (Co 86032, CoC 671 and Co 09004) were multiplied for conducting AVT and IVT during 2021-22 at Coimbatore Centre.

(R.M. Shanthi and C. Mahadevaiah)

Advanced Varietal Trial - Plant I

Co 09004 was the best among the standards in the trial for CCS yield (16.66 t/ha) and three test entries *viz.*, Co 11015 (22.75 t/ha), Co 15017 (20.01 t/ha) and Co 15021 (19.57 t/ha) recorded significantly higher CCS yield than Co 09004. Two entries *viz.*, Co 11015 (148.98 t/ha) and Co 15009 (144.49 t/ha) recorded significantly higher cane yield than the best standard Co 86032 (118.77 t/ha). At 360 days Co 11015 was the only test entry that recorded numerically higher sucrose % (21.53) as well as CCS % (15.27) than the best standard CoC 671 (sucrose%: 21.22; CCS%: 14.64). At 300 days, the entries Co 11015 (21.55%) and Co 15007 (21.49%) recorded numerically higher sucrose than the best standard Co 09004 (21.07%). CCS% of Co 15007 (15.14) and Co 11015 (15.12) at 10th month were higher than the standard Co 09004 (14.73). The test entry Co 11015 recorded numerically higher sucrose at 240 DAP (18.32%) in comparison to the standard Co 09004 (17.66%). Based on the cane yield and juice quality parameters, Co 11015 was identified as the best entry.

(R. Karuppaiyan and V. Sreenivasa)

Advanced Varietal Trial - Plant II

Among the 15 entries evaluated, Co 14027 recorded the highest juice sucrose of 16.21% followed by Co 14012 (16.13 %) and Co 14004 (16.05 %) compared to the sucrose rich standard CoC 671 (15.62%) at 240 days. CoC 671 was the best standard with 20.84% sucrose at 300 days as well, and five entries namely Co 14032 (19.89%), Co 14004 (18.99%), CoVc 14062 (18.71%), Co 14030 (18.54%) and CoTl 14111 (18.20%) were found to be promising. At 360 days Co 14027 recorded the highest sugar yield (19.11 t ha^{-1}) and cane yield (143.29 t ha^{-1}) in comparison with the standard Co 86032 (16.24 t ha^{-1} and 123.37 t ha^{-1} respectively) and the entries Co 14002, Co 14016, CoN 14073, CoSnk 14102, CoTl 14111 and MS 14082 were numerically superior to standard Co 86032. Co 14032 recorded the highest juice sucrose (20.90%) followed by Co 14004 (19.92%) in comparison to the standards Co 86032 (18.70 %) and CoC 671 (20.92%). Among the entries, Co 14027 combined both yield and quality and it recorded 19.92 per cent improvement for cane yield and was on par for quality in comparison with the standard Co 86032.

(S. Karthigeyan and S. Alarmelu)

Advanced Varietal Trial- Ratoon

For CCS yield, CoC 671 (17.30 t/ha) was the best standard and Co 14027 (19.77 t/ha), Co 14002 (17.80 t/ha) and MS 14082 (21.70 t/ha) were superior to CoC 671. Three entries *viz.*, Co 14027 (132.67 t/ha), Co 14002 (124.22 t/ha) and MS 14082 (147.43 t/ha) were superior to the best standard Co 86032 (117.07 t/ha) for cane yield. Co 14032 with 21.74 % juice sucrose content was found superior to CoC 671 (21.29%) at 270 days. Three entries *viz.*, Co 14004 (21.12%), Co 14030 (20.93%) and Co 14032 (21.74%) were identified

to have significantly higher sucrose content than Co 86032 (19.63%). At maturity, none of the test entries recorded significantly higher sucrose than the best standard CoC 671 (22.66%). Co 14012 (21.80%) and Co 14027 (21.70%) recorded significantly higher sucrose content than the popular variety Co 86032 (20.49%). Based on cane yield and juice quality traits Co 14027 and Co 14002 were identified as the best entries.

(A. Anna Durai and H.K. Mahadevaswamy)

Advanced Varietal Trial (Mean performance of two plant and one ratoon 2019-21)

At Coimbatore, 15 entries were evaluated along with three standards (Co 86032, CoC 671 and CoSnk 05103) under Advanced Varietal Trial (AVT) Plant I during 2019-20, and AVT Plant II and AVT Ratoon during 2020-21. Pooled analysis revealed that MS 14082 (20.44 t/ha) followed by Co 14027 (19.8 t/ha), Co 14016 (19.06 t/ha) and Co 14002 (18.45 t/ha) were superior for CCS yield compared to the best standard CoC 671 (17.46 t/ha). For cane yield, MS 14082 (151.81) was the best entry followed by Co 14016 (138.82 t/ha), Co 14027 (138.42 t/ha) and Co 14002 (133.73) compared to the best standard Co 86032 (120.8 t/ha). None of the entries was found superior to the best standard CoC 671 for CCS% (15.21%) and sucrose % (21.57%). However, compared to the standard Co 86032 (19.43 %), five entries *viz.*, Co 14032 (21.04%), Co 14027 (20.54%), Co 14012 (20.11%), Co 14004 (20.43%) and Co 14002 (19.77%) recorded numerically superior sucrose % (Table 13).

(S. Alarmelu, S. Karthigeyan, A. Anna Durai, K. Mohanraj and H.K. Mahadevaswamy)

Initial Varietal Trial (2021-22)

In IVT (2021-22) 13 entries were evaluated along with three standards for juice quality at 240 days. Co 86032 was the superior standard with 15.76% sucrose and Co 18013 was the only entry that recorded numerically superior juice sucrose of 15.92%. Three test entries *viz.*, Co 18013, Co 18002 and Co 18003 recorded more than 95,000

Table 13. Performance of entries for cane yield and juice quality in two plant and one ratoon (Pooled mean)

Entries	CCS yield (t/ha)	Cane yield (t/ha)	CCS (%)	Sucrose (%)
Co 14002	18.45	133.73	13.82	19.77
Co 14004	15.74	109.77	14.33	20.43
Co 14012	16.13	115.76	14.01	20.11
Co 14016	19.06	138.82	13.77	19.70
Co 14027	19.80	138.42	14.33	20.54
Co 14030	13.61	99.57	13.66	19.56
Co 14032	14.11	95.65	14.72	21.04
CoN 14073	15.11	123.06	12.30	17.88
CoSnk 14102	16.58	129.01	12.87	18.47
CoSnk 14103	13.09	101.00	12.96	18.62
CoT 14367	10.15	82.02	12.41	17.93
CoTl 14111	15.06	116.03	12.97	18.69
CoVC 14062	12.99	94.45	13.70	19.76
MS 14081	15.32	113.54	13.51	19.35
MS 14082	20.44	151.81	13.51	19.38
Standards				
Co 86032	16.35	120.8	13.55	19.43
CoC 671	17.46	115.16	15.21	21.57
CoSnk 05103	15.09	120.39	12.58	18.12

millable canes per hectare as compared to the better standard Co 86032 (85,690/ha).

(R.M. Shanthi and C. Mahadevaiah)

Advanced Varietal Trial: Plant I (2021-22)

In AVT plant I, five entries were evaluated along with three standards and among the entries, Co 16006, Co 16010 and CoVSI 16121 recorded good tiller population at 120 days. Co 16006 and Co 16010 recorded more number of cane formed shoots at 180 days and good cane population at 240 days in comparison with the standards Co 86032 and CoC 671. Co 09004 was the best standard with juice sucrose of 17.68% at 240 days and none of the entries was found to be better than this standard. At ten months of age, CoC 671 was the best standard with 19.57% sucrose followed by Co 09004 (19.30%) and Co 86032 (17.46%). Two entries *viz.,* Co 16006 (19.82%) and CoVSI 16121 (20.55%) were promising for quality at 300 days.

(S. Alarmelu and S. Sheela Mary)

Advanced Varietal Trial: Ratoon (2021-22)

The NMC ('000/ha) at 9th month showed that the test entries Co 14005 (128.53), Co 15006 (104.05), Co 15017 (100.12) and Co 11015 (94.21) recorded numerically higher NMC than the standards. Juice parameters recorded at 9th month indicated that the entries, Co 11015 (21.14% sucrose & 14.98% CCS), Co 15007 (20.97% & 14.85%) and Co 15017 (20.68% & 14.65%) were numerically better than the best standard Co 86032 (18.53% sucrose & 12.99% CCS).

(V. Sreenivasa and R. Karuppaiyan)

Physiological parameters

Salinity

Plant data, juice quality and harvest data were recorded for AVT 2014 series and are reserved for verification. AVT 2014 series (eight clones) were replanted in micro-plots for confirming the data. AVT 2015 series (six clones) and 2016 series (four clones) were also planted in micro-plots.

(R. Arun Kumar, S. Vasantha and V. Krishnapriya)

Drought

Ten AVT clones from 2013 series and eight AVT clones of 2014 series along with resistant standards (Co 99004 and Co 86032) were planted in strip plot design. After 90 days of drought stress, plant height of control varied from 42.56 cm (Co 13008) to 72.10 cm (Co 13014) with an average of 60.68 cm, while in drought plot the variation was 32.68 cm (Co 13008) to 60.25 cm (Co 13013) with an average plant height of 43.62 cm. Drought induced 24.65% reduction of shoot population and the clones, Co 13006 and Co 13013 recorded high shoot population under drought situation. In 2013 series, control recorded an average NMC of 85.7 thousand per hectare, while drought plot recorded 62.5 thousand per hectare with mean reduction over control of 27.10 per cent. Drought induced reduction of 15.7, 17.2, 22.2 and 23 percent in cane length, cane girth, single cane weight, and cane yield, respectively. Among the AVT entries, Co 13013, Co 13009, Co 13002 and Co 13018 recorded comparatively high biometric observation under drought condition.

In Co 2014 series, control recorded an average NMC of 87.75 thousand per hectare, while drought plot recorded 65.5 thousand per hectare with mean reduction over control of 25.10 per cent. Drought induced 18.78, 17.0, 21.86 and 27.5 percent reduction in cane length, cane girth, SCW and yield, respectively. Among the 2014 AVT entries, Co 14016, Co 14002, Co 14012 and Co 14027 recorded comparatively higher biometric observation under drought condition. Based on the results of two years field experiments, Co 13013, Co 13009, Co 13002 and Co 13018 were rated as tolerant (T), Co 13020, Co 13006, Co 13008 and Co 13014 were rated as moderately tolerant (MT) and Co 13003 and Co 13004 were rated as susceptible (S) among the 2013 series, and Co 14016, Co 14012 and Co 14002 were rated as tolerant (T), Co 14027 and Co 14032 were rated as moderately tolerant (MT) and Co 14004 and Co 14030 were rated as susceptible (S) among the 2014 series (Table 14).

During 2021-22 planting season, 10 AVT clones from 2015 series and three AVT clones of 2016 series along with resistant standards (Co 99004 and Co 86032) were planted in strip plot design.

Table 14. Rating for drought tolerance in 2013 and 2014 AVT clones

Rating	2013 Series	2014 Series
Tolerant	Co 13013, Co 13009, Co 13002 & Co 13018	Co 14016, Co 14012 & Co 14002
Moderately Tolerant	Co 13020, Co 13006, Co 13008 & Co 13014	Co 14027 & Co 14032
Susceptible	Co 13003 & Co 13004	Co 14004 & Co 14030

(R. Gomathi, R. Arun Kumar and V. Krishnapriya)

Nutrient uptake and nutrient use efficiency, fodder value

The tops (fodder value) and canes of 12 entries of AVT-Plant I were analysed for nutritive values. The nitrogen content of the both tops and cane were estimated in terms of percentage. The leaf sample of Co 15005 had the least value of 0.48 and the maximum of 1.23 for Co 14005. In cane sample, nitrogen estimation revealed the least value of 0.32 for Co 15021 and the maximum value of 0.77 for Co 15007. Potassium was found to be high in the leaf of Co 15005 with the value of 0.94 and the least in Co 15017 with 0.63 and high in stem of Co 15006 and low in Co 15017 with the values of 0.49 & 0.11 respectively. Phosphorus was found to be high with the values of 0.107 & 0.070, and the low values of 0.067 & 0.025 for the leaf and stem samples of Co 11015, Co 15005, Co 15017 and Co 15007, respectively. Evaluation of 10 clones of AVT-II plants with three standards revealed that the leaf sample of Co 14004 had the least value of 0.50 and the maximum of 1.01 for Co 14032. For cane samples, Co 14030 had the least value of 0.37 and the maximum of 0.48 for Co 14032. Potassium was found to be high in the leaf of Co 14002 with the least in Co 14030 with the values of 1.22 & 0.74 and high in stem of Co 14002 and low in Co 14012 with the values of 0.89 and 0.26. Phosphorus was found to be high with the values of 0.107 & 0.070 and the low values of 0.067 & 0.025 for the leaf and stem samples respectively.

(I. Rajendran)

Evaluation and identification of climate resilient ISH and IGH genetic stocks

Multiplication

A total of 49 climate resilient clones comprising 18 waterlogging tolerant, eight drought tolerant, 20 ISH and three IGH genetic stocks were multiplied and supplied to the participating centres of AICRP(S).

(P. Govindaraj and K. Elayaraja)

Fluff supply / National hybridization programme

During 2020, since COVID-19 pandemic has restricted travel, the Institute took the responsibility of making crosses for the entire country. About 401 bi-parental crosses, 342 general collections and 10 poly-crosses were effected for 21 fluff receiving centres. Fluff weighing 17.27 kg of crosses made at Coimbatore was supplied to the 21 centres that had sent the list of crosses to ICAR-SBI, Coimbatore (Table 15). The centres in

Table 15. Details of crosses made and quantity of fluff supplied to the fluff receiving centres

Centre	No. of bi parental cross	Fluff weight (g)	No of GCs	Fluff weight	No. of PCs	Fluff weight (g)	Total quantity of fluff (g)
Peninsular Zone							
Mandya	20	469.0	15	203.0	5	49.0	721.0
Navsari	20	494.0	15	406.0	5	46.0	946.0
Padegaon	20	452.0	15	333.0	5	46.0	831.0
Powarkheda	20	367.0	15	204.0	5	40.0	611.0
Pune	20	325.0	15	455.0	5	43.0	823.0

Centre	No. of bi parental cross	Fluff weight (g)	No of GCs	Fluff weight	No. of PCs	Fluff weight (g)	Total quantity of fluff (g)
Rudrur	20	429.0	14	395.0	5	56.0	880.0
Sankeshwar	20	560.5	14	383.0	5	45.0	988.5
Thiruvalla	20	391.0	15	224.0	5	44.0	659.0
Total	*160*	*3487.5*	*118.0*	*2603.0*	*5**	*369.0*	*6459.5*
East Coast Zone							
Anakapalle	20	428.0	14	340.0	5	51.0	819.0
Cuddalore	20	464.0	15	230.0	5	49.0	743.0
Nayagarh	20	392.0	14	261.0	5	48.0	701.0
Vuyyuru	20	504.0	15	318.0	5	61.0	883.0
Total	*80*	*1788.0*	*58.0*	*1149.0*	*5**	*209.0*	*3146.0*
North West Zone							
Faridkot	19	518.5	17	330.0	3	38.0	886.5
Kapurthala	20	574.0	15	372.0	3	40.0	986.0
Lucknow	19	518.0	20	296.0	2	33.0	847.0
Pantnagar	3	45.0	16	418.0	2	58.0	521.0
Shahjahanpur	20	470.5	20	482.0	4	115.0	1067.5
Uchani	20	434.0	20	480.0	2	33.0	947.0
Total	*101*	*2560.0*	*108.0*	*2378.0*	*5**	*317.0*	*5255.0*
North Central Zone							
Bethudahari	20	342.0	20	334.0	1	15.0	691.0
Pusa	20	480.0	18	422.0	2	49.0	951.0
Seorahi	20	471.0	20	255.0	2	40.0	766.0
Total	*60*	*1293.0*	*58.0*	*1011.0*	*5**	*104.0*	*2408.0*
Grand total	401	9128.5	342	7141.0	10	999.0	17268.5

* Excluding the duplicates; GCs: General collections; PCs: Poly-crosses

Peninsular zone received the maximum quantity of 6.46 kg of fluff followed by those in North West Zone (5.26 kg). The centres in East Coast Zone and North Central received 3.15 and 2.41 kg of fluff, respectively. Apart from these, 25 bi-parental crosses were made in National Distant Hybridization facility at SBI Research Centre, Agali and 775.1 g of fluff was supplied to the five centres *viz.*, Cuddalore, Navsari, Padegaon, Pune and Sankeshwar having sent the list of wide crosses to be effected at Agali. Altogether 18.04 kg of fluff was sent to the 21 centres.

National Hybridization Programme 2021-22: Out of 431 parents, 365 flowered with flowering intensity of 84.69%. Information on flowering of parental clones was made available to the participating centres by hosting the data on different stages of flowering and updating the same on weekly interval during September to December 2021 in the SBI website. Breeders of seven centres *viz.*, Padegaon, Powarkheda and Sankeshwar from Peninsular Zone, Cuddalore from East Coast Zone, Kapurthala, Lucknow and Shahjahanpur from North West Zone participated in the crossing programme 2021. Three centres Motipur, Gurdaspur and Seorahi were represented by the scientist from Lucknow, Faridkot and Shahjahapur, respectively. Other 14 centres sent the cross list and ICAR-SBI effected the crosses for these centres. Hybridization work was done during 29 October 2021 to 7 December 2021. Totally 424 bi-parental crosses were effected for the 24 centres.

(A. Anna Durai, V. Sreenivasa and N. Rajendra Prasad)

Identification of pathotypes / races of red rot pathogen

Three new isolates (Cfv09356- Mundiampakkam, Cf11015- Periyasevalai and Cf11015 Thiruvendhipuram) along with five old isolates and two designated pathotypes (CF06 and CF12) were inoculated on 19 sugarcane differentials and disease intensity was rated. The new isolate, Cf11015- Thiruvendhipuram (isolated from Co 11015) showed highest virulence among all the tested isolates and even it showed more virulence than designated pathotypes. In contrast another new isolate collected from Co 11015, *i.e.,* Cf11015- Periyasevalai showed least virulence among all the isolates. These two isolates exhibited entirely opposite reaction on Co 7717 and CoC 671 and differential reactions on many other varieties. The isolate Cf11015-Thiruvendhipuram also exhibited differential reactions from two designated pathotypes on many varieties. The other isolates *viz.,* Cfv09356- Mundiampakkam, Cf86032- Nellikuppam, CfM0265- Palapatti and Cf86027- Amaravathi showed moderate virulence and among these, the new isolate Cfv09356- Mundiampakkam exhibited many differential reactions from designated pathotypes on many varieties. The remaining isolates exhibited more or less similar reactions of designated pathotypes.

(V. Jayakumar and R. Selvakumar)

Evaluation of IVT / Zonal varieties for resistance to red rot, smut, YLD, brown rust and pokkah boeng

Eighteen entries of IVT and AVT in the zonal trials were evaluated against the *C. falcatum* pathotypes, CF06 and CF12 under field conditions by adopting plug and nodal methods of inoculation. All the 13 IVT clones exhibited resistance under nodal methods whereas one AVT entry, CoVSI 16121 exhibited susceptible reaction in the nodal testing. In plug method of testing, eight clones of IVT behaved as R/MR to CF06 as against 10 to CF12. Five IVT clones exhibited MS reaction against CF06 as compared to two for CF12. Four AVT clones exhibited MR reactions to both the pathotypes and similarly one clone behaved as MS to CF06 and CF12. The same 18 IVT+AVT entries were evaluated against sugarcane smut and among the 18 entries, one entry – CoT 16366 was identified as resistant, whereas two entries, *viz.,* Co 17009 and Co 18024 were identified as moderately resistant.

IVT and AVT entries were monitored throughout the crop season with regard to YL severity based on the 0-5 scale. In IVT, all the 16 entries were identified as YLD-free. In AVT I plant, out of five entries only one CoVSI 16121 had shown S, PI 16131 was MR and the rest of three entries (60%) were free from YLD. In AVT II plant, all the 12 entries were YLD-free whereas the same entries in previous year AVT I plant ratoon had shown MR, MS and R reactions *viz.,* Co 11015 was MS, Co 15010, Co 15006, Co 15007, Co 15009, and PI 15131 were MR and CoSnk 15102, Co 14005, Co 15017, CoN 15071, Co 15005, and Co 15002 were repeatedly exhibited R reaction to YLD.

Out of 13 clones, only five clones *viz.,* Co 18001, CoN 18071, CoN 18072, Co 18009 and CoVc 18061 showed rust in traces and other entries were free from rust. Out of five AVT clones, only Co 16006 and CoVSI 16121 showed rust in traces and other entries were free from rust.

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

Assessment of elite ISH clones for resistance to red rot

About 30 ISH/IGH clones were evaluated for red rot resistance under field conditions by plug and nodal methods against two virulent pathotypes Cf86032-Srikandapuram and Cf95020-Gujatat. Among them, 13 and 11 were identified as R/MR to these pathotypes, respectively under plug method of testing and in nodal method. When compared to the ratings of the clones against CF06 and CF12 done during the previous season, new isolates were highly virulent.

(R. Viswanathan)

Efficient delivery of fungicides and other agro inputs to manage major fungal diseases in sugarcane

Field experiment was laid out to evaluate mechanized means of sett treatment with *Trichoderma*

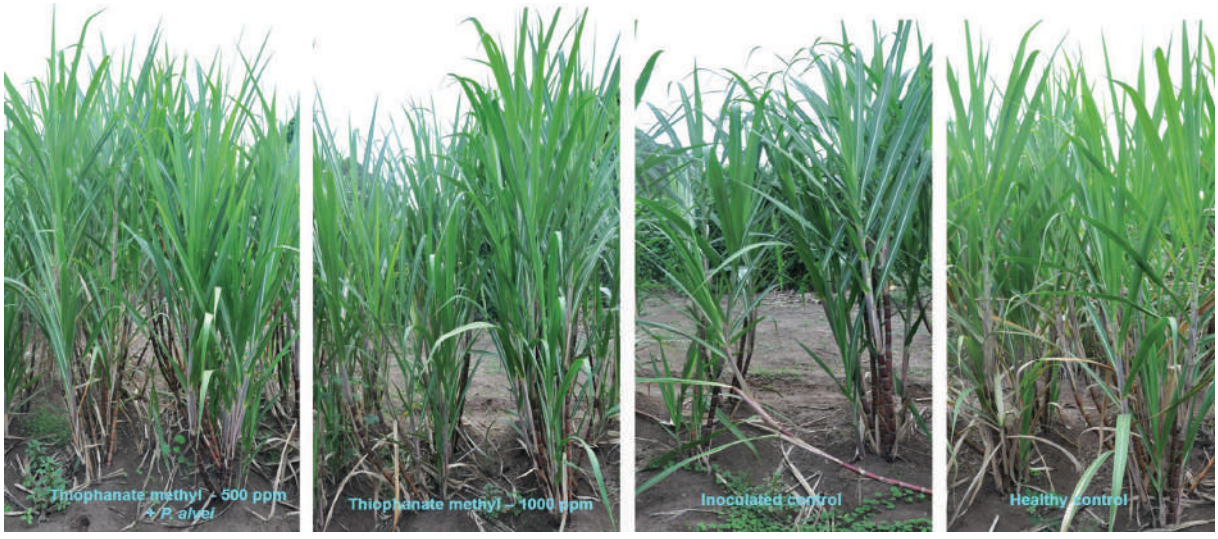


Fig. 28. Efficacy of mechanized sett treatment with fungicides and biocontrol agents against red rot in CoC 671

harzianum and *Paenibacillus alvei* individually at 1% concentration and in combination at 0.5% concentration each, fungicide alone (Thiophanate methyl at 1000 ppm) and its combination with *P. alvei* at 50% concentration along with suitable healthy and inoculated controls for the management of red rot using susceptible cultivar CoC 671. Except healthy control, soil borne inoculum of red rot has been artificially placed over the setts at the time of planting. Invariably all the sett treatments were carried out in STD at 200 mmHg vacuum level for 15 min. Results clearly indicated that treating setts in the STD with the combination of thiophanate methyl and *P. alvei* at 50% concentration was found to be significantly superior (0% PDI), as against 66.6% PDI in inoculated control. Further, mechanized sett treatment with both the biocontrol agents and fungicide individually or in combination were not harmful to buds and were effective in reducing the disease incidence, improving plant growth and yield attributes. The yield improvement by the combination of *P. alvei* and thiophanate methyl was found to be 84.6%, over inoculated control and it was 15.5% increase over healthy control (Fig. 28).

(P. Malathi)

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

Out of 14 entries in AVT-I, two entries (Co 14005 & Co 15010) were Tolerant (T) to the borer; six were Moderately Tolerant (MT) and the remaining six were Susceptible (S) to the borer. Cumulative incidence of the borer varied from 11.3% (Co 14005) to a maximum 58.2% (Co 15009). Bored plants were minimum (4475/ha) in Co 15017 and the maximum number (13580/ha) of bored plants was recorded in the entry CoSnk 15102.

In AVT-II, four entries were T to the borer, 12 MT and the remaining two were S. Overall incidence of the borer varied from 7.3% in CoSnk 05103 to a maximum of 44.9% in CoT 14367. Number of bored plants/ha was minimum (2160) in Co 14030 and the maximum number (11111) of bored plants was recorded in the control entry Co 86032.

Out of 14 entries in AVT-I, Co 15009 was tolerant (T) to INB recording 18.6% incidence whereas the standard CoC 671 recorded the highest incidence (41.1%) and the remaining 12 entries were moderately tolerant (MT) to INB. Intensity of attack was minimum (1.33) in the variety Co 15009 and the standard CoC 671 recorded the highest intensity (2.79) of the borer attack. The infestation index varied from 0.25 in Co 15009 to 1.15 in CoC 671.

Out of 18 entries in AVT-II including three standards, 15 entries were MT to the borer and the remaining three entries were S. Incidence of the borer recorded at the time of harvest varied from 20% in CoT 14111 to 66.7% in CoSnk 05103, which also recorded the highest intensity (6.43) of attack. The infestation index was the least

(0.33) in CoT 14111 and highest (4.29) in CoSnk 05103.

In AVT ratoon, INB incidence varied from 33.3% (CoSnk 05103) to 69.3% (Co 14032). Out of 18 entries, two entries were MT to INB and the remaining 16, including the standards, were S to the borer. Intensity of attack was the least (1.48) in CoSnk 05103 and the highest (3.51) in the entry CoVC 14062. Infestation index ranged between 0.49 in CoSnk 05103 and 2.39 in CoVC 14062.

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

Survey and surveillance of sugarcane insect pests

Overall incidence of borer pests, *viz.*, shoot borer (SB) and internode borer (INB) and the subterranean white grub in Tamil Nadu indicated medium incidence of SB (2.3 - 32.2%) and INB (4.5 - 20.1%); white grub incidence in endemic areas varied from 8 to 11 grubs/m^2. Whitefly incidence was 24-104/leaf in Mundyampakkam area alone. Other pests like mealybug and white woolly aphid were low in individual farmers' fields which were kept under check by periodical detrashing and natural enemies, respectively. Severe incidence of a new mealy bug in association with pokkah boeng has been reported from several sugar factories in Tamil Nadu in the summer months. The mealybug has been identified as *Phenacoccus* sp. (Fig. 29, 30).

Fig. 29 Field symptoms of* Phenacoccus *sp. incidence

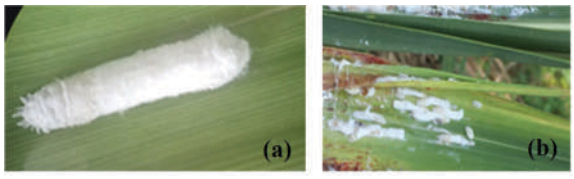


Fig. 30 Different stages of* Phenacoccus *sp. (a): Female with ovisac, (b) Different developing instars

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

Monitoring of insect pests and bioagents in sugarcane agro-ecosystem

In monitoring plot planted in March 2020, pest incidence was assessed at monthly intervals in five random spots. Shoot borer and internode borer were the borer pests but both occurred at low intensity. Shoot borer deadhearts ranged from1.23 to 6.9% during March-July. Internode borer incidence ranged from 0.9 to 4.9% during September-January, but it was slightly higher (18.8%) at harvest. Whitefly, mealybug and yellow mite were observed at low levels. Parasitoid activity was also observed. Sturmiopsis inferens activity in shoot borer was 12.3 and 10.7% in June and July, respectively.

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

Standardization of simple and cost effective techniques for mass multiplication of sugarcane bio-agents

For economizing mass production of entomopathogenic fungi (EPF), cotton seed cake was found best for *Metarhizium anisopliae,* sesame seed cake extract for *Beauveria bassiana* and wheat bran and rice bran extracts for *B. brongniartii* based on spore production. Multiplication of the *M. anisopliae* strain (SBIMA-16) was done through liquid fermentation. An improved medium with increased concentrations (10 and 15%; named SBI I & II respectively) of jaggery and amended with supplements was assessed for culturing the EPF and compared with jaggery media without supplements. Efficacy data showed that highest mortality was seen with SBI-I (94.44%) compared to jaggery 15% and SBI-II (91.67%) but higher than that obtained with YPSS (83.33%). Corresponding colony growth and spore viability of several EPF on solid media revealed superiority of SBI-I medium. In pot culture experiments with various combinations of *B. brongniartii, B. bassiana, M. anisopliae, Heterorhabditis indica, Steinernema glaseri* and six selected insecticides at field recommended dose,

EPFs showed high mortality rates of white grub.

(N. Geetha, J. Srikanth, T. Ramasubramanian, P. Mahesh and L. Saravanan)

Assessment of yield losses caused by borer pests of sugarcane under changing climate scenario

Yield loss due to INB attack was assessed at harvest in an experimental plot with the popular variety Co 86032. Infested canes were segregated based on the position of INB bore holes in the canes, *viz.*, top, middle, bottom, top-middle, middle-bottom, top-bottom and top-middle-bottom, representing attack in different broods. Measurements of cane girth, internode number, cane length and cane weight were taken for sample canes (5-40) in different categories and control. The category 'bottom', though collected, was excluded from analysis since it had only one cane. Data were analysed for variance using the categories as treatments. The percent of canes with bore holes in top was the highest (37.4) followed by top-middle (26.2) and top-bottom and middle categories (12.1 each). TMB (6.5) and MB (4.7) had lower percent of canes. The proportion of canes attacked in all the three portions was low (2.9%). Cane girth, internode number and cane length did not differ among the different categories. However, cane weight differed significantly with TMB and TM damage reducing it marginally over control. Overall, the results indicated that repeated attacks of internode borer in different broods did not result in significant loss in cane yield parameters.

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

All India Coordinated Research Project on Biological Control

Aschersonia placenta for the management of whitefly in sugarcane ecosystem

Isolation of A. placenta *and cultures:* Cadavers of whitefly *A. barodensis* nymphs encased in the stroma of the orange fungus were collected from sugarcane fields from Tiruvannamalai, Tamil Nadu, India. Since morphologically the spores of *A. placenta* and *A. aleyrodis* are hardly distinguishable, through molecular characterization the species was confirmed as *A. placenta* (strain SBIAP01: Genbank No. MT586700).

Media tested: Two types of media were used for assessment of colony growth of *A. placenta.* In the first set, fifteen semisynthetic commercially available standard media were studied while in the second test eight economic media developed from locally available jaggery/molasses were assessed with Yeast Phosphate Soluble Starch (YpSs) Agar as the standard.

Growth on standard media: Colony growth of A. placenta was highest on oatmeal agar (OMA) and lowest on All Culture Agar (ACA) on 7 days post inoculation. On day 21 OMA continued to show highest and significantly better colony diameter as well as fruiting zone with Dextrose Peptone Agar (DPA) being the next best. However, several media such as DPA, Sabouraud Maltose Agar (SMA), Sabouraud Dextrose Agar (SDA), Nutrient Base Agar (NBA), Dextrose Agar (DA), Czepek Yeast Extract Agar (CYEA) performed better than (p=0.05) than YpSs indicating the wider nutritional adaptability of this fungus. Similarly, the Fruiting Zone (FZ) on OMA was significantly better than that of all media but several other media too had good growth of OMA despite the significant difference.

Growth on economic media: On 21st day, it could be seen that the jaggery IV had the highest and significantly different colony growth than all other media tested followed by ICAR-SBI-1 as well as ICAR-SBI-II medium and jaggery Agar-II. FZ was the highest on JA-IV but was comparable with several other jaggery based media. 3% Molasses agar was not suitable for culturing *A. placenta.*

Correlation among the different zones of growth and outer colony size: Correlation matrix showed that on standard media, Outer Zone (OZ) and Aging Zone (AZ) of *A. placenta* colony were strongly correlated (p=0.01) only on day 21 but on economic media, OZ and AZ were strongly correlated (p=0.001) on day 14 and 21. On both media spectra, the correlations between OZ and Production Zone (PZ) as well as OZ and FZ were highly correlated on all days (p=0.001). This shows that both productive and fruiting zones are strong indicators of colony growth. Based on the observations on 7th, 14th and 21st days post inoculation, although OMA was the best for radial growth followed by DPA, it could be conclud-

ed that the fungus *A. placenta* could grow and sporulate on all the 15 standard media indicating its versatility. On the economic media, two media based on jaggery, developed at ICAR-SBI proved superior to other jaggery or molasses-based media for colony growth.

Field experiment

A preliminary trial at Perani, Villupuram district (TN) in a severely affected field with a single application of *A. placenta* against *Aleurolobus barodensis* @1x10^{12}/ha was found to effectively reduce the population.

Mass production of entomopathogenic fungi

A. placenta

Media tested since molasses is a by-product during sugar production in sugar mills and rich in sugar and other organic compounds that can support microbial growth, media of molasses was tested for suitability for *A. placenta* growth and sporulation. Various concentrations of jaggery with or without amendments were also tested. During the course of experiments new media (ICAR-SBI liquid media) was found suitable for *A. placenta*

Comparison of pooled data of experiments with all the standard media at 25 ^{0}C as well as 30 ^{0}C showed the significantly better performance of SBI media over Oats broth and SDB and comparable performance with YpSs and PDB. Although spore production was slightly lesser at 30 ^{0}C than at 25 ^{0}C, the change was dependent on media but considering both sporulation and germination of spores, SBI-10% was better choice among all media tested, for large scale cultivation of *A. placenta* that can be recommended. It could be observed that the initial vigour of growth was high in SBI-10 and 15% and exudates were high.

(N. Geetha and P. Malathi)

EXTERNALLY FUNDED PROJECTS

Identification, characterisation and verification of new sugarcane varieties for DUS testing at Coimbatore

DUS testing: First year DUS testing of candidate variety, Co 09004 and two Farmer's varieties (FV) *viz.,* Jeet Katari and Sugam Katari along with the reference varieties and zonal checks was completed. The two FV's belonged to the group *S. officinarum* and DUS test for these varieties were conducted along with closely resembling *S. officinarum* clones obtained from World Sugarcane Germplasm Collection, ICAR – SBI, Research Centre, Kannur. The results indicated that the candidate variety, Co 09004 was distinct from the three reference varieties CoV 89101, CoN 95132 and Co 7717 in respect of DUS traits *viz.,* leaf blade curvature, adherence of leaf sheath, leaf sheath hairiness, internode colour. The farmers' variety Jeet Katari was distinct from both the reference varieties Tahiti-3 and NG 77-015. The farmers' variety Sugam Katari was distinct from the three reference varieties IJ 76-317, NG 77-137 and 57 NG 192 for traits *viz.,* adherence of leaf sheath, spines, internode diameter, growth crack, ligule shape and shape of inner auricle. Both the FV's were distinct from their respective reference varieties but resembled each other.

Maintenance breeding: A total of 233 RV of sugarcane (tropical varieties) were clonally maintained in field at Lead centre (Coimbatore, Tamil Nadu).

New planting: Two candidate varieties *viz.,* Co 11015 and Co 10026 along with RV's Co 85002, Co 85019 (for Co 11015), Co 7508 and CoN 95132 (for Co 10026) and zonal checks *viz.,* Co 86032 and CoC 671 were raised for conducting first year of DUS test. Candidate variety Co 09004 along with RV's (CoV 89101, CoN 95132, Co 7717 and zonal checks *viz.,* Co 86032, CoC 671) were planted to conduct second year of DUS testing. Single buds of CoA 14321and CoA 14323 from Anakapalle centre and CoM 0265 from Maharashtra were multiplied to conduct DUS testing in 2022-23 season. DUS characterization at 240 days was completed in the DUS trials.

(R. Karuppaiyan, S. Alarmelu and C. Jayabose)

ICAR Seed Project: Seed production in agricultural crops

Breeder seed production

The period was most favourable to undertake quality seed production by the seed unit both at the Institute and the seed villages. Overall, the

indents for both breeder seed cane and tissue culture plants received from Commissioner of Sugar, Govt. of TN and sugar factories were considered for supply to the fullest. Maintenance breeding and multiplication of nucleus seed of all released varieties in seed chain from the Institute *viz.,* Co 86032, Co 0212, Co 11015 and Co 09004 were continued. The selected canes from each variety were micropropagated to supply disease free plantlets for further multiplication as breeder seed.

Breeder seed multiplication was taken up using the initial source of the tissue culture plants produced from the nucleus clones at the Institute. The varieties included were Co 86032, Co 0212, Co 09004 and the newly released variety Co 11015. Production of breeder seed using TC plants for further multiplication in farmers' fields in 2021 had also been taken up. About 80 tons of breeder seed thus produced had been supplied to the selected farmers to undertake quality seed production in July 2021 under the guidance from ICAR-SBI in addition to the seed indents from sugar factories. Further, a total of 50,000 settlings of Co 11015 and Co 86032 have been produced with the participation of a trained seed farmer and supplied for further multiplication. About 5000 bud chip transplants of Co 11015 produced at the Institute were provided to farmers of Tamil Nadu.

The need to produce a large quantity of quality seed cane coupled with the limited availability of resources in the Institute provided an opportunity to explore the farmers' participatory mode under ICAR Seed Project. A huge indent of about 1500 tons of quality seed has been received from Director of Sugars, Govt. of Tamil Nadu for subsidy scheme under NADP. Progressive seed farmers have been selected to undertake farmers' participatory seed production from Seyur, Pasur, Vellamadai and Neelambur and seed production was undertaken in about 37 acre. The seed crops were strictly monitored and about 1689 tons of quality seed has been supplied in February 2021 to both cooperative and private sugar factories as per allotments received from Directorate of Sugar, Govt. of Tamil Nadu.

A Field day on the new variety Co 11015 followed by Seed Village day were conducted at Vaiyapurigoundanpudur village near Seyur and Pasur village, Tiruppur dt., on 04 February 2021. Seed Day was conducted at the Institute on 18 March 2021.

(A.J. Prabakaran, S. Karthigeyan and N. Rajendra Prasad)

Production of tissue culture plants

Through apical meristem tip culture, the varieties Co 86032, Co 11015 and Co 0212 were multiplied. *In vitro* cultures of varieties, Co 86032, Co 11015 and Co 0212 were virus indexed and found to be free from SCYLV, SCMV, SCSMV and GSD. A total of 1,13,555 tissue culture plants were supplied to private and co-operative sugar factories, breeder seed production and progressive farmers generating Rs. 9,14,350 revenue. About 42 mother culture flasks were supplied to various sugar factories earning revenue of Rs. 1,05,000. Training on 'Sugarcane micropropagation' was imparted to three staff from Tissue Culture Lab, Bannari Institute of Technology, Sathyamangalam during 4-6 January 2021.

(D. Neelamathi, R. Valarmathi and C. Jayabose)

Enhancing sugar productivity in Tamil Nadu through institute-industry participatory approach

Performance of varieties: Seventeen clones were evaluated along with Co 86032 and local standards in a replicated trial (Plant II and ratoon crop) during 2020-21. Harvest was completed in all factory locations by February 2021. Data of two plant and one ratoon crops were compiled and analyzed. Clones were classified based on sucrose accumulation and cane yield at harvest. Clone with on par performance or better for cane yield and quality than Co 86032 was identified as suitable for particular location (Table 16). Overall, Co 12009, Co 14027, Co 14002 and Co 18009 performed better than Co 86032 for yield and sugar yield at harvest. Clones, Co 14027 (18.28%) and Co 17003 (19.28%) recorded higher sucrose than Co 86032 (18.05%).

Table 16. Location specific variety combing yield and quality

Sugar factory	Suitable variety
Bannari Amman Sugars, Sathyamangalam	Co14002, Co14027, Co18009
Dharani Sugars, Polur	Co14027, Co12009
EID Parry (India), Nellikuppam	Co12009, Co18009
Kothari Sugars, Sathamangalam	Co16010
Ponni Sugars, Erode	Co18009, Co14005
Rajshree Sugars, Mundiampakkam	Co 12009, Co 14002, Co 14027, Co 16009, Co 17003, Co 18024
Sakthi Sugars, Sivaganga	Co1402, Co17001, Co18009
Dhanalakshmi Srinivasan Sugars, Perambalur	Co14027, Co17001

Co 17003 was found suitable for harvesting, starting from 8 months onwards and thus considered as a short duration (early maturing) clone although not for cane yield when compared to Co 86032. Clones, Co 14027 and Co 17003 were grouped as high quality based on sucrose content compared to check variety, Co 86032 at harvest. Clone, Co 18009 combines high yield and quality at harvest. Clones, Co 14027 and Co 18009 topped for cane yield in five locations each out of eight locations.

Clone identified for release: Overall, Co 12009, Co 14027, Co 14002 and Co 18009 performed better than Co 86032 for yield and sugar yield at harvest across the locations. Of these, Co 12009 recorded 11.33% and 7.03% improvement over Co 86032 for cane yield and sugar yield, respectively across Tamil Nadu. This clone is already been released for commercial cultivation in Peninsular zone. The clone, Co 18009 recorded improvement in cane yield, sucrose content and sugar yield than the standard variety, Co 86032. Overall mean performance of the clone was 153.85 t/ha of cane yield, 19.95 t/ha of sugar yield and 18.94 % of sucrose. The per cent increase over the standard Co 86032 for cane yield, sugar yield and sucrose % was 10.85, 11.45 and 1.99, respectively. It is a good ratooner with excellent field stand, with erect and medium thick canes (Fig. 31). An improvement of 7.96% and 5.24% for cane yield and sugar yield was recorded by Co 14027 while Co 14002 recorded an improvement of 5.02% and 2.50% over Co 86032 for cane yield and sugar yield, respectively. Hence, these clones were identified as best performing clones combining yield and quality. SISMA TN

Fig. 31. A. Excellent field stand of sugarcane variety Co 18009 (9 months – Plant crop) B. Excellent field stand of sugarcane variety Co 18009 (11 months – Ratoon crop) at Bannari Amman Sugars Mills

committee members meeting held on 13.05.2021 recommended Co 14002, Co 14027 and Co 18009 for release in Tamil Nadu.

Action taken by factories: Based on performance in plant and ratoon crops, the clones that performed better than Co 86032 and local standards in respective factory locations were planted for further multiplication. All the factories have taken interest in multiplying the variety, Co 12009, Co 14002, Co 14027 and Co 18009 due to superior performance for yield and quality.

(Bakshi Ram, G. Hemaprabha, A.J. Prabakaran, R.M. Shanthi, S. Alarmelu, P. Govindaraj, D. Neelamathi, S. Karthigeyan, A. Anna Durai, R. Karuppaiyan, K. Mohanraj, C. Appunu, C. Mahadevaiah, V. Sreenivasa, Adhini S Pazhani, 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)

Identification of location specific sugarcane varieties suitable for different agro-climatic zones of Tamil Nadu (Cooperative sugar factories)

Varietal Trial

A total of 21 promising genotypes (Co 09004, Co 11015, Co 12008, Co 12009, Co 14002, Co 14005, Co 14016, Co 14027, Co 15007, Co 15015, Co 15018, Co 16009, Co 16010, Co 16018, Co 17001, Co 17003, Co 17004, Co 17012, Co 17013, Co 18009 and Co 18024) were evaluated in second plant and ratoon crops during 2020-21 in six locations *viz.,* Kallakurichi-I Cooperative Sugar Mill, (KCSM K1) Moongilthuraipattu, Amaravathy Cooperative Sugar Mills Ltd. (ACSM), Krishnapuram, Udumalpet, Subramaniya Siva Cooperative Sugar Mills Ltd. (SSCSM), Harur, Salem Cooperative Sugar Mills Ltd. (SCSM), Mohanur, Arignar Anna Sugar Mills (AASM), Kurungulam, Thanjavur and Tiruttani Coop. Sugar Mills Ltd. (TCSM), Tiruvalangadu, Thiruvallur.

Two plant crop and one ratoon crop trials were completed during 2019-2021 seasons at six locations distributed across Tamil Nadu. The entries were classified based on sucrose accumulation and cane yield at harvest. Overall, Co 11015 (14.87%), Co 09004 (14.29%) and Co 17003 (14.18%) recorded better sucrose % than Co 86032 from 8 months onwards. Clones, Co 09004, Co 11015, Co 12009, Co 14005, Co 14027, Co 17003 and Co 18009 recorded better sucrose content (%) than standard Co 86032 (17.49%) at harvest. The entries, Co 12009, Co 15018, Co 16018, Co 11015, Co 17012 and Co 18009 recorded more than 10 tonnes higher cane yield than Co 86032 (127.65 t/ha) at harvest (12 months). Location specific varieties combining yield and quality is given in Table 17.

(Bakshi Ram, G. Hemaprabha, S. Alarmelu, S. Karthigeyan, A. Anna Durai, R. Karuppaiyan, K. Mohanraj, C. Appunu, C. Mahadevaiah, V. Sreenivasa, S. Sheela Mary, H.K. Mahadevaswamy, T. Lakshmipathy and K. Elayaraja)

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

Phenotyping of clones III year: The population, BO 91 x Co 775 scored for Cf response through plug method, Co canes, Co 86002 x BO 91 and CoM 0265 x Co 775 through CCT method. During 2020-21, more number of clones categorized under MR category. Recorded the number of tillers, plant height, number of millable canes and Brix for the above population. Clone selection was done from first ratoon crop of all the populations based on sucrose, red rot reaction and other criteria. Nine clones from the population BO 91 x Co 775 were selected (clone numbers 260, 294, 229, 303, 224, 293, 268, 217 and 275). Clone number 260, 294, 224 and 229 had high pol% (> 18), clones such as 303, 293, 229 and 260 had higher CCS (t/ha). About 18 clones were selected from the other populations, CoM 0265 x Co 775 and Co 86002 x BO 91 for validation. High yielding clone from the population CoM 0265 x Co 775 was evaluated for yield, sucrose and drought tolerance (Co 21002). The broad sense heritability was calculated for all the traits. The heritability %

Table 17. Variety suitable for different factory locations

ACSM	AASM	KCSM (K1)	SCSM	SSCSM	TCSM
Co 17001	Co 12009	Co 12009	Co 14002	Co 14002	Co 12009
Co 17004	Co 14027		Co 14027	Co 17003	Co 14027
Co 17013	Co 18009		Co 18009	Co 18009	
Co 18009					

for the red rot trait from the all populations ranged from 94 to 97%. However, the heritability values for CCS and yield ranged from 54 to 73% for BO 91 x Co 775 under control and drought conditions; for Co 86002 x BO 91, the heritability ranged from 73 to 81% and for CoM 0265 x Co 775 it ranged from 45 to 51%. Flowering data was recorded for all the populations from the clone maintenance plot.

Validation of phenotypes in field trials: All the selected clones (63 clones) were planted in RBD with two replications in March, 2021 for validation of phenotypes to increase the prediction efficiency of the genomic selection models.

Development of genomic prediction models for sucrose and red rot resistance: All the genotyped clones were subjected to develop genomic selection / prediction models. BayesA, BayesB, BL, GBLUP, RKHS Single models showed significant SNPs for the sucrose and red rot traits. For developing sucrose prediction models, we used 15,040 SNPs and 545 sugarcane clones. The phenotypic and SNPs marker data were combined and genomic selection models are developed. The populations were split into two sets; Testing (20%) and Training (80%) population. The Test population with 109 genotypes has only marker data. The training population with 436 genotypes has both phenotype and marker data. The correlation between prediction models for the sucrose trait with training and testing population was high (> 0.9). The GS model predicts the unknown phenotype with the regression of training population. Out of the prediction methods, the RKHS Single & RKHS- averaging was most promising with 0.70 and 0.71 accuracy for sucrose % (Fig. 32). The prediction accuracy for red rot was comparatively less but showed gradual increase between the model types (from 0.39 to 0.59) (Fig. 33 and Table 18). Bayes A and Bayes B are better in prediction of red rot resistance. Identified top 100 SNP markers and their co-located genes for sucrose and red rot resistance traits. The expressions of putative candidate genes for red rot resistance were tested in BO 91 x Co 775 population (Fig. 34).

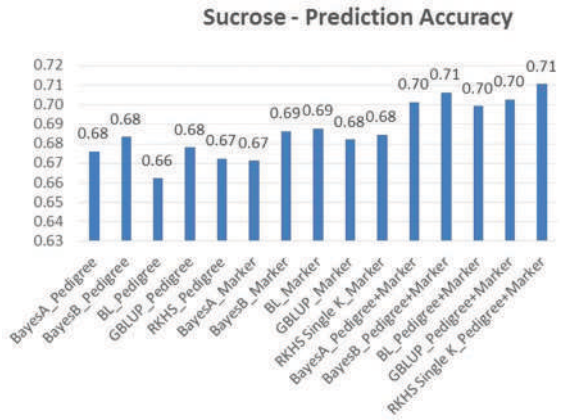


Fig. 32. Prediction accuracy for different GS models for sucrose trait

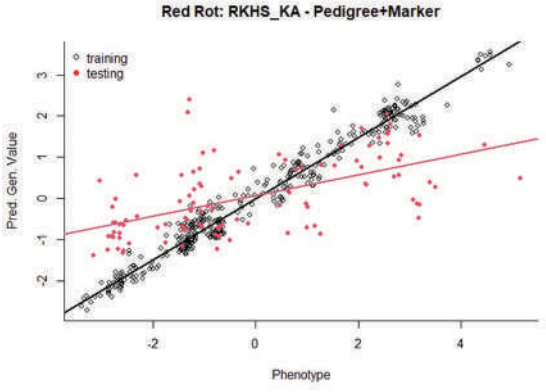


Fig. 33. Corelation between testing and training data for red rot traits

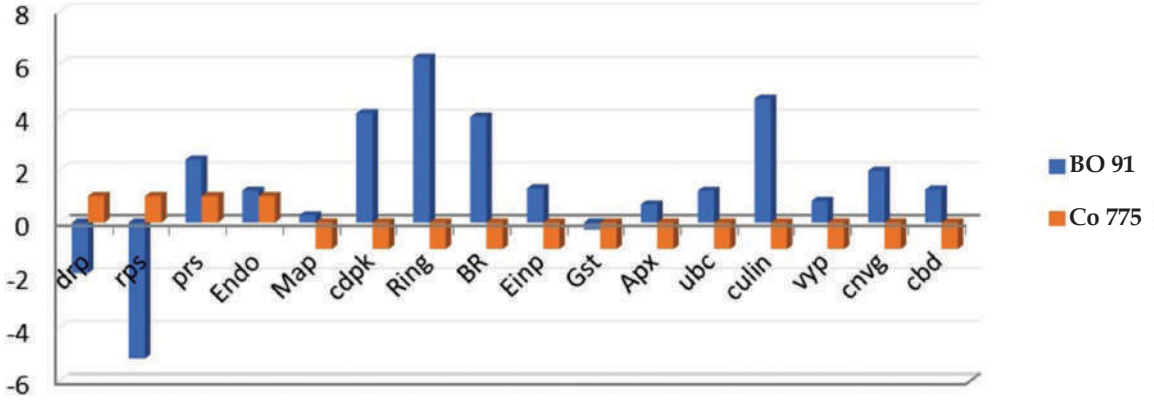


Fig. 34. Expression pattern of candidate genes in BO 91 and Co 775

Table 18. Prediction accuracy for different GS models for red rot resistance

Model	Prediction accuracy	
	Testing population	Residual Variance
BayesA	0.348	1.514
BayesB	0.372	1.621
Bayes LASSO	0.349	1.834
GBLUP or BRR (X=A)	0.358	1.692
RKHS	0.362	1.057
BayesA	0.567	0.783
BayesB	0.61	0.702
Bayes LASSO	0.566	0.931
GBLUP or BRR (X=X)	0.549	0.884
RKHS Single K	0.561	0.87
RKHS Multi K	0.551	0.64
BayesA	0.593	0.805
BayesB	0.593	0.834
Bayes LASSO	0.555	0.994
GBLUP	0.56	0.609
RKHS Single K	0.562	0.628
RKHS Multi K	0.548	0.505

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

Isolation, functional characterization and evaluation of water deficit stress tolerance responsive genes from high drought tolerant *Erianthus arundinaceus* by comparative drought transcriptome analysis

Drought tolerant *E. arundinaceus,* a wild relative of sugarcane and drought-sensitive sugarcane variety, Co 86032 were evaluated under water-deficit stress. Pots containing 90 days grown plants were saturated with water to field capacity (FC 100%; soil moisture 25%). The amount of water the soil can hold is expressed as mass percentage, and it is considered as 100% field capacity (FC) of soil. Three months old plants (sugarcane variety and *E. arundinaceus),* maintained at 100% FC were stressed by decreasing the soil water status gradually (decreasing water status by approximately 5-10% FC/day). Plants were maintained at specific FC (100, 65 and 45% FC), and stress was monitored by gravimetrically weighing the pots twice a day. This allowed to maintain a control over the kinetics of water stress imposition between plants that vary in growth rate and size (leaf area), so that the decrease in soil moisture level followed roughly the same pattern both in cultivated sugarcane variety and *E. arundinaceus.*

Ninety days grown plants were given water deficit stress and effects of stress on different physiological and biochemical parameters in leaves of *E. arundinaceus* and Co 86032 were recorded. Samples were collected after stress for isolation, functional characterization and evaluation of drought responsive genes by comparative analysis of stress transcriptome from cultivated sugarcane and from *E. arundinaceus.* Transcripts of both stressed (S) and control (C) samples were combined to the size ≥ 300bp and were clustered together using CD-HIT at 95% identity. Master control transcriptome data (unigenes) were generated. The expression profile for those transcripts expressed only in C, expressed in both C and S and expressed only in S was generated individually. The combination of RNA-Seq and digital gene expression analysis in this work provides a powerful approach for investigating the transcriptional changes and obtained a large number of unigenes annotated to water stress responsive genes available in public databases.

The new leads obtained from these experiments are as follows:

- For the first time in India, whole genome transcriptome of drought responsive genes generated both for root and leaf tissues with *E. arundinaceus* and commercial sugarcane variety, Co 86032.
- Many unigenes with specific functions and transcriptional factors responsive under water deficit stress conditions were identified. This repository of potentially important drought tolerance responsive genes from *E. arundinaceus,* a wild relative of *Saccharum* expected to have significant impact in improving performance of sugarcane under drought conditions.
- Obtained a large number of unigenes annotated to water deficit stress responsive genes available in public databases. Interrelationship of transcriptional factor regulation is studied.

- Important drought responsive genes *viz., EaALDH, EaEXPA1, EaGly I, EaGly II, EaGly III* and deeper rooting 1 *(DRO1)* genes, transcriptional factor EaNFYB were cloned and obtained full length sequence.
- Markers and unique genes responsible for water deficit stress tolerance in *E. arundinaceus.* identified in this study could be used for marker assisted selection to faster the genetic improvement.
- Potential candidate genes identified cane be used for development of sugarcane transgenics for improved drought tolerance.

Overall, large number of water deficit stress responsive genes (with known putative functions and unknown functions) were upregulated in leaves and roots during stress. These genes directly or indirectly play a role in increasing the water deficit stress tolerance in *E. arundinaceus.* In addition to already characterized genes, more work was initiated to isolate full length sequence of the upregulated genes *viz.,* Expansins, Glyoxalase genes, plant nuclear factor YB *(EaNF-YB),* a drought responsive transcriptional factor and aldehyde dehydrogenase *(EaALDH)* and deeper rooting 1*(DRO1).*

More than 89 transgenic events (EaEXPA1 – 32 events; EaGLY III – 11 events; EaNF-YB2 – 24 events; ALDH – 22 events) with different abiotic stress tolerance genes were developed. Transgenic events with EXPA1, GLY III, NF-YB2 and ALDH were vegetatively multiplied from V0 plants using single bud setts thus taking the transgenic events to V1 stage. These transgenes were driven by the constitutive ubiquitin promoter PD2 (isolated at ICAR-SBI, Coimbatore). Transgene integration was confirmed through gene specific PCR and also the promoter specific forward primer and the gene specific reverse primers. Maker gene was amplified from these events and confirmed by sequencing. All these plants were grown in 18" plastic pots containing equal quantity soil, sand and farmyard manure (1:1:1 ratio). Five replications per event were used and screening was carried out at formative phase (90 days after planting) by withholding irrigation for a period of 10 days.

Physiological studies i.e. cell membrane thermostability, gas exchange parameters (photosynthesis rate, stomatal conductance and transpiration rate), relative water content, chlorophyll content and photosynthetic efficiency were assessed on 0^{th} and 10^{th} day of stress. In all experiments, untransformed Co 86032 was used as negative control.

Phenotypic analysis showed that transgenic sugarcane events displayed a higher tolerance to drought stress compared to control (Fig. 35).

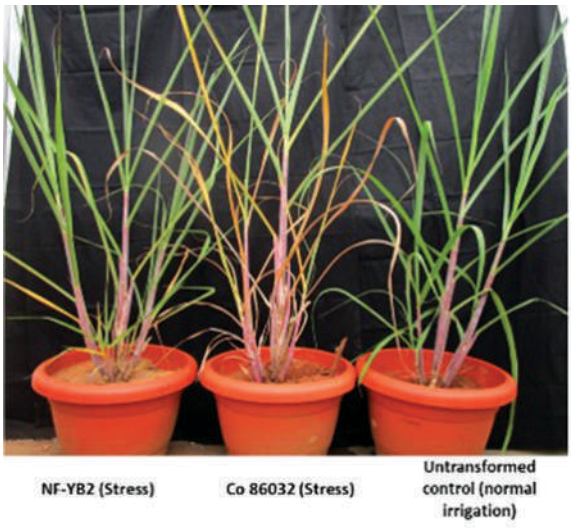


Fig. 35. Screening of pSBI-NF-YB2 transgenic events along with the untransformed control (Co 86032) for soil moisture stress. A) ~24.8% soil moisture B) ~8.1% soil moisture

RWC analysis revealed that in transgenics there is high water retention compared to control. Accordingly higher gas exchange parameters too. Chlorophyll content and photosynthetic efficiency were comparatively higher in transgenic events compared to the control. Over expression of transgene these genes showed significant positive increase in response to drought tolerance. Transformants showed significantly higher level of transgene expression compared to untransformed control. All these events were screened for drought tolerance and identified the promising events.

(C. Appunu, G. Hemaprabha and G.S. Suresha)

Network project of transgenics in crops – transgenic development in sugarcane

The sugarcane variety Co 86032 was chosen for genetic transformation with an idea to enhance the performance under water deficit stress conditions. In response to abiotic stresses, plants

Fig. 36. Aerial view of drought tolerance screening of codA sugarcane transgenic events. Screening of transgenics (V1 stage) for drought tolerance performed under rainout shelter facility. Stand of transgenic replicated events after imposition of drought stress (10 days) by withholding irrigation

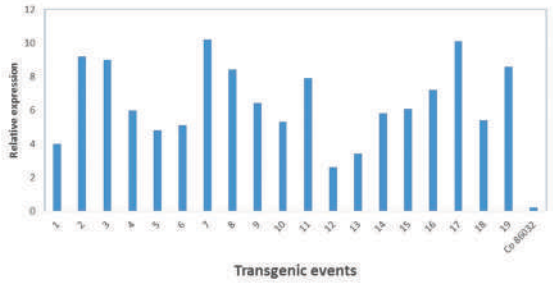


Fig. 37. Differential expression of codA in sugarcane transgenic events

Fig. 38. Improved drought tolerance of transgenic events compared to untransformed control plant

produce low molecular weight compound known as Glycine betaine (GB), compatible solutes, to cope with stresses by increasing water potential and in turn protect the plants against the damaging effects of secondary stresses such as osmotic and ionic stresses. A total of 76 putative transgenic events were developed for *codA* gene. Transgenic events are in vegetative multiplication stage (V0). Part of these *codA* transgenic events was confirmed for presence of transgene and screened them for drought tolerance (Fig. 36). Quantitative real time PCR expression analysis revealed the multifold expression of *codA* in transgenic events (Fig. 37). Transgenic sugarcane events exhibited better drought tolerance compared to untransformed transgenic events (Fig. 38).

New construct was developed for EaDREB2 gene. In this construct, the candidate gene is driven by stress inducible RD29 promoter. The cloning was confirmed through PCR using gene specific primers. A total of 24 putative transgenic events were generated with DREB gene. Transgenic events are in different stages of developments and work is in progress.

(C. Appunu and R. Valarmathi)

Novel application of sugarcane vacuolar targeting technology for recombinant protein

The project was initiated with the idea to validate vacuolar technology developed by ICAR-SBI for commercial recombinant protein production in sugarcane.

Gene details: Three genes *viz.,* Glucocerebrosidase (GCS), Insulin and Interferon *(Ifn2A)* are being used in this project. Based on the functions, enzymes in the lysosome are sometimes called housekeeping enzymes. Glucocerebrosidase (GCS) is an enzyme with glucosylceramidase activity that is needed to cleave, by hydrolysis, the beta-glucosidic linkage of the chemical glucocerebroside, an intermediate in glycolipid metabolism that is abundant in cell membranes. Beta-glucocerebrosidase is a housekeeping enzyme that helps break down a large molecule called glucocerebroside into a sugar (glucose) and a simpler fat molecule (ceramide). Glucocerebroside synthesis of an enzyme called glucocerebrosidase, leading to the accumulation of lipids

called glucocerebrosides in Gaucher cells. Gaucher cells are large, wrinkled-appearing cells that store glycolipids and are usually found in the bone marrow and the spleen.

Insulin is a hormone that is responsible for allowing glucose in the blood to enter cells, providing them with the energy to function. A lack of effective insulin plays a key role in the development of diabetes.

Interferon *(Ifn2A),* a common medication used to treat hepatitis B, hepatitis C. These are infectious disease caused by the hepatitis B (HCB) and hepatitis C virus (HCV) that primarily affects the liver normal function.

Construction of vector: The GCS, *Insulin* and *Ifn2A* gene nucleotide sequences were retrieved from GenBank, codon optimized and synthesised by TRANA LAB for better expression in sugarcane. These genes were cloned in binary vector 1305.2 and the candidate gene is driven by port ubi882, which was isolated from *Porteresia coarctata* at the Institute. Cloning was confirmed through PCR using gene specific primers and also (promoter-gene fusion) the promoter specific forward primer and the gene specific reverse primers.

Sugarcane transformation: Sugarcane variety Co 86032 was used for transformation with *GCS, Insulin* and *Ifn2A* gene constructs either through *Agrobacterium* mediated or particle bombardment method of transformation.

A total of 89 events are generated and all of them are in multiplication stage. Screening was done with gene fusion primer of amplicon size 968bp. 56 events were found positive (Fig. 39) Untransformed control doesn't show signal.

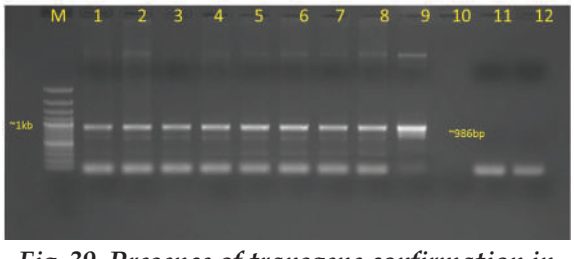


Fig. 39. Presence of transgene confirmation in glucocerebrosidase transgenic events through PCR amplification using gene-promoter fusion primers. Lanes M- 100bp ladder, Lanes 1-9 - transgenic events, lanes 11- Untransformed control and lane 12- Negative control

(C. Appunu and G.S. Suresha)

A proteomic approach for identification and characterization of new ligninolytic enzymes for improved sugarcane bagasse delignification

Biomass preparation and analysis: Biomass prepared from *Erianthus* clone IK-76-81 was examined for enzymatic pretreatment. The crude extracellular fractions from isolates S1, S2, S3, S6, S8 and S10 were used as the enzymatic solutions for the pretreatment of the *Erianthus* baggase material. A sample was digested with the purified laccase from *Trametes versicoloras* a positive control, and a sample was processed similarly without enzyme as negative control. The biomass was treated overnight with the enzyme preparations. The resultant biomass slurry was neutralized with distilled water and dried. Further, the biomass samples were analyzed by SEM, FT-IR and GC-MS.

Biomass surface alterations detected by scanning electron microscope: SEM analysis revealed alterations in the morphology of the *Erianthus* baggase that occurred after enzymatic pretreatment (Fig. 40). The negative control (without enzyme) showed smooth surface with a slight peel-off due to the overnight digestion (Fig. 40A). While the surface of the biomass samples treated with the commercial laccase enzyme (6 U/mL) had holes and pinholes (Fig. 40B). Likewise, the biomass treated with the crude enzyme preparations from the six isolates (S1, S2, S3, S6, S8 and S10) also had numerous potholes range of 1.28 to 2.56 µm and cavities on the surface of the material (Fig. 40C-H) suggesting the action of the enzyme on the biomass disintegration. The surface morphology of the EB treated with the enzymatic extract from S2 isolate showed wider pores (Fig. 40D) indicating the efficiency of the enzyme.

Biomass-derived products detected by gas chromatography-mass spectrometry: The GC-MS analysis was used to detect the biochemical products generated after pre-treatment of the EB. Pretreatments included a control, crude enzymes from the S1, S2, S3, S6, S8 and S10 strains and a commercial laccase. Metabolites were identified based on peak area and the probability of the detected component. The GC-MS analysis of the bagasse

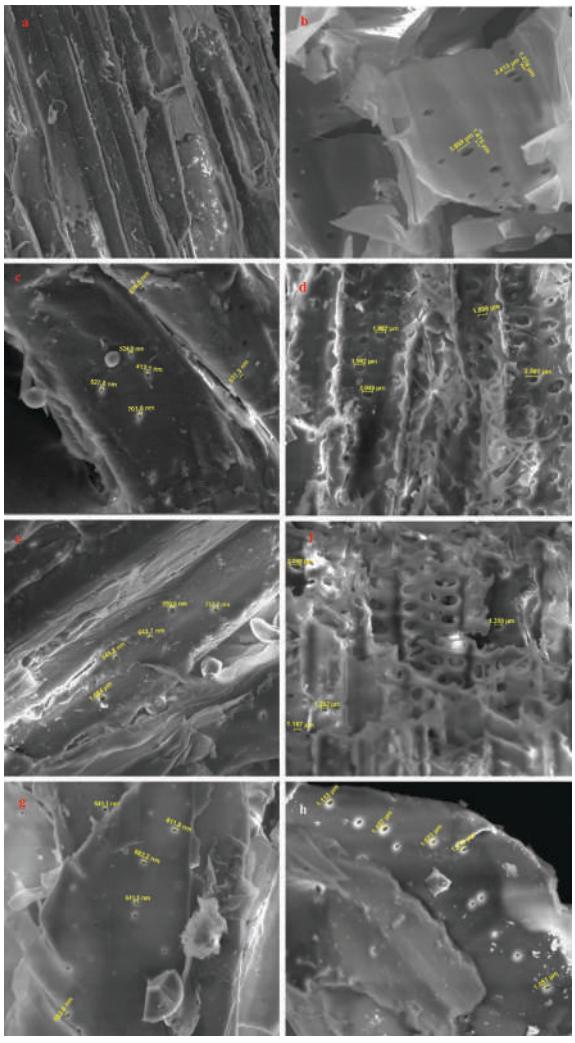


Fig. 40. SEM analysis of **Erianthus** *baggase after enzymatic pretreatment*

treated with the enzymes showed 96 metabolites which were totally absent in the control biomass (without enzymatic treatment). Out of the 96 metabolites 43 metabolites with high probability and peak area, along with their component name and retention time, were identified and selected. These 43 metabolites were compared among the different isoaltes using a heat map (Fig. 41). Certain compounds, such as tetradecanoic acid, n-hexadecanoic acid and octadecanoic acid, were identified in all the isolates digested samples. Derivatives of these components, were identified to be of high abundance in the enzyme-treated bagasse when compared to the untreated control that indicate the breakdown of lignin and the formation of derivative compounds. The breakdown products included low molecular weight metabolites, such as propionic acid, likely generated by the breakdown of ester and phenyl-linked components. The GC-MS

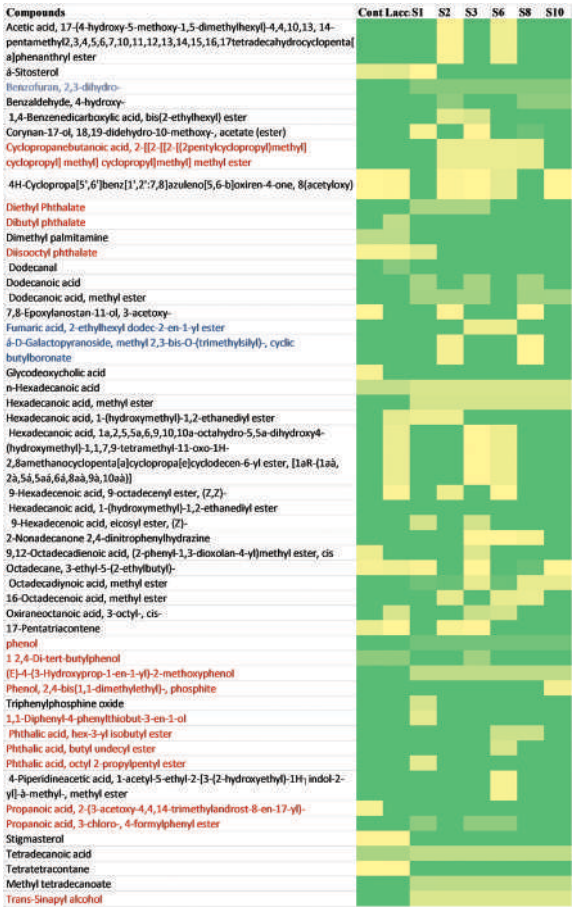


Fig. 41. Heat map of 43 metabolites among the different isolates

analysis also detected metabolites with phenolic, acidic and ester groups due to the breakdown of the β-aryl and benzoylether bonds in the lignin. Metabolites associated with the formation of lignin beneze-diols and the breakdown of the cellulose and hemicellulose fractions of biomass were also detected. The metabolites generated from EB treated with crude enzymes of isolates S1, S3 and S6 predominately showed phenol, phthalates (diisootcyl and dietyl phthalate) and trans-sinapyl alcohol.

(K. Lakshmi)

Development of white grub (*Holotrichia serrata*) resistance in sugarcane and groundnut by deploying novel Cry toxin holotype genes

Bacillus thuringiensis isolate Bt 62 genome was characterized using Illumina and Nanopore sequencing and hybrid assembly approach. Whole genome sequencing revealed the presence of two *cry* genes *viz., cry8Sa1* and *cry8Ib.* Bt 62 iso-

late was toxic to white grub *Holotrichia serrata.* The NASF empowered committee, recommended that the project may be carried out to initially prove the toxicity of these genes to white grubs before developing white grub resistance transgenic sugarcane and groundnut. In order to identify the individual role of these two crystal toxin genes on mortality of the white grub *H. serrata,* cloning and expression of these *cry8* toxins genes *(cry8Sa1 and cry8Ib)* individually in crystal negative (acrystalliferous) *B. thuringiensis* HD73- strain was done.

Based on the data generated from whole genome sequencing, full length coding sequence of *cry8Sa1* and *cry8Ib,* were cloned in shuttle vector pSTK and transformed in to *E. coli* DH5α. Before transforming in *B. thuringiensis* HD73-, recombinant plasmid was isolated from DH5α and transformed into methylation deficient *E. coli* strain E7 *(Dam-Dcm-)* to remove methylation sensitivity in *Bacillus* background. The recombinant plasmids isolated from the E7 were transformed into *B. thuringiensis* HD73 through electroporation. The transformants were then screened for the presence of recombinant plasmid by colony PCR and restriction digestion analysis. Transformed positive colony was subjected to phase contrast microscopic observation and toxin expression was confirmed by the presence of crystals along with spores in the Bt HD73 cell (Fig. 42). Spore crystal mixture was isolated from the recombinant clones and toxin expression was

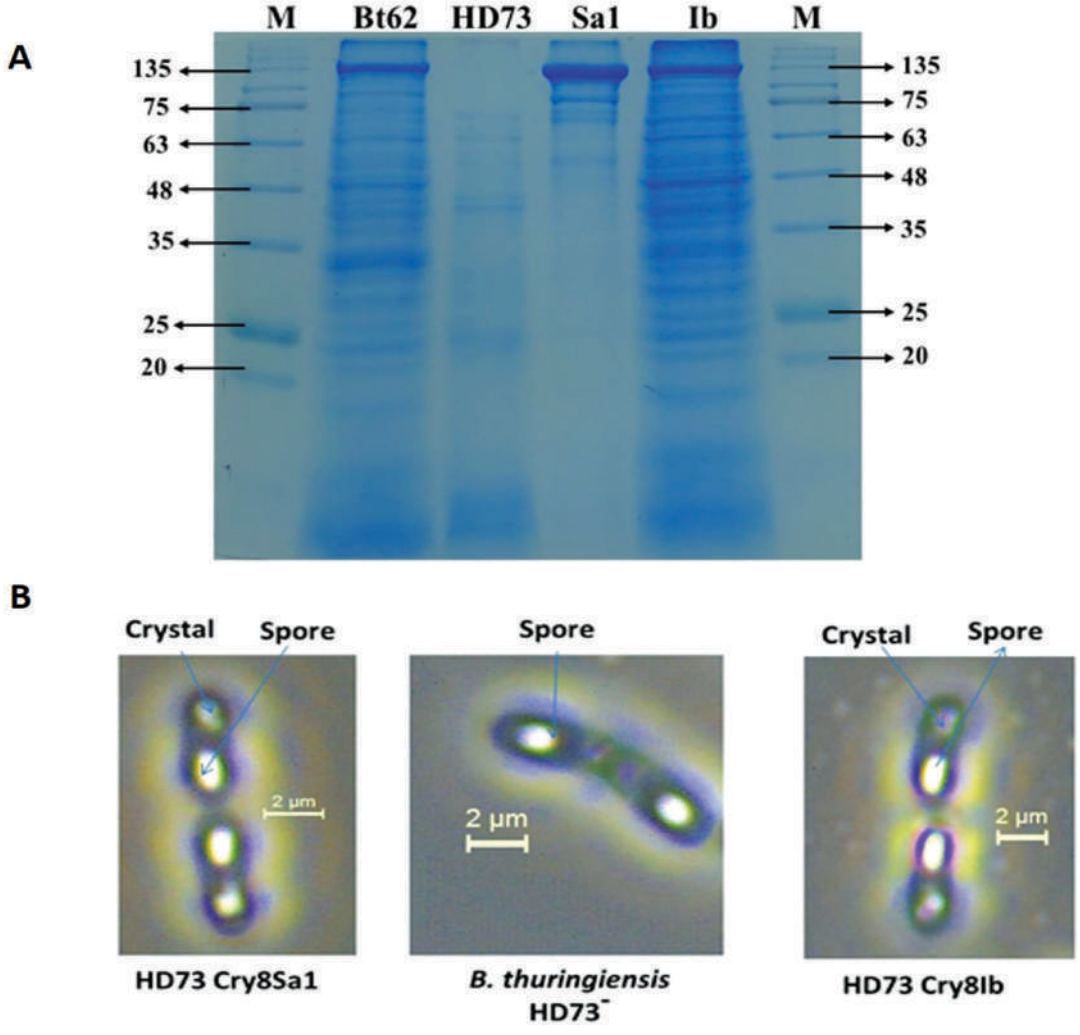


Fig. 42. (A) SDS-PAGE analysis of* Bacillus thuringiensis *isolate Bt 62 Cry protein. Lane 1 & 6: (10 – 250 kDa protein marker), 2: Bt 62 spore crystal mixture protein profile (wild type), 3: Bacillus HD73- (acrytalliferous) strain, 4: cry8Sa1 in HD73- spore crystal mixtureprotein profile, and 5: cry8Ib in HD73- spore crystal mixtureprotein profile. (B) Phase contrast microscopic observation of acrytalliferous Bacillus producing cry8 (cry8Sa1 and cry8Ib) crystal toxins

confirmed by identified SDS PAGE using HD73 as negative control and Bt 62 strain (wild type) as positive control. The SDS PAGE analysis, clearly revealed that Cry8Sa1 and Cry8Ib toxin was successfully expressed in the acrystalliferous Bt strain. To study the individual toxicity of the Cry8Sa1 and Cry8Ib toxicity spore crystal mixture from transformants expressing the toxins individually was isolated for conducting bioassay against 1st instar larvae. The bioassay was conducted in 12 well tissue culture plate containing carrot disc contaminated with spore crystal mixture of Cry8Sa1 and Cry8Ib toxin. Ten first instar larvae of whitegrub *(H. serrata)* were released for each replication of cry8Sa1, cry8Ib, HD73 (negative control), Bt 62 (positive control) and distilled water (control). Bioassay was replicated thrice for each toxin along with positive and negative control. Insect mortality data was recorded at 24 h interval for a week. The bioassay results indicated that Cry8Sa1 toxin exhibited significantly higher mortality of up to 90% in the replications as compared to 60% mortality obtained with Cry8Ib toxin. Bioassays with spore crystal mixtures of Cry8Sa1 and Cry8Ib was conducted on 2nd and 3rd instar grubs. The results for the 2nd and 3rd instar grubs revealed the antifeedant effect of these toxins and grubs going into forced starvation. Purification of individual recombinant Cry8 toxins (Cry8Sa1 and cry8Ib) was initiated to conduct bioassay for next white grub season.

(C. Appunu, B. Singaravelu, K. Hari and G.S. Suresha)

Potential application of genomic in situ hybridization (GISH) to understand the genomic constitution of *Saccharum* hybrids

For the preparation of probes genomic DNA was isolated from *S. officinarum* (28 NG 210), *S. spontaneum* (Coimbatore), *Erianthus* (IK 76-91), Sorghum and Bamboo. The quality and quantity of the DNA was checked, fragmented to 500-1000bp size by sonication and the fragmented DNA was labelled with biotin and probe efficiency was tested in the mitotic slides of respective species. For GISH analysis, mitotic as well as meiosis slides were prepared and slides having cells with division were freeze dried in liquid nitrogen.

An intergeneric hybrid between *E. procerus* and *Saccharum,* GU 04(28) EO-2, has been identified as potential source for diversifying the genetic base of the sugarcane varieties. The presence of 40 *E. procerus* chromosomes in this hybrid was already reported through GISH. Five BC_1 progenies of this hybrid were subjected to classical and molecular cytogenetics. The plant materials used for the study are five back cross progenies (BC_1) of the cross *E. procerus* x *Saccharum* i.e., GU 12-19, GU 12-23, GU 12-34, GU 12-37 and GU 12-38. These were derived from the cross between the F_1 progeny GU 04 (28)-EO2 (2n=80) x Co 06027 (2n=108).

Mitotic analysis revealed that the somatic chromosome number for the BC_1s. GU 12-19, GU 12-23, GU 12-34, GU 12-37 and GU 12-38 were 2n=92, 2n=92, 2n=92, 2n=94 and 2n=96 respectively. In all these clones during meiotic analysis bivalents were more predominant and abnormalities like laggards and bridges were observed during anaphase.

GISH analysis was done in mitotic and meiotic cells, where in biotin labeled *E. procerus* DNA has been used as probe. In mitosis 20 chromosomes of *E. procerus* were obtained whereas in meiosis 10 *E. procerus* were observed. The hybrids showed 20 chromosomes of *E. procerus* on using *E. procerus* genome DNA as the probe during GISH has been suggested that it follows n+n chromosome transmission pattern. The GISH analysis confirmed that there were no recombination events between *Saccharum* and *E. procerus* chromosomes. As these genomes are distantly related it is suggested that *E. procerus* may be introgressed into cultivars as only in whole chromosomes by conventional breeding programs.

The true hybridity has been confirmed by 5S rDNA markers and bands were in the size of approximately 400 bp in *Erianthus* and 230 bp in *Saccharum.* The hybrids GU 12-19, GU 12-23, GU 12-34, GU 12-37 and GU 12-38 had both the bands and confirmed as genuine hybrids of *Erianthus.*

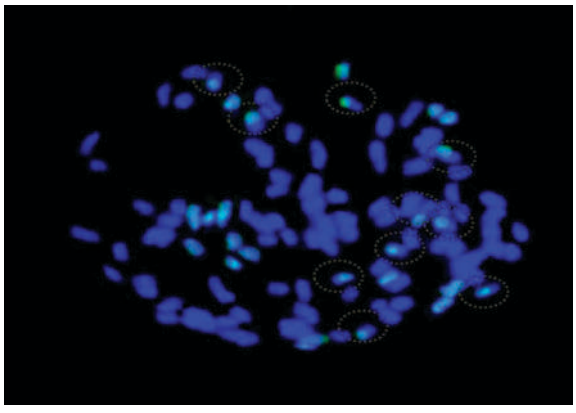


Fig. 43. GISH analysis of Co 86032 (16* S. spontaneum *chromosomes and 10 recombinant chromosomes)

The pre-breeding hybrids (TSGS) which were developed from crosses between *S. officinarum* and *S. spontaneum* were cytologically analyzed and subjected to GISH analysis. GISH analysis with *S. spontaneum* as labeled probe revealed that 27-36 chromosomes of *S. spontaneum* were present in these hybrids. The variety, Co 86032, was subjected to GISH analysis with *S. spontaneum* probe. Sixteen *S. spontaneum* chromosomes and 10 recombinant chromosomes were observed in this variety (Fig. 43).

(V.P. Sobhakumari)

CRISPR/Cas mediated targeted editing for virus resistance in sugarcane

Yellow leaf disease (YLD) caused by Sugarcane yellow leaf virus (ScYLV) occurs in sugarcane across the varieties and locations in epidemic form and is one of the major factors responsible for varietal degeneration. Multiplication of sugarcane through tissue culture gives protection only for shorter period due to secondary infection by the virus and needs repeated supply of virus-free plantlets which is very expensive to the farmers. One of the most efficient and sustainable strategies for controlling plant virus infections is the use of genetically resistant plants. Recent advances in precision genome engineering make it possible to precisely alter DNA sequences in living cells, providing unprecedented control over a plant's genetic material. Potential future crops derived through precision genome engineering include those that better withstand pests and diseases attack with enhanced performance and valuable traits. Plant RNA viruses require host translation initiation factors (IFs) to initiate the infection cycle in plants. There is specific interaction between RNA viruses and translation initiation factors. Hence, one of the eukaryotic translation initiation factors elF4G was isolated from commercial sugarcane variety to study the functional interaction with the virus. Full length of elF4G is identified to be 9399 bp, in that coding sequence length is ~5010bp (Fig. 44). Coding sequence of elF4G was cloned from Co 86032 and sequenced through Sanger method. The elF4G isolated from *Saccharum* hybrid is located on chromosome number 6 (Fig. 45). Gene structure and domain identification through bioinformatics analysis revealed that elF4G has four exonic and three intronic regions (Fig. 46). Protein docking and the interaction analysis of eukaryotic translation initiation factor (elF4G) with sugarcane yellow leaf virus

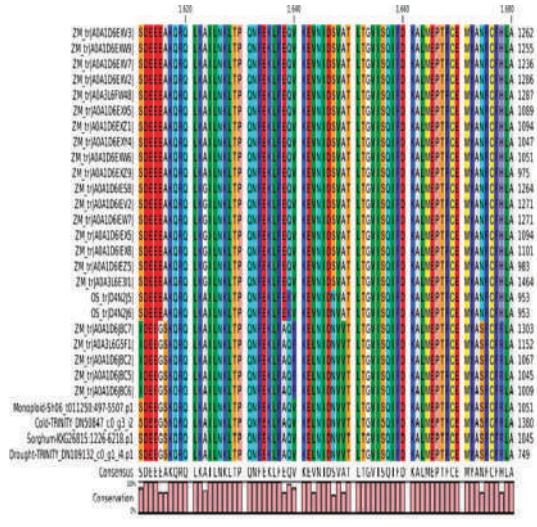


Fig. 44. Protein sequence homology of Eukaryotic Translation Initiation Factor 4G (elf4G) from Saccharum species with other related species and genera

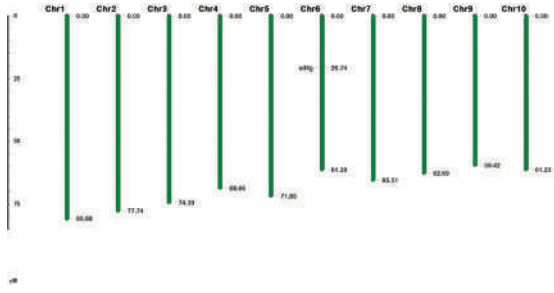


Fig. 45. Chromosomal location of Eukaryotic Translation Elongation Factor 4G (elf4G). Numbers on top of each chromosome represent chromosome numbers

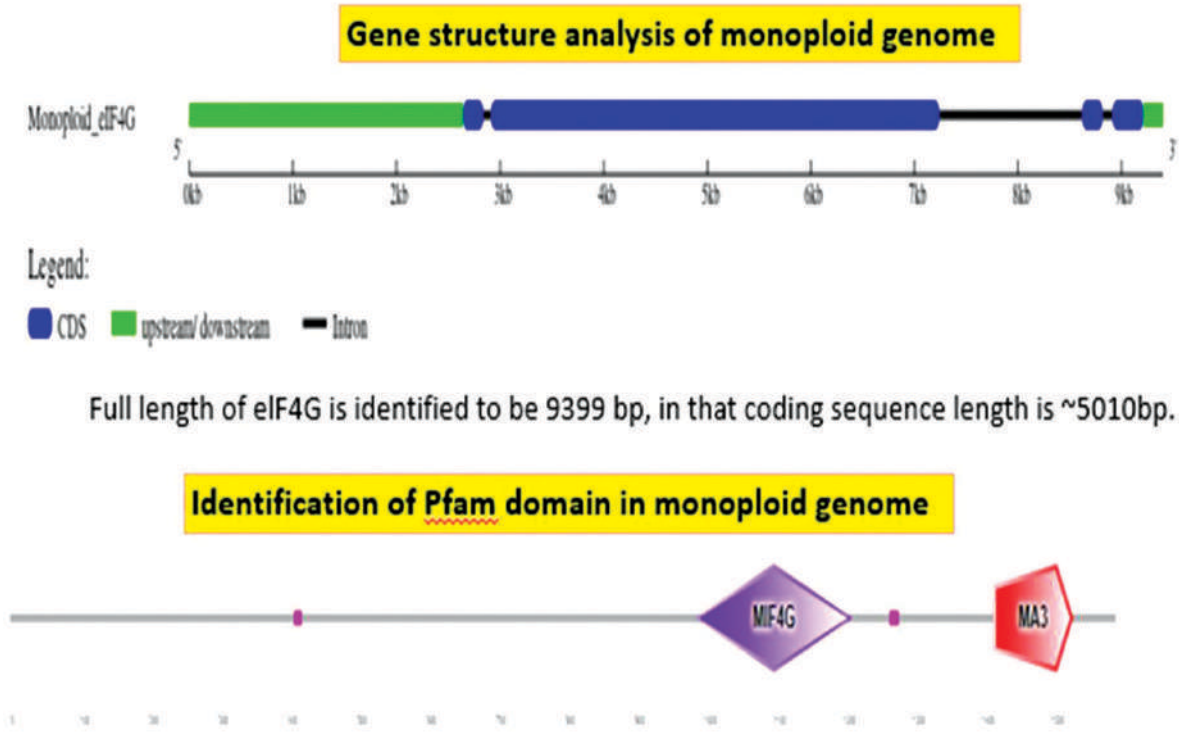


Fig. 46. Gene structure analysis and domain identification in Eukaryotic Translation Elongation Factor 4G (elf4G) from Saccharum hybrid

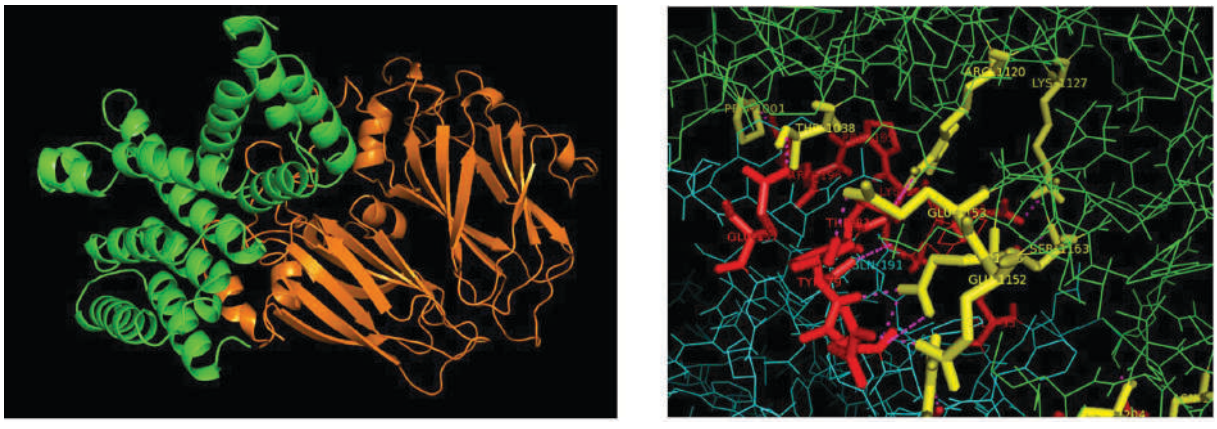


Fig. 47. Molecular docking and interaction analysis of Eukaryotic Translation Elongation Factor 4G (elf4G) from Saccharum hybrid with Sugarcane Yellow Leaf Virus coat protein

coat protein revealed strong interaction between these partners (Fig. 47). CRISPR/Cas9 guide RNAs were designed with pRGEB31 vector. Three eIF4G sgRNA *viz.,* pCas9-eIF4G-gRNA1, pCas9-eIF4G-gRNA2 and pCas9-eIF4G-gRNA3 guide RNAs are being used for transformation after construct confirmation through restriction and sequence analysis.

(C. Appunu, R. Viswanathan and R. Valarmathi)

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

Development and promotion of tools and machinery for sugarcane mechanization

Development of mini tractor operated EPN applicator: A mini tractor operated entomopathogenic nematode (EPN) applicator for applying EPN formulation continuously at the root zone of the sugarcane crop grown in wide row spacing has been developed (Fig. 48). This can apply the EPN formulation at the root zone, 15-20 cm below the surface. The unit was developed jointly by ICAR-SBI and ICAR- Central Institute of Agricultural Engineering, Regional Centre, Coimbatore. This equipment consists of main frame which can be attached to standard three-point hitch arrangement of the tractor, solution (EPN formulation) tank, solution tank holding frame, furrow openers, water pump, agitator assembly, flow and speed control unit. The rear side of the main frame has been provided with telescopic arrangement for row spacing adjustment (4 feet & 5 feet). A 150 litre tank is placed to carry the EPN solution. The tank consists of agitator and two EPN solution outlet flexible tubes. The agitator consists of two numbers of baffles at the end of vertical shaft. The EPN powder is diluted in water tank with help of agitator. The agitator is powered by 12 V high torque DC motor at maximum rpm of 150. A shoe type furrow opener with wings have been fitted to the main frame in rear side of unit. The diluted EPN solution is pumped by using battery operated diaphragm pump with the output capacity of 4l/min. The solution outlet is taken from the bottom side of the tank through pump to behind the furrow opener. Sensors have been provided to stop the flow of EPN solution when the applicator is lifted while turning the tractor. The capacity of the tank is 150 l. The field capacity of the equipment is 0.18 ha h^{-1} at the operating speed of 1 km h^{-1}. The cost of operation was worked out as Rs. 2550 per ha and the cost saving is around 47%. The developed unit was field tested in ratoon sugarcane crop field at ICAR-SBI, Coimbatore.

Fig. 49. Field demostration at BAS, Unit 1

Demonstration of EPN applicator: Conducted field demonstration of manually operated EPN applicator and mini tractor operated EPN applicator

Fig. 48. Working of mini tractor operated EPN applicator

for 50 progressive farmers and 50 cane officers of Bannari Amman Sugars (BAS) Limited-Unit I, Sathyamangalam, on 3 February 2021 (Fig. 49).

(T. Arumuganathan, C. Palaniswami, V. Venkatasubramanian, C. Sankaranarayanan; T. Senthil Kumar and S. Syed Imran- ICAR-CIAE RC, CBE)

Inter institutional collaborative research project on testing and evaluation of IISR sugarcane machineries under tropical condition

Performance evaluation of IISR model disc type ratoon management device: To evaluate the IISR model disc type ratoon management device, a harvested field of sugarcane plant crop (variety Co 86032) with wide row spacing was selected. The experiment was planned in split plot design. The field was made into two blocks (main plots) and the first block was subjected to stubble shaving and off-barring using the IISR model disc type ratoon management device in the ratoon crop in February 2020. In the second block, stubble shaving and off-barring were performed manually. Four sub plot treatments namely trash shredding, trash removal, trash shredding + microbial consortia and trash shredding + microbial consortia + pocket manuring were scheduled in the field experiment. The sugarcane yield (t/ha) by RMD (87.36 t/ha) was comparable with manual ratooning (89.10 t/ha). Different trash management practices followed in the sugarcane ratoon crop could not reach to the level of significance, however, trash shredding +microbial consortia + pocket manuring recorded marginally higher cane yield (92.48 t/ha) over rest of the trash management practices.

Demonstration of IISR two row deep furrow sugarcane cutter planter

- Conducted field demonstration of tractor operated two row deep furrow sugarcane cutter planter and tractor operated two row sugarcane seedling transplanter for cane officers from Bannari Amman Sugars limited-Unit 5 and sugarcane farmers from Thirukoilur, Villupuram district at the R&D farm of the mill on 19 March 2021 (Fig. 50). About 100 farmers from Villupuram district and more than 50 cane officials from the mill witnessed the demonstration.

Fig. 50. Field demonstration at BAS, Unit 5

Fig. 51. Field demonstration at BAS, Unit 4

- Conducted field demonstration of tractor operated two row deep furrow sugarcane cutter planter and tractor operated two row sugarcane seedling transplanter for cane officers from Bannari Amman Sugars Ltd., Unit 4 and sugarcane farmers from Thiruvannamalai district in afarmers field in Kolunthampattu on 20 March 2021 (Fig. 51). More than 150 farmers from Thiruvannamalai district and

more than 50 cane officials from the sugar mill attended the demonstration.

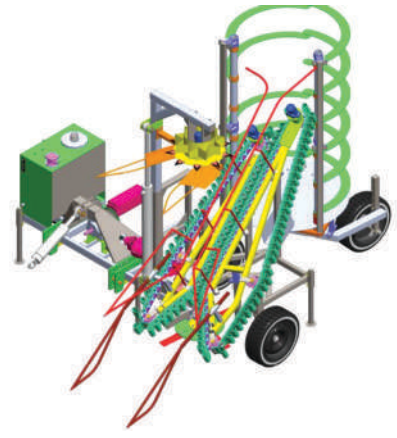
(A.K. Singh – ICAR-IISR, Lucknow, T. Arumuganathan, A.S. Tayade and T. Senthil Kumar - ICAR-CIAE RC, CBE)

Development of tractor operated whole cane harvester

Design and development of mini tractor operated whole cane harvester: A mini tractor operated whole cane harvester has been designed and CAD drawing of the whole cane harvester has been prepared. An initial model of mini tractor operated sugarcane harvester has been developed for harvesting sugarcane crop growing in wide row spacing. The developed unit consists of main frame, base cutting unit, crop windrowing system and power transmission system. The base cutting unit consists of four numbers of blade and the provisions were provided to change the approach angle of cutting blades and number of blades from two to four. The harvester is suitable for attaching with mini tractors ranging from 18-24 hp. The power from tractor PTO is transmitted through gear box and belt pulley drive to base cutting unit. The developed unit was field tested initially at the Institute, (variety: Co 86032, age of cane: 14 months) and further at TNAU, Coimbatore. Performance of the harvesting system is satisfactory and still further studies on influence of cutting blade thickness on cutting of sugarcane in terms of smooth cut/ partial cut/broken cut has to be conducted (Fig. 52).

CAD drawing for the design of tractor operated whole cane harvester: Computer aided drawing (CAD) for development of whole cane harvester was prepared with individual components (Fig. 53).

Fig. 52. Field evaluation of mini tractor operated whole cane harvester



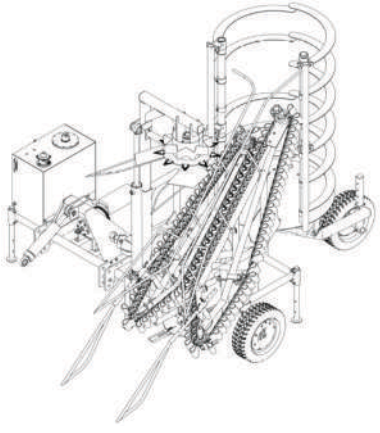


Fig. 53. CAD drawing of tractor operated whole cane harvester

The conceptual tractor operated whole cane harvester consists of main frame, power transmission system, base cutting unit, cane conveying system, detopping system, and cane collection box. The fabrication of individual components have been completed and assembling of components to develop the unit is in progress.

(T. Senthilkumar (ICAR-CIAE), T. Arumuganathan, A.K. Singh and M.K. Singh (ICAR-IISR))

Development and promotion of mini tractor operated sugarcane planters for small-farm mechanization

CAD drawings for the design of mini tractor operated sugarcane sett cutter planter: CAD for development of mini tractor operated sugarcane sett cutter planter was prepared with individual components (Fig. 54). It consists of hopper, main frame, hitch frame, power transmission gearbox system, pesticide tank, fertilizer hopper, cutting mechanism, furrow opener with ridger, furrow closer, row marker and operator seat.

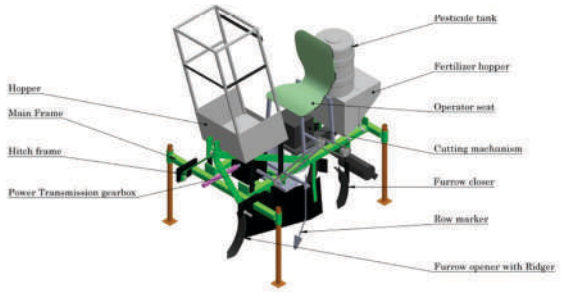


Fig. 54. CAD drawing of mini tractor operated sugarcane sett cutter planter

(T. Arumuganathan, T. Senthilkumar (ICAR-CIAE) and S. Anusha)

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

Experiments were conducted in protrays to study the effect of sett treatment with bioinoculants on bud chip and single buds made using 12 months old sugarcane and treatments were given using sett treatment device. The treatments consist combinations of seven sett treatments, six microbial cultures and seven sugarcane varieties. Sett treatments (single bud and chip bud) with microbial cultures, *Frateuria aurantia (FA), Gluconoacetobacter diazotrophics (GD-01), Gluconoacetobacter xylinus (GX-01), Pink Pigmented Facultative Methylobacteriam (PPFM-03), Beijerinckia (BE-03), Azospirillum brazilense (AB-01),* and control were taken up in sett treatment device at -150 mm/Hg for 15 minutes. The settlings in protrays were recorded for sett germination, settling vigor (Vigor index = seedling weight x germination), and microbial count. Sett treatment of rhizobacteria in sett treatment device had significant influence on germination of both single bud and bud chip setts at 20th and 30th day of planting. Among the rhizobacteria, *Beijerinckia* has recorded higher germination of 70% at 20th day of planting, and also on 30th day of planting *Beijerinckia* has recorded higher germination of 80% when compared to all other bio-inoculants with single bud setts. Similar results were obtained with chip buds, where *Beijerinckia* has recorded, 46% and 58% germination at 20th and 30th days, respectively. Among the varieties tested, the variety Co 86032 has recorded significantly higher germination of 85.71 and 92.86 % at 20th and 30th day after planting, respectively in the case of single bud setts, while in chip bud setts, it was 47.15 and 62.86 % at 20th and 30th day after planting, respectively. Sett treatment with bio-inoculants in Sett Treatment Device had significant influence on settling vigor of both the single bud and bud chips. *Beijernickia* spp. has recorded high settling vigor in single bud (857.72) and bud chip (437.11) settlings on fresh weight basis and on dry weight basis, the settling vigor was 290.18 and 136.05 in single bud and chip bud respectively. The performance of varieties revealed that, Co 86032 has recorded highest settling vigor of 834.68 and 421.00 (single bud and chip bud setts) on fresh weight basis, on dry weight basis, the settling vigor was 352.07 and 188.36 with single bud and chip bud respectively. Among the bio-inoculants, higher microbial count was observed in *Beijernickia* spp. (BE-03), followed by *Gluconacetobacter diazotrophicus* and *Methylonbacterium spp.* (PPFM). Among the bio-inoculants, higher microbial count was observed in *Beijernickia* spp. followed by *G. diazotrophicus* (GD) and *Methylonbacterium* spp. (PPFM). Overall results indicate that sett treatment with bioinoculants prior to planting in protrays with *Beijernickia* @ 0.5 ppm has advantage in improving the germination and vigor of sugarcane transplants.

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

Weed management in sugarcane under wide row planting

A field experiment was initiated in February 2020 to evaluate the crop injury and yield response of two sugarcane varieties, Co 86032 and Co 0212

to the application of herbicide molecules like topramezone, tembotrione, halosulfuron methyl and ametryne. The experiment was laid out in split plot design with three replications. Treatments are (1) Three hand weeding 30, 60 and 90 DAP (2) Unweeded control (3) Topramezone 29.4 g ha^{-1} + atrazine 250 g ha^{-1} (4) P (4) Tembotrione 120 g ha^{-1} + atrazine 250 g ha^{-1} at (5) Halosulfuron methyl 67.5 g ha^{-1} + metribuzin 750g ha^{-1} (6) Ametryne 2.4 kg ha^{-1} + 2,4-D 1 kg ha^{-1}. The mean germination in all plots at 45 DAP was more than 50% Major weed flora observed in the field were *Datura metel, Trianthema portulacastrum, Commelina benghalensis, Cyperus rotundus, Brachiaria reptans, Dactyloctenium aegyptium, Chloris barbata, Digitaria sanguinalis and Cyanadon dactylon*. The herbicides were applied at 35 days after planting. Visual phytotoxicity evaluations were taken at 7, 14, 30 and 60 days after herbicide application. Phytotoxicity ratings of the different treatments ranged between 0 and 5. Co 86032 showed no visual injury and found tolerant to all the herbicides applied. Treatment ametryne + 2,4-D caused persistent injury in terms of leaf scorching to sugarcane variety Co 0212 initially and had a visual injury recovery later. All the weed management practices led to significant reduction in density and dry matter of weeds when compared to weedy check. Hand weeding done at 30, 60, 90 DAP recorded lowest weed density and weed dry matter. Significant difference in cane yield was noted among sugarcane varieties under different treatments. Highest cane yield of 116.8 t/ha was recorded in sugarcane raised with three hand weeding at 30, 60, 90 DAP. Application of ametryne in combination with 2, 4-D also caused significant yield reduction in Co 0212 indicating its susceptibility to the herbicide.

(S. Anusha and P. Geetha)

Conservation agriculture for sustainable use and management of natural resources to improve productivity in sugarcane based cropping system

Conservation agriculture is a management system that maintains a soil cover through surface retention of crop residues, reduced or zero tillage and the use of cover or green manure crops in rotations and has not been tried in sugarcane farming. This project aims to provide information on the functioning of agricultural soil and sugarcane cropping ecosystem insight into the carbon sequestration retention by different component of agro-ecosystem. This information will be crucial for modelling activity and will allow understanding possible management option under present and future climate change scenarios along with the coping capacity of the sugarcane agro-ecosystem and its potential in the changing environment.

(P. Geetha, A.S. Tayade, K. Hari and A. Vennila)

AICRP (Sugarcane)

Agronomic performance of elite sugarcane genotypes

The experiment was laid out in split plot design with two replications with nine elite sugarcane genotypes, Co 14002, Co 14004, Co 14012, Co 14016, Co 14027, Co 14030, Co 14032, Co 86032, and CoC 671 with two fertilizer levels (100% RDF and 125% RDF) planted in wide row spacing (150 cm). Sugarcane cane yield was influenced significantly due to different elite genotypes wherein, elite sugarcane genotype Co 14016 (122.56 t/ha) and Co 14012 (117.98 t/ha) recorded significantly higher cane yield than CoC 671 (77.50 t/ha). Cane yield and juice quality were not influenced significantly due to fertilizer levels. Juice Brix, sucrose%, purity% and CCS% at harvest showed significant varietal differences. Among the entries, Co 14012 recorded significantly higher mean sucrose% of 21.16 than Co 86032. Amongst the nine elite sugarcane genotypes, Co 14012 was found more promising and recorded significantly higher CCS yield of 18.26 t/ha than the check entries, CoC 671 (12.28 t/ha) and Co 86032 (14.46 t/ha).

(A.S. Tayade, P. Geetha, S. Anusha, C. Palaniswami and P. Govindaraj)

Evaluating efficacy of PSAP for enhancement of sugarcane growth, yield and quality

Field trial was initiated under AICRP to evaluate the efficacy of Potassium Salt of Active Phosphorus (PSAP) in sugarcane with the objective of optimizing the dosage of application,

to assess its effects in sugarcane growth, yield and juice quality and to analyze the impact of the product on soil fertility and cost of cultivation. In all 12 treatments were imposed and it comprises, T_1- Application of RDF without sett soaking, T_2- RDF+ sett soaking with 0.8 % PSAP solution, T_3- Recommended N, 50% P and 50% K, T_4- T_3 + sett soaking with 0.8% PSAP solution, T_5- T_2 + Foliar spray of PSAP @0.4, 0.65 and 0.8% at 60, 90 and 120 DAP, T_6- T_2 + Foliar spray of PSAP @0.4, 0.65 and 1.10% at 60, 90 and 120 DAP, T_7- T_2 + Foliar spray of PSAP @0.4, 0.65, 1.10 and 1.10% at 60, 80,100 and 120 DAP, T_8- T_4 + Foliar spray of PSAP @0.4, 0.65, 0.8 and 1.10% at 60, 90 and 120 DAP, T_9 - T_4 + Foliar spray of PSAP @0.4, 0.65 and 1.10% at 60, 90 and 120 DAP, T_{10}- T_4 + Foliar spray of PSAP @0.4, 0.65, 1.10 and 1.10% at 60, 80, 100 and 120 DAP, T_{11}- Absolute control, T_{12}-STCR 150T . The germination percentage was recorded on 30th day after planting and found that, sett soaking with 0.8% PSAP solution has recorded higher germination than control.

(A.S. Tayade, P. Geetha, S. Anusha. V. Krishnapriya and C. Palaniswami)

Doubling income of small farms through sugarcane based farming system

The project has been sanctioned by Government of India under the National Agriculture Development Programme (NADP) / Rashtriya Krishi Vikas Yojana (RKVY) during 2019-20 with the objectives of setting up a model farm to demonstrate the extent of diversification and possibility

Farm House | Sugarcane settling production unit | Honey Beehive

Fish cum poultry unit | Vermicompost Unit

Goat Unit | Duck Unit

Fig. 55. Sugarcane based farming system unit

of varied agro-based enterprises at the Institute and for empowering human resource for sustenance of the proposed activities through on-farm capacity development programs. The sugarcane based farming system model with various components such as sugarcane intercropping system with pulses, and allied enterprises like dairy, goat, vermicompost unit, fish cum poultry + duck unit, sugarcane settling production unit, mushroom production and apiary has been established. Now the model is in working condition with 2 milch cows + 4 calves (2 heifer and 2 bull calves), 22 goats (12 female + 10 kids), duck-15 and composite of fishes (surface feeder-catla, column feeder-rohu, and bottom feeder- mirgal) in the fish pond of 300m^3 size (Fig. 55).

Sugarcane - intercropping system

New planting of sugarcane intercropping system under sub-surface drip irrigation was taken up in February 2021 and ratooning of the previous plant crop has been taken up. Three intercrops such as mint, coriander and blackgram has been cultivated in plant crop. Due to heavy waterlogging at the field site, performance of mint and coriander was not up to the mark to get a marketable produce, while blackgram has performed well.

(P. Geetha, T. Rajula Shanthy, C. Palaniswami and A.S. Tayade)

NFSM demonstration of pulses intercropping with sugarcane

Participatory on-farm research trials on sugarcane + blackgram intercropping in 40 hectares of farmers' fields were conducted in collaboration with Sakthi Sugars Ltd. Unit IV, Erode, Tamil Nadu, in the villages Aval Poondurai, Modakuruchi, Rajapalayam, Perumapalayam, Poondurai Semur, Thottipalayam, Devanampalayam, etc. Wide row spacing (150cm) was followed for sugarcane and the intercrops were sown on both sides of the ridges on the third day after planting sugarcane. At 10th day after sowing, the intercrops were thinned to maintain optimum population. The fertilizer recommendation followed for sugarcane was 280:62.5:120 kg N: P_2O_5:K_2O/ha. Blackgram, VBN- (Bg) 6, a newly released variety from TNAU, Coimbatore was supplied as critical input to the farmers. The fertilizer doses of 25:50:25 N: P_2O_5:K_2O/ha and Pulses wonder @ 5 kg/hectare was applied to blackgram. Since the population of the intercrops was 50% of the sole crop, half the recommended doses of fertilizers were applied to the intercrops. For management of weeds, post emergence application of Pendimethalin @ 0.75 kg a.i./ha was followed in sugarcane + blackgram intercropping. Recommended irrigation and plant protection measures were followed. The results revealed that sugarcane-based intercropping systems yielded significantly higher CEY (134.73 t/ha) than sugarcane alone (122.30 t/ha). Sugarcane + blackgram intercropping had a maximum production efficiency of 369.13 kg cane day-1 in 2020-21, which was 10.17 percent higher than sole sugarcane cropping. In terms of gross returns (3,53,000.87 Rs/ha), net returns (1,46,673.87 Rs/ha), and BC ratio (1.71), sugarcane + blackgram cropping system was found to be significantly superior to sole sugarcane cropping. The highest economic efficiency of 401.85 Rs/ha/day was recorded by sugarcane + blackgram intercropping which was 22.04 percent higher than mono sugarcane cropping.

(A.S. Tayade, P. Geetha, S. Anusha and. D. Puthira Pratap)

Intellectual Property Management and Technology Transfer/ Commercialization – Institute Technology Management Unit (ITMU) (National Agricultural Innovation Fund Scheme (NAIF) - Component I, IP & TM, ICAR)

Two ITMC meetings and two techno commercial meetings of Agrinnovate were conducted to discuss different aspects pertain to technology disclosures, patent applications and commercialization of technologies developed by ICAR-SBI. Coordinated submission of new sugarcane varieties, annual renewal of nine varieties, submission of NBA Status reports, signing MoUs for Clean healthy seed production, MoA with Kumaraguru College of Technology, Coimbatore for energycane bagasse for textile fibre, MoU with T. Stanes Co., Coimbatore for upscaling and efficacy testing of Bt62 for white grub control. Processed eight technology disclosures. The formalities for global license terms were finalized for ICAR-SBI technologies. Coordinated

signing of MoU for Bt gene licensing and a PPP project with Rasi Seeds (P) Ltd, Salem and M/s SKR Agrotech, Nagpur for soil moisture sensor. ICAR-SBI technologies were licensed to different firms *viz.*, Soil Moisture indicator technology to five firms, EPN biopesticide formulation to three firms, Cane Jam technology has been licensed to two firms, Liquid Jaggery production to six firms, Quatro sugarcane single bud cutter Machine, Sugarcane de-trashing tool, Sugarcane dietary Fibre food Products, ICAR-SBI-CIAE Sett treatment Device, ICAR-CIAE-SBI sugarcane rind removing equipment, ICAR-CIAE-SBI Motorised double headed sugarcane single bud cutting machine and ICAR-IISR-SBI Deep Furrow Sugarcane Cutter Planter each to one firm. Overall by licensing and commercialization of ICAR-SBI technologies, the institute has realised a revenue of Rs. 38,25,398.

(K. Hari, K. Rathnavel (ICAR-CICR), G. Hemaprabha, J. Srikanth, A. Ramesh Sundar, P. Murali, R. Viswanathan C. Palaniswami B. Singaravelu, K. Mohanraj and Bakshi Ram)

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

Two separate trials in split plot design were initiated with irrigation treatments as main plot and varieties (20 numbers of 'Co' hybrids in first trial and 16 representatives from species clones in second trial) as sub plot. Recommended cultural practices followed up to 60 DAP. The treatments were imposed during formative phase and continued up to harvest. Soil samples were drawn during cycle of irrigation in all the treatments.

Physiological traits: Chlorophyll SPAD index reduced by 5.8 and 11.4% (I_1 & I_2 respectively) in restricted irrigation treatments during formative phase and Co 15007, Co 15018, Co 12009 and Co 13014 had higher SPAD index for both the treatments (I_1&I_2). SPAD index did not vary significantly among the species clones and among irrigation treatments suggested that restricted irrigation doesn't influence the chlorophyll pigment in species clones unlike 'Co' hybrids. At formative phase, chlorophyll fluorescence declined in both the restricted irrigation treatments in 'Co' hybrids and the differences smoothened during grand growth phase, perhaps due to rainfall and conducive climate experienced. In species clones the variations for chlorophyll fluorescence were marginal and irrigation treatments effects were not pronounced. Canopy temperature depression (CTD) was positive and significant for I_0 while, in I_1 and I_2, it was negative in most of the genotypes. Few had positive change for CTD in I1 (Co 09004, Co 11015, Co 12009, Co 15007). Genotypes, Co 11015, Co 12009, Co 14002, Co 15007, Co 16018, had higher sucrose% juice over general mean for treatments and varieties. Among species clones Khakkai (18.2%), Pathri (17.9%), ISH 107 (17.5%) had moderate sucrose% juice in treatments. In most of the species clones there was mild increase in sucrose% juice in restricted irrigations.

Consolidated report

2017-19: The results of 2017-18 trials indicated few traits having good correlation with cane yield. Cane yield decreased in restricted irrigation treatments in both the years with higher reduction in the year 2017-18 (41 & 55% in I_1 and I_2 respectively). Improvement in WUE in I_1 and I_2 correspond with moderate reduction in cane yield during 2018-19. The mild impact of the restricted irrigation treatments during 2018-19 observed may be due to the congenial climate prevailed during early growth stages (atmospheric temperature with moderate vapour pressure demand). IWUE and WP improved significantly in restricted irrigation treatments. Despite variation in climatic condition between the years, several traits had positive and significant relation with cane yield *viz.*, CTD, chlorophyll fluorescence,canopy photosynthesis, biomass, cane volume and juice volume (Table 19). Few varieties consistently had high IWUE and WP (Co 85019, Co 86010, Co 86249, Co 10026 and Co13006) and can be used in future breeding programs for evolving WUE types.

2019- 2021: Eighteen 'Co' hybrids and 14 species clones were studied for their WUE. Among the traits studied, CTD, chlorophyll fluorescence, biomass, cane volume and juice volume had sig-

nificant association with cane yield. Commercial hybrids exhibited better efficiency as compared to species clones. IWUE and WP improved in both the restricted irrigation treatments for 'Co' hybrids. I_2 was more detrimental for species clones

Table 19. Traits association with cane yield for higher WUE

Traits	'r' value
CTD (Canopy temperature depression)	0.450*
Fv/Fm (Chlorophyll fluorescence)	0.425*
Biomass (Early stage)	0.495*
Biomass (Maturity Phase)	0.720**
Cpn (Canopy photosynthesis)	0.299
Cane volume	0.787**
Juice volume	0.758**

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

Plant architectural traits for developing ideotype concept in sugarcane for tropical conditions

Observations recorded from six different trials comprising species clones, pre breeding clones, commercial types (total-296) on various physiological traits at early growth stage showed vast variation for the traits studied.

SPAD chlorophyll index ranged from 11.2 (Lalri) to 41.37 (2019-75) among the genotypes studied with the mean of 29.95. Chlorophyll fluorescence ranged from 0.584 (Fiji 55) to 0.774 (Co 17013) with a mean of 0.714, indicating more number of genotypes with high range of photochemical efficiency at early growth stage. Canopy temperature ranged from 28.8 ^{0}C (Co 17003) to 37.8 ^{0}C (81GUK242) with a mean of 32.7 ^{0}C. Epicuticular wax content varied from 74.8 µg/cm2 (ISH 9) to 355.3 µg/cm^2 (Co 09004) and mean being 158.1 µg/cm^2.

Morphological observations: Mean leaf angle of the first three fully opened leaves were 6.03^0, 10.08^0, 14.87^0 during early growth stage. Canopy cover represented as percentage at early growth stage had significant association with biomass.

Leaf anatomical studies; Variability for the anatomical traits in juvenile leaves was higher among germplasm and pre-breeding materials as compared to commercial hybrids (Table 20). The mean values were invariably on the higher side in commercial hybrids while, variability was higher among improved species materials. For instance number of bulliform cells in single bunch varied between 3-7 in commercial hybrids while in species clones it varied from 3-10, however genotypic mean was higher in 'Co' hybrids. Similarly, area occupied by bulliform cells was greater in 'Co' hybrids, indirectly indicating more intermediate bundles (in microscopic field). Leaf rolling percentage in desiccation test varied from 0-79% in 'Co' hybrids and in germplasm clones, the variability was from 2.3 to 73.6%. Variability among the commercial types and species clones (Fig. 56-57). The bulliform cells are well organized in bunches in adult leaves as compared to juvenile ones.

Observations at maturity and harvest: Leaf dry weight varied from 126.6 g/m² (Reha) to 1472.3 g/m² (Co 17013). Sheath dry weight ranged from 37.52 g/m² (99-19) to 1268.9 g/m² (81GUK192). Variability for stem dry weight was from 228.9 g/m² (57NG77) to 6932.4 g/m² (81GUK192). Number of leaves varied from 45.56 (ISH 23) to 462.22 (92GUK 220), while number of stalks varied from 3.33 (004-73) to 42.22 (81GUK 527) with a mean of 11.96. Stalk height ranged from 42.66 cm (57NG77) to 306.5 (Fiji 55) with a mean of 166.82. Sucrose% juice varied from 3.0 (Fiji 55) to 21.32 (2019-104) with a genotypic mean of 17.04. Cane yield varied from 1.704 t/ha (57NG77) to 264.11 t/ha GUK 06-402.

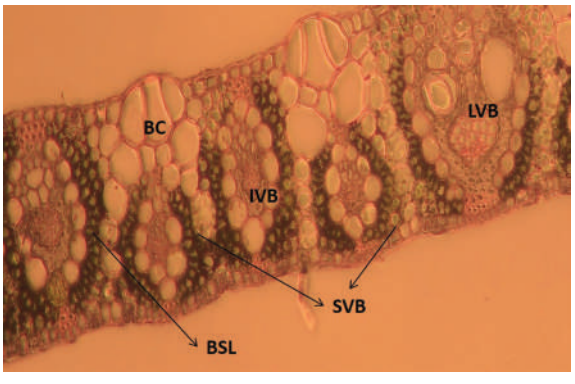


Fig. 56. Transverse section of leaf tissue of sugarcane variety Co 11015, showing distinct anatomical features. BC: Bulliform cells, BSL: Bundle sheath layer, IVB: Intermediate vascular bundle, LVB: Large vascular bundle, SVB: Small vascular bundle

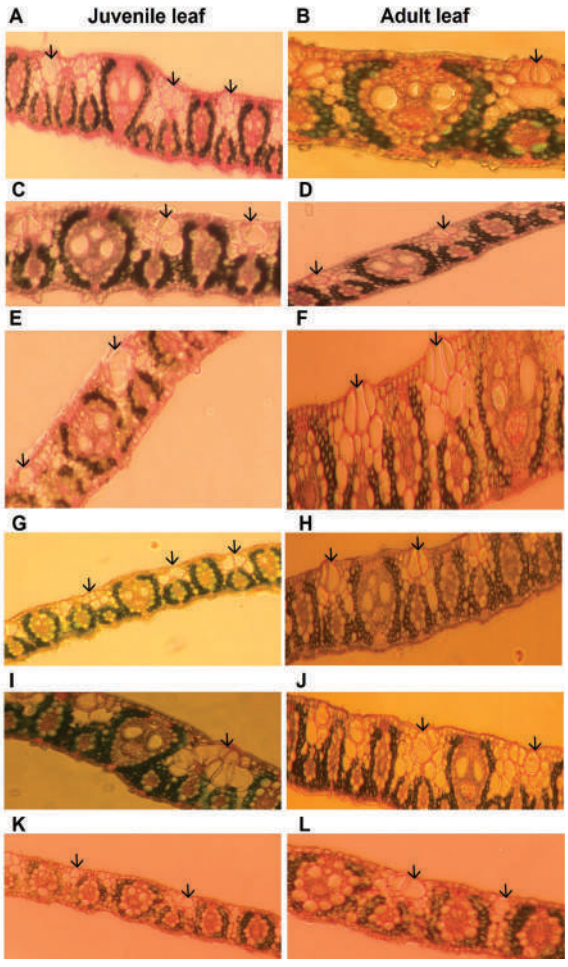


Fig. 57. Transverse section of juvenile (left panel) and adult (right panel) leaf tissues in sugarcane hybrids, pre-breeding material and germplasm clones. A and B: 004-73, C and D: 2019-24, E and F: Co 11015, G and H: ISH 107, I and J: Kheli, K and L: CoM 0265. Bunches of bulliform cells are shown by arrows

Correlation among traits: Early growth phase (150DAP): Several physiological parameters had significant association with cane yield at harvest. Traits *viz.*, SPAD index, total chlorophyll content, canopy temperature were positively and significantly associated with cane yield (0.166, 0.161, 0.484). However, with CCS (t/ha), only canopy temperature had significant association (*r*= 0.322).

Grand growth phase: During grand growth phase, SPAD index, total chlorophyllcontent, canopy temperature and chlorophyll fluorescence (*r*=0.451, 0.452, 0.484 and 0.416 respectively with cane yield) had significant association with cane yield as well as CCS (ton/ha) (0.370, 0.371, 0.322 and 0.305 respectively) (Fig. 58-59).

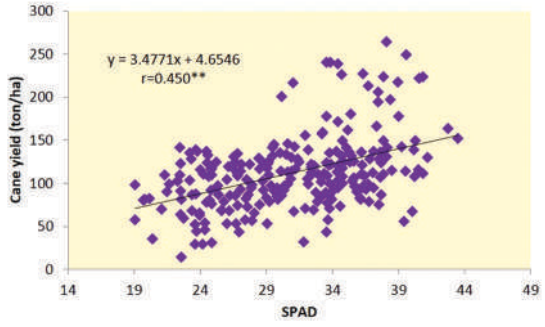


Fig. 58. Correlation between SPAD index with cane yield

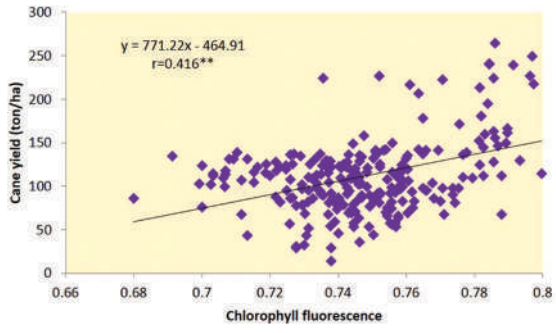


Fig. 59. Correlation between chlorophyll fluorescence with cane yield

Biomass: Total dry biomass, stem dry biomass were positively and significantly associated with cane yield sucrose % and CCS (t/ha) yield. Total dry matter had significant correlation with many of the traits studied.

Cane traits: Cane height, cane volume significantly correlated with cane and CCS yield.

Table 20. Leaf anatomical traits in the juvenile leaves in commercial hybrids and germplasm clones

Traits recorded at juvenile phase	Co canes		Germplasm	
	Range	Mean	Range	Mean
Leaf thickness (mm)	0.182-0.299	0.239	0.156-0.312	0.227
Leaf rolling (%)	0-79.3	40.8	2.4-73.7	40.0
Average diameter of bulliform cells (mm)	0.039-0.075	0.055	0.024-0.066	0.045
Area occupied by bulliform cells (mm2)	0.027-0.122	0.058	0.012-0.184	0.045

Traits recorded at juvenile phase	Co canes		Germplasm	
	Range	Mean	Range	Mean
Average diameter of metaxylem elements (mm)	0.027-0.063	0.045	0.012-0.066	0.039
Area occupied by metaxylem elements (mm2)	0.001-0.008	0.004	0.0002-0.0102	0.003
Number of bundle sheath layers	2-3	2	1-3	2
Number of large bundles	1-2	1	1-3	2
Number of intermediary bundles	3-5	4	2-6	3
Number of small bundles	4-7	5	3-8	5
Number of bunches of bulliform cells	4-7	5	4-8	5
Number of bulliform cells in one bunch	3-7	5	3-10	4
Number of metaxylem elements	1-4	2	2-4	2

(S. Vasantha, G. Hemaprabha, S. Alarmelu, K. Mohanraj, R. Arun Kumar, V. Sreenivasa, V. Krishnapriya and S. Anusha)

Comparative physiological analysis of tropical and sub-tropical varieties of sugarcane

Experiment at tropical condition

A field experiment was initiated using six tropical (Co 86032, Co 0212, Co 14012, Co 06022, Co 11015 and Co 13006) and six sub-tropical varieties (Co 0238, Co 15023, Co 98014, Co 15027, BO 91 and CoLk 8102) in RBD and germination was more than 90% in both tropical and sub-tropical varieties.

Biometric observation at different growth phases: Data on biometric observation on plant height, LAI and TDMP of tropical and sub-tropical groups showed an increasing trend from formative phase (FP) to maturity phase (MP) of the crop. Tropical group recorded higher plant height at FP (104.5 cm), GGP (184.6 cm) and MP (209.5 cm) as compared to sub-tropical group (78.4, 143.8 and 167.3 cm at FP, GGP and MP, respectively). Among the varieties, Co 13006, Co 14012 and Co 11015 in tropical group and Co 98014, Co 15027 and BO 91 in sub-tropical recorded comparatively higher plant height at all growth phases. Irrespective of the stages, tropical group recorded higher TDMP of 2.69, 3.97 and 4.78 kg m^{-2} compared to sub-tropical group 2.01, 2.93 and 3.70 kg m^{-2} at FP, GGP and MP, respectively. Among the groups, Co 13006, Co 14012 and Co 11015 (tropical) and Co 15027 and Co 98014 (sub-tropical) recorded high biomass. At MP, data on partitioning efficiency towards stem was comparatively higher in tropical group (78.43%) than sub-tropical group (73.43%), while sub-tropical group showed higher leaf and sheath partitioning efficiency (15.75 and 11.01%) compared to tropical group (12.65 and 8.92%).

Physiological and biochemical parameters at different growth phases: Except for total phenolics content, other metabolic traits *viz.*, total chlorophyll content, NRase activity, soluble protein, total soluble sugars, sucrose synthesis and accumulating enzymes were high in tropical varieties compared to sub-tropical varieties. The results showed that the soluble protein content was comparatively high in tropical varieties (55.38 mg g^{-1}) than the sub-tropical varieties (47.08 mg g^{-1}), indicating that tropical groups possess higher photosynthetic efficiency favouring higher biomass production. Unlike other biochemical parameters, total phenolics content comparatively was high in sub-tropical varieties (103.06 µg g^{-1}) than tropical varieties (80.59 µg g^{-1}) particularly in Co 15027 (120.0 µg g^{-1}) and Co 15023 (115.5 µg g^{-1}).

Irrespective of the groups and varieties, auxin content showed declining trend from FP (876 ppm) to maturity phase of the crop (586 ppm). Among the tropical group, Co 11015 has comparatively higher auxin content of 1350 ppm at FP, similar varietal trend followed at GGP and MP. In sub-tropical group, Co 98014 and Co 15027 possessed higher auxin content of 1300 and 1250 ppm, respectively than tropical group. Among the groups except at MP, tropical group possessed higher auxin content compared to sub-tropical varieties (Fig. 60A). Gibberellic acid (GA) content was comparatively high in

Co 13006 (905 ppm) in tropical group while, in sub-tropical group, the variety Co 15027 recorded higher GA content of 89 ppm (Fig. 60B). Irrespective of the groups, GA showed declining trend from FP to MP. Among the groups, tropical showed higher GA content in all stages compared to sub-tropical group. Unlike other hormones, ABA content was comparatively higher in sub-tropical group (188, 288 and 385 ppm) than the tropical group (146, 220 and 356 ppm) at FP, GGP and MP, respectively (Fig. 60C). Irrespective of the groups, ABA content showed increasing trend from FP (167 ppm) to MP (370 ppm). At MP, among the tropical group, Co 0212 recorded higher ABA content (356 ppm), while in sub-tropical group CoLk 8102 showed the highest ABA content (423 ppm).

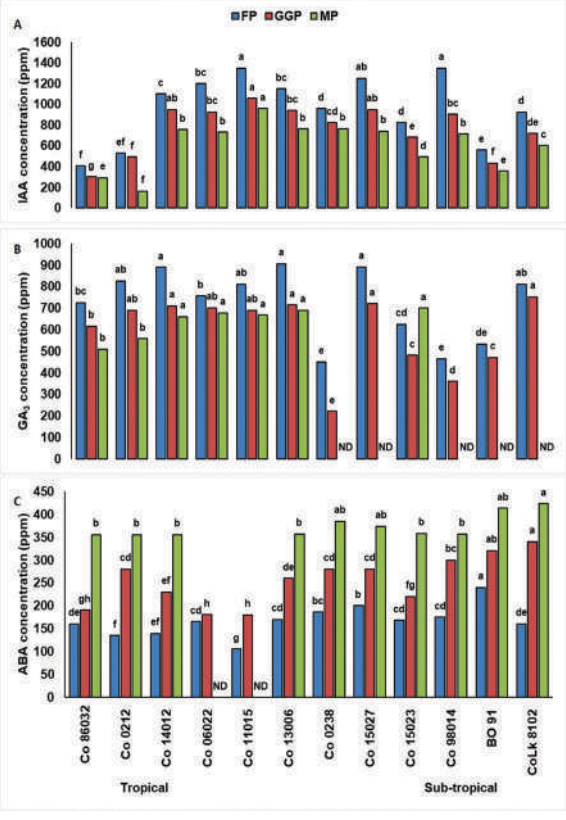


Fig. 60. Hormone concentration of (A) IAA, (B) GA3 and (C) ABA in apical meristem of tropical and sub-tropical varieties at different growth phases of the crop. Data represent mean of three replications. Different alphabets denote significant difference among the mean values based on Duncan's new multiple range tests at 0.05 probability levels. FP, GGP and MP denote formative phase, grand growth phase and maturity phase, respectively

Juice quality parameters: Data on juice quality parameters at 12thmonth showed that the tropical group recorded higher juice quality parameters *viz.,* juice volume (451.75 g/cane), Brix (20.82%), sucrose(18.94%), purity (90.86%) and CCS% (13.66%) compared to sub-tropical (300.16 g/cane, 19.85%, 17.6%, 88.48% and 12.06% respectively). Among the tropical group, Co 11015 recorded comparatively higher juice quality parameters *viz.,* Brix (21.95%), sucrose% (20.47%), purity% (94.10%) and CCS% (14.57%), respectively and lowest values found in Co 06022 (20.10, 18.40, 88.32, & 12.77%, respectively). In sub-tropical group, the Co 15023 recorded comparatively higher juice quality parameters of Brix (22.20%), sucrose (20.43%), purity (92.82%) and CCS(14.45%) and lowest juice quality was found in BO 91 (18.05, 15.97, 83.84 and 10.09%, respectively).

Yield and yield components: Among the varieties studied in tropical, Co 13006 recorded the highest single cane weight of 1.18 kg/cane closely followed by Co 14012 (1.17 kg) and Co 06022 (1.10 kg) with average SCW of 1.01 kg/cane. In sub-tropical group the highest SCW was recorded in Co 98014 (1.02 kg/cane) followed by Co 15027 (0.862 kg/cane), while lowest SCW was recorded in CoLk 8102 as 0.528 kg/cane. The result of cane girth showed that the variety Co 06022 (3.3 cm) recorded the highest cane girth in tropical group and Co 86032 showed the lowest cane girth of 2.70 cm. In sub-tropical, the variety, Co 15027 recorded the highest cane girth of 3.20 cm and CoLk showed the lowest cane girth of 2.2 cm with an average cane girth of 2.63 cm. The number of internodes was found to be comparatively higher in tropical group (20.50/plant) than sub-tropical group (15.33/plant). In tropical group, the highest number of internodes was found in Co 11015 (23.00/cane) and the lowest found in Co 0212 (18.0/cane). In sub-tropical group, variation was 13.00 (Co 0238) to 19.00/cane (Co 98014). Cane yield was comparatively higher in tropical group (85.53 tonnes/ha) than sub-tropical group (70.48 t/ha). Among the tropical group, Co 13006 recorded higher cane yield of 92.90 t/ha and lowest cane yield in Co 06022 (75.68 t/ha). In sub-tropical group, the highest cane yield was found in Co 98014 (82.0 t/ha) and it was closely followed by Co 15027 (74.50 t/ha) and lowest value noticed in Co 0238 (65.41 t/ha).

Experiment in sub-tropical condition

Six subtropical and tropical clones (Co 0238, Co 15023, Co 15027, Co 98014, BO 91, CoLk 8102, Co 11015, Co 0212, Co 06022, Co 13006, Co 14012 and Co 86032) were planted in March 2021 at ICAR-SBIRC Karnal. Germination was recorded at 45 days after planting (DAP), biochemical and growth parameters were recorded at FP, GGP and MP, juice quality was assessed at 10th month.

Germination: Overall experimental average germination was 54.23%. In sub-tropical clones, germination was in the range of 47.3% (Co 15027) to 73.5% (BO 91), and 27.3 % (Co 86032) to 60.5% (Co 06022) in tropical clones.

Biometric observation at different growth stages: Average shoot population was 1,14,088/ha, 1,02050/ha and 92,077/ha in sub-tropical clones and 93,045/ha, 81,088/ha and 75017/ha in tropical clones during FP, GGP and MP, respectively. CoLk 8102 (1,26, 033/ha) and Co 13006 (96,000/ha) recorded maximum shoot population at MP among sub-tropical and tropical clones, respectively. Plant height was at par among tropical and sub-tropical clones in all the growth stages, with an average of 73.3, 142.8 and 270.0 cm at FP, GGP and MP, respectively.

Physiological parameters at different growth stages: Sub-tropical clones showed relatively higher chlorophyll content than tropical clones at FP and GGP (Fig. 61). Among the growth stages, maximum chlorophyll content was recorded at GGP with average values of 41.9 µg/cm^2 and 40.6 µg/cm^2 in sub-tropical and tropical clones, respectively. At MP, total chlorophyll content decreased in the tested clones as compared to FP and GGP, however at this growth stage tropical clones (34.1 µg/cm^2) showed higher chlorophyll content than sub-tropical clones (30.9 µg/cm^2). During FP, the average phenolic content was 93.2 µg/g, ranging from 84.0 to 144.4 µg/g in sub-tropical group, and 59.0 to 132.0 µg/g in tropical group. During GGP phase, average phenolic content increased up to 155.0 µg/g. During MP, higher phenolic content was recorded in tropical clones (243.3 µg/g) as compared to sub-tropical clones (232.6 µg/g).

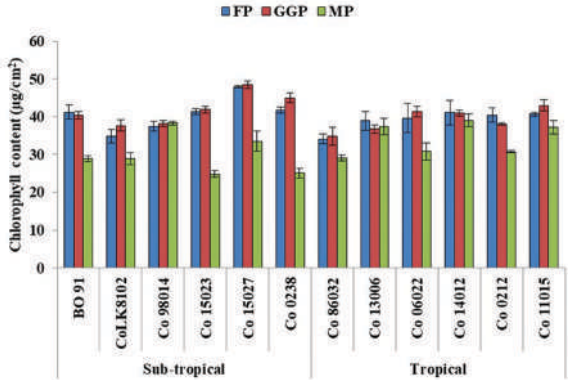


Fig. 61. Chlorophyll content of tropical and sub-tropical varieties at different growth stages under sub-tropical condition

Juice quality: At 10th month, sub-tropical and tropical clones were at par in juice quality parameters. Overall experimental average of sucrose in juice was 19.03%. Among sub-tropical clones, sucrose ranged from 16.39% (BO 91) and 21.07% (Co 15023), while among the tropical clones, it varied from 17.82% (Co 13006) to 20.32% (Co 11015).

(R. Gomathi, R. Arun Kumar, Pooja, K. Elayaraja and V. Krishnapriya)

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

A field experiment was conducted with five varieties *viz.*, Co 62175, Co 85019, Co 86032, Co 86249 and Co 99004 planted under three different spacing (Row to row:75cm, 90cm and 150cm) for studying radiation use efficiency (Fig. 62). Line quantum sensors (LICOR) along with digital data logger (LI-1400) were used to record the light interception data. The cumulative global solar radiation (GSR) was recorded during the germination phase, formative phase, grand growth phase and maturity phase (Fig. 63). The mean GSR during germination phase, formative phase, grand growth phase and maturity phase were 16.86, 13.69, 13.07, and 13.29 MJ/m^2/day, respectively. Significant difference in light interception was observed between different spacing i.e. the clones planted in narrow spacing was recorded with more light interception (>40%) than broader row spacing (<20%). Better leaf area index (more than 1.0) was observed during early stage in narrow spacing (75 cm and 90cm), while the 150 cm spacing recorded with less leaf area index (<0.8). Biomass production

Fig. 62. Aerial view of radiation use efficiency experimental field with different row spacing (75 cm, 90 cm and 150 cm)

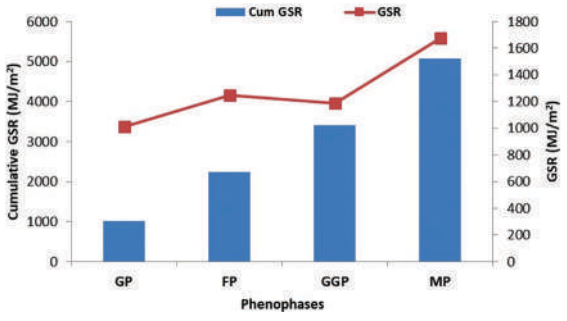


Fig. 63. Cumulative global solar radiation (GSR) during different phenophases of sugarcane

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 narrow spaced sugarcane clones had better biomass accumulation and RUE compared to the wider row spaced sugarcane. Growth analysis has revealed significant differences among clones for the crop growth rate (CGR) i.e the Co 85019 registered more than 20 g/m^2/day as compared to Co 99004 (<15 (g/m^2/day). The SPAD and chlorophyll content were also recorded in all the treatments and non-significant differences were observed. Among the clones, Co 86032 and Co 99004 was observed with more SPAD (>30) and chlorophyll content compared to other clones in all the row spacing. Non-significant differences in internode length, plant height and sucrose % juice was observed. Co 86032 and Co 85019 recorded better RUE in all the spacing, while Co 99004 had less RUE.

Another experiment with species clones under limited irrigated condition for studying radiation use efficiency has revealed better biomass production in ISH 111, Kheli, ISH 107 and Fiji 55 clones under both control (full irrigation at recommended interval, with 100% crop evapotranspiration replacement) and mild water deficit condition (irrigation at recommended interval, with 50% crop evapotranspiration replacement), while Fiji 55, Khakai, ISH 107, ISH 111 Pathri showed better biomass production under severe water deficit condition (skipping alternate irrigation and irrigation with 50% crop evapotranspiration replacement). Fiji 55 recorded better RUE in all the treatments compared to other clones.

(R. Arun Kumar and P. Geetha)

Deciphering the physiological basis of nutrient use efficiency in sugarcane

An experiment was conducted under hydroponic culture to investigate the effects of low N (20 µM), low P (2 µM) and low K (10 µM) stress in five sugarcane varieties (Co 86032, Co 0212, Co 09004, Co 0238, Co 10026) under controlled condition. Control treatment comprised sufficient (2 mM) supply of N, P and K. Physiological traits were recorded in three month old plants when the visible symptoms of deficiency were observed. Visible symptoms of deficiency in sugarcane varieties included stunted growth and chlorotic leaves due to low N stress, dark green colouration of leaves due to low P and relatively slight reduction in plant height and leaf area with older leaves showing chlorosis at low K supply. Low N stress significantly reduced the total chlorophyll concentration by 60%, leading to marked chlorosis in leaves. Highest decline was observed in Co 09004 (70%), whereas in varieties Co 0238 and Co 10026 it was reduced by half. Similarly, low K caused 20% reduction in total chlorophyll averaged over varieties. Low P stress caused a marginal decrease in chlorophyll content, with some varieties (Co 86032 and Co 0238) showing dark green colouration, attributable to the greater reduction in leaf area under low P supply. Anthocyanin concentration was significantly higher under low P (38%) and low K (25%) stress as compared to control. Highest anthocyanin concentration was recorded in Co 86032 and Co 10026 under low P stress. Photosynthetic efficiency measured as chlorophyll a fluorescence (F_v/F_m) reduced significantly due to N, P and K deficiency. Highest F_v/F_m values

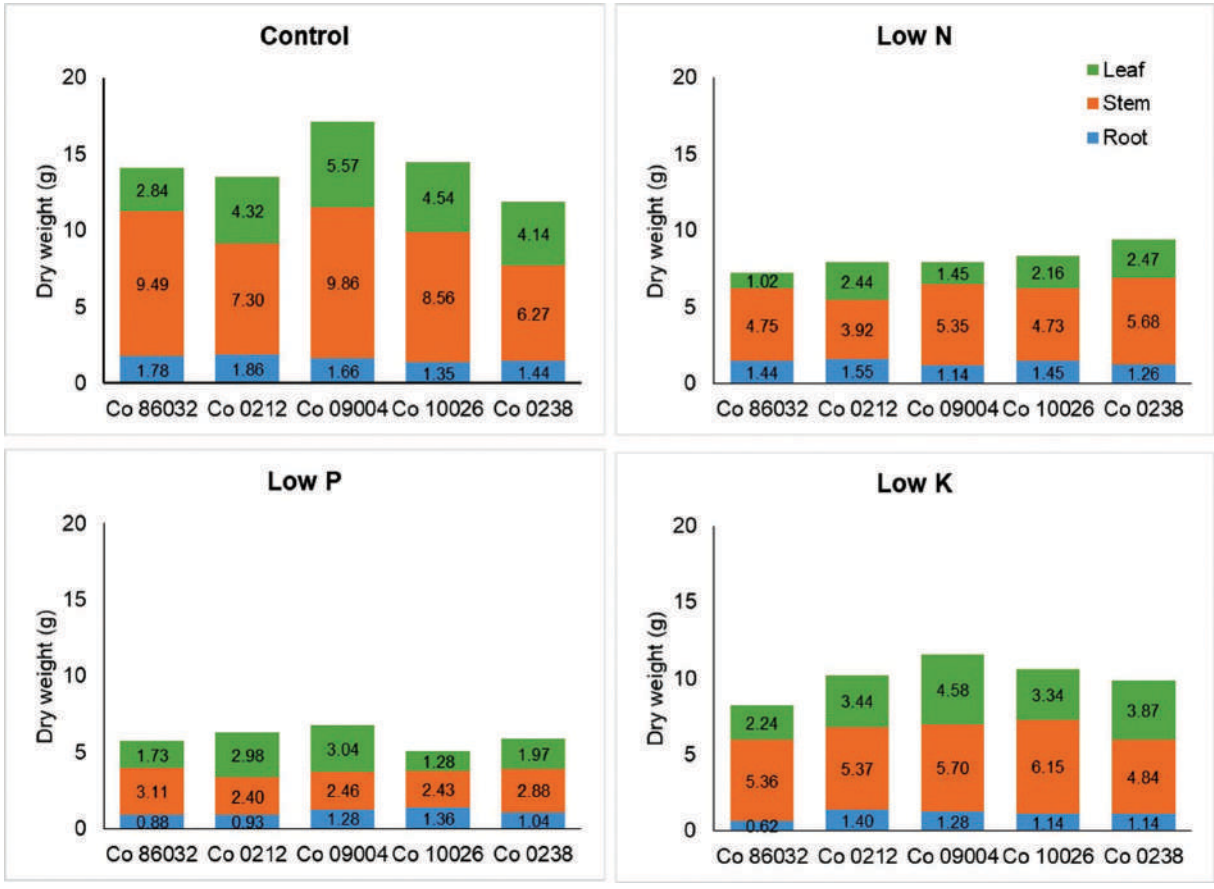


Fig. 64. Variation in biomass accumulation and partitioning among leaf, stem and root tissues of sugarcane varieties in response to macronutrient deficiency

were recorded in variety Co 10026 in control and low P stress, while Co 0212 and Co 09004 showed highest values of F_v/F_m at low N and low K, respectively. Averaged over varieties, the canopy temperature depression (CTD) reduced under low N (25%), low P (14%) and low K (17%) as compared to control. CTD is an indirect measure of the transpirational cooling operating in the plant to maintain normal metabolic activity, with significant correlation with biomass and yield. Higher the CTD, better is the plants adaptability to stress situations.

On the whole, low N stress significantly reduced total above-ground biomass (TBM) by 46%, while low P and low K caused 61% and 29% reduction in TBM, respectively as compared to control (Fig. 64). Among the varieties, Co 10026 recorded least reduction in TBM under low N (22%) as well as low K (16%) stress. Highest reduction under low N supply was observed in Co 09004 (56%) while Co 86032 recorded 38% reduction in TBM at low K stress as compared to control. Low P stress resulted in more than 50% reduction in TBM in all the tested varieties. Based on biplot analysis and percent reduction over control, Co 10026 at low N, while Co 09004 was efficient at low P and low K. Such differential response may be attributed to lesser reduction in root dry weight as observed in Co 10026 at low N (13%).

Varieties Co 10026 and Co 09004 exhibited specific root traits for enhanced nutrient uptake, including but not limited to appropriate root distribution pattern, longer root length and surface area, reduced root diameter, low specific root length and root length density and greater allocation of photosynthates to the roots. Increased cortical area, decreased stele diameter, thickened exo- and endodermis and formation of cortical aerenchyma were important anatomical modifications under nutrient deficiency (Fig. 65). Low P induced reduction in leaf area coupled with higher leaf chlorophyll was observed in all varieties, except Co 09004. At low K, Co 09004 recorded highest photochemical efficiency of PSII (Fv/Fm). Superior photosynthetic pig-

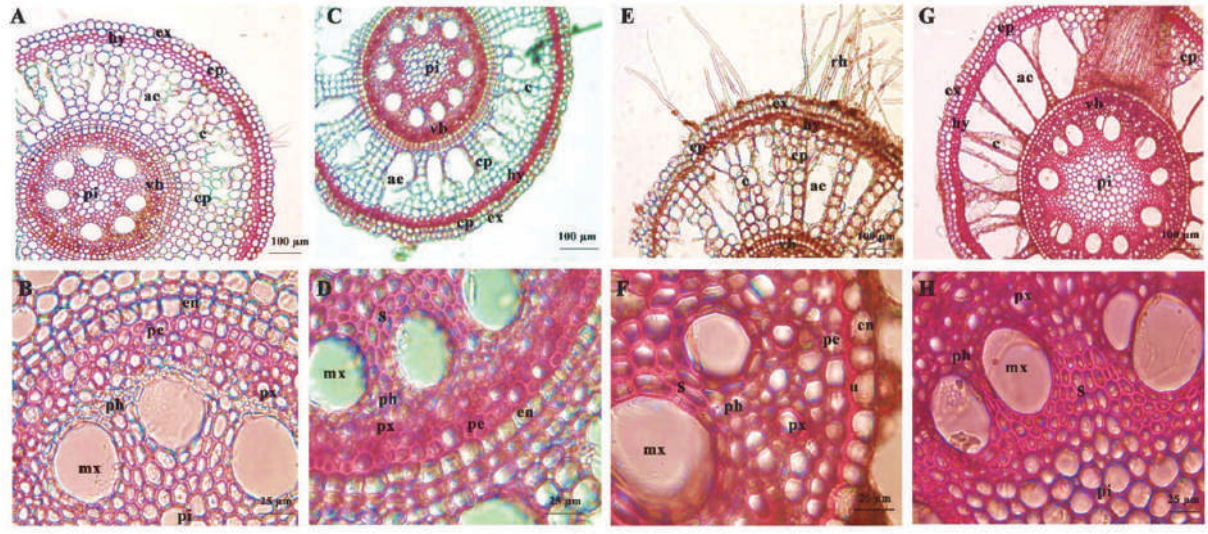


Fig. 65. Variation in root anatomical traits of sugarcane varieties in response to macronutrient deficiency

ments and photosynthetic efficiency, metabolite levels and antioxidant potential of varieties under low nutrient supply as reported in this study may be due to higher NUE in sugarcane

(V. Krishnapriya, S. Vasantha, R. Arunkumar, S. Anusha and V. Vinu)

Development of hydroponic screening methodologies for sugarcane varietal evaluation in response to abiotic stress under controlled condition

Three sugarcane clones *viz.*, Co 86032, Co 10026 and Co 8021 were planted in plastic trays and well established plants were shifted to hydroponic culture (Fig. 66) condition (Tank size: LxBxH=20x20x50cm) and Hoagland solution (Major nutrienst: $Ca(NO_3)_24H_2O$, KNO_3, $MgSO_46H_2O$, KH_2PO_4 Minor nutrients: Fe EDTA, H_3BO_3, $MnCl_24H_2O$, $ZnSO_47H_2O$, $CuSO_45H_2O$ (NH_4), $6MO_7O_{24}$ $4H_2O$) were used for nutrient supply and maintenance of crop. Artificial aeration by bubbling air from the bottom of the tank was provided and the tanks were covered by black color polythene sheet for avoiding algal growth. Morphological traits *viz.*, plant height, root length, number of leaves, leaf length and leaf width were recorded.

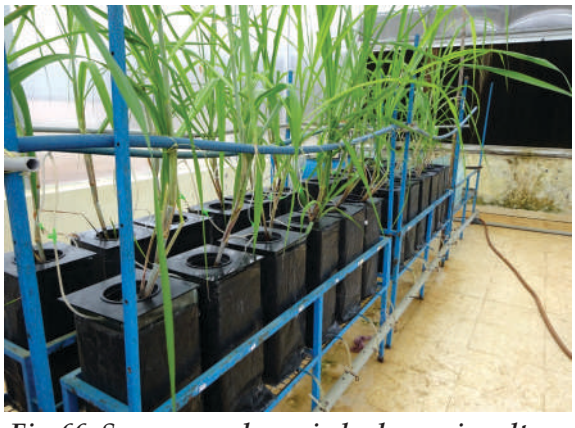


Fig. 66. Sugarcane clones in hydroponic culture

Sugarcane clones *viz.*, Co 8021, Co 86032 and Co 10026 were subjected to dehydration stress (imposed by treating hydroponically grown plants to 5% polyethylene glycol/PEG) and the physiological responses *viz.*, proline accumulation, lipid peroxidation, nitrate reductase and pigment carotenoid content were recorded and differential response among clones were observed. Significant increase in peroxidase, superoxide dismutase activity was observed under dehydration stress (Fig. 67). At molecular level, over

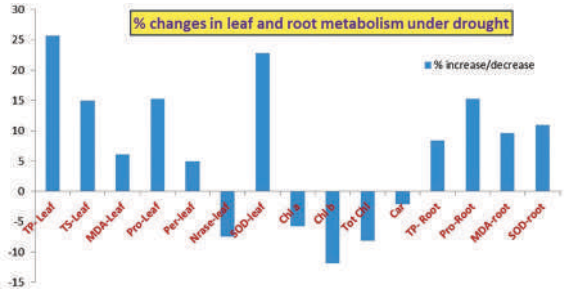


Fig. 67. Leaf and root metabolism under PEG induced drought/dessication stress in sugarcane clones(TP:Total phenols, TS: total sugars, MDA: malonaldehyde content, Pro: proline, Nrase: nitrate reductase, SOD: superoxide dismutase, Chl: chlorophyll, Car: carotenoid, Per: peroxidase)

expression of peroxidase, DREB 1 and P5CS indicated the defence as well as osmoregulation mechanisms operating in stress conditions. Differential response among varieties and treatment suggest the role of the genes/ TFs *viz.,* POX, DREB 1 and P5CS.

Another set of sugarcane clones Co 8021, Co 10026 and Co 86032 were grown under hydroponic facility and subjected to waterlogging stress for a period of three weeks by inhibiting the aeration to the solution and significant metabolic changes were observed in both leaf and root tissues under waterlogged condition. The results showed that there was a significant increase in proline content (leaf and root), phenolics content (leaf and root), malonaldehyde content, superoxide dismutase, peroxidase activity under waterlogging stress in all the sugarcane clones *viz.,* Co 8021, Co 10026 and Co 86032 with difference between the varieties used. This significant increment showed that the sugarcane clones tend to adapt and acclimatize under anoxia caused by waterlogging stress compared to control condition. Significant decline in chlorophyll 'a' and 'b' and total chlorophyll content and carotenoid content and nitrate reductase activity were observed under waterlogged condition compared to control. Differences among the studied sugarcane clones were also observed for the plant pigments confirming the genotypic responses. The polymerase chain reaction (PCR) results for the transcripts *viz.,* aldehyde dehydrogenase (ADH), 1-Aminocyclopropane-1- carboxylic acid oxidase (ACO), superoxide dismutase (SOD) and peroxidase (POX) obtained from both leaf and root tissues under waterlogged condition has shown better expression in confirming the acclimatization of sugarcane clones to tolerate the waterlogging stress.

Significant positive correlation of r=0.758 was observed between the root weight and biomass of sugarcane under hydroponic condition. Also significant positive correlation of r=0.658 was observed between the root weight and stem weight of sugarcane.

Characterisation of root system traits in sugarcane germplasm

Variation in root exudates type and quantity: Significant variation was observed in diverse sugarcane germplasm consisting of 40 genotypes with respect to organic compounds exuded from roots including proteins, sugars, phenols and free amino acids. Among the exuded compounds, the proportion of total protein was the highest, followed by carboxylates, sugars, phenols and free amino acids. On an average, total root exudation was highest in *S. officinarum* clones (6.814 mg g^{-1} RFW h^{-1}), and least in the inter-generic hybrid of *S. robustum* (3.664 mg g^{-1} RFW h-1). *S. officinarum* clones showed highest total carboxylate exudation (3.295 mg g^{-1} RFW h^{-1}), while least was recorded in Pennisetum sp. clones (1.299 mg g^{-1} RFW h^{-1}). Highest total protein exudation was observed in *S. sinense* clones (3.408 mg g^{-1} RFW h^{-1}), while sugars and free amino acids were highest in *S. robustum* inter-specific hybrids (0.184 mg g^{-1} RFW h^{-1}) and *S. spontaneum* clones (0.026 mg g^{-1} RFW h^{-1}), respectively. Inter-generic hybrid of *Saccharum sp.* × Bambusa sp. recorded the least exudate values for total protein (1.822 mg g^{-1} RFW h^{-1}), sugars (0.070 mg g^{-1} RFW h^{-1}) as well as free amino acids (0.010 mg g^{-1} RFW h^{-1}), whereas it exuded the highest amount of total phenolic compounds (0.078 mg g^{-1} RFW h^{-1}) amongst the genotypes tested.

Variation in root traits at germination phase in response to drought and waterlogging: Ten sugarcane germplasm clones were evaluated for their responses to drought and waterlogging stress at formative phase. The experiment was completely randomised with two factors: genotype (G) and treatment (T). Plants were raised in plastic pots filled with 5 kg of potting mixture, with two single-budded setts in each pot, and nine pots for individual treatment (G×T). Pots in control were maintained at field capacity, while drought was imposed at formative phase by withholding irrigation for 15 days. Waterlogging was imposed by saturating the pots for 30 days. Averaged over genotypes, drought stress caused a significant reduction in root surface area (RSA) (272.86 cm^2 $clump^{-1}$) and root volume (RV) (2.35 cm^3 $clump^{-1}$) recorded at germination phase with 25% decline in area and volume as compared to control. Waterlogging stress had a more pronounced effect on root morphology as it reduced the surface area (181.65 cm^2 $clump^{-1}$) and volume (1.51 cm^3 $clump^{-1}$) by half. Among

the clones tested, Pansahi and Oshima recorded significantly higher RSA under drought as well as waterlogging stress. The percentage reduction in RSA due to drought was least in Pansahi (↓4%), while Oshima (↑13%), Seleri (↑35%) and IK 76-166 (on par) showed higher RSA under drought as compared to control. Likewise, Oshima recorded least reduction (↓33%) in RSA under waterlogging stress compared to control, followed by Putli Khajee (↓41%) and IK 76-166 (↓44%). Similar genotypic trend was observed in case of variation in RV in response to drought and waterlogging stress. In the case of root diameter, thickest roots were observed under waterlogging stress (0.35 mm), while drought stress led to formation of thin roots (0.31 mm). Irrespective of stress imposition, Awela Green Sport had the thickest roots (0.44 mm), followed by IK 76-99 (0.38 mm), while IK 76-166 (0.30 mm), IND 85-490 and Seleri (0.26 mm) exhibited thin roots amongst the tested genotypes. Longer root hairs, sclerenchymatous exodermis, reduced cortical cell layers, increased cortical aerenchyma, increased stele area and xylem vessel number with larger diameter were the main traits observed in response to drought condition as compared to control (Fig. 68). Under waterlogging condition, increased root diameter, proportionately higher cortical cell area with increased aerenchymatous cells imparted mechanical strength, root porosity and enhanced oxygen diffusion. Oshima, IND 85-490, IK 76-99 and IK 76-166 exhibited stress adaptive root anatomical phenes such as longer root hairs with increased root diameter and root porosity, sclerenchymatous exodermis and larger xylem vessels. Djantoer-1 and Putli Khajee showed prominent increase in stelar area

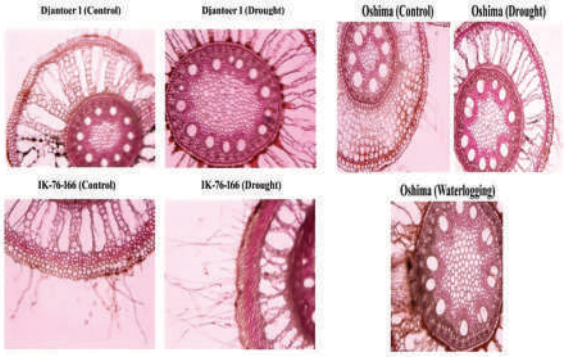


Fig. 68. Variation in root anatomical traits of sugarcane germplasm clones in response to drought and waterlogging stress

and xylem vessel number with more protoxylem poles with senesced cortical tissues for improved axial water conductance under drought stress.

Wide variation was observed in case of root architectural responses to drought and waterlogging stress in terms of both the root angle and length of roots (Fig. 69). *S. sinense* clone Oshima showed superior root architecture under drought and waterlogging stress as compared to control, in agreement to the root morphological traits such as RSA and RV. *S. officinarum* clone Awela Green Sport had poorly developed root system under drought stress and a moderate one under waterlogging stress compared to control. The other tested *S. officinarum* clone Seleri also exhibited a poorly developed root system, nevertheless the responses to drought and waterlogging stress was not significant as that observed in Awela Green Sport, re-emphasizing the wide variation prevalent in root system traits within and among the *Saccharum* species clones.

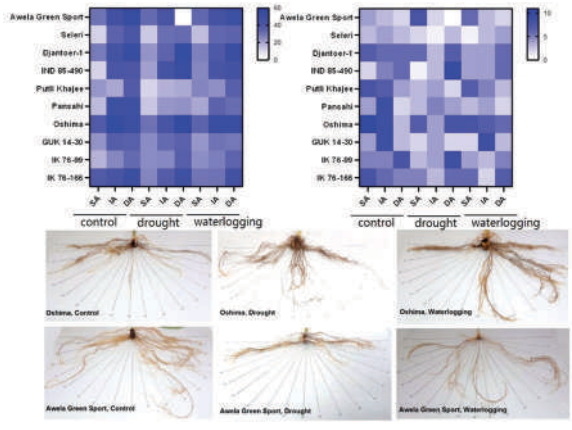


Fig. 69. Variation in root system architecture of sugarcane germplasm clones in response to drought and waterlogging stress

Variation in biochemical adaptation and antioxidant capacity: Chlorophyll content in physiologically active leaves measured as the SPAD index was significantly reduced by stress, with wide variation among the tested genotypes. Averaged over stress treatments, highest SPAD index was recorded in IK 76-166 (43.26), and Awela Green Sport (38.21), while Djantoer-1 (29.42) and Pansahi (24.56) had the least values. Nitrate reductase activity (NR) reduced significantly under drought (15%) and waterlogging stress (30%) as compared to control. The clones Oshima, IND 85-490 and Djantoer-1 recorded higher

activity of NR under drought and waterlogging stress, on par with that of control. Similarly, total soluble protein concentration in physiologically active leaves was superior in the clones Oshima, IND 85-490 and Djantoer-1 with minimum reduction under stress over control, as against the average reduction of 12% and 16% across genotypes under drought and waterlogging stress, respectively. On an average, the activity of superoxide dismutase (SOD) reduced by 11% and 17% under drought and waterlogging stress, respectively, whereas the clones Djantoer-1 and Oshima recorded slightly higher SOD activity under stress. Peroxidase activity reduced significantly due to drought (36%) and waterlogging (42%) as compared to control, while catalase (CAT) activity reduced by about 27% in response to both drought and waterlogging stress. Under drought, highest POX activity was observed in IK 76-99 (3.78), while genotypic response to waterlogging stress showed wide variation, with Awela Green Sport recording highest POX activity (2.31) followed by Djantoer-1 (1.87). CAT activity was the highest in IND 85-490 both under drought (2.43) and waterlogging stress (2.44), whereas Pansahi showed about 20% higher CAT activity under stress as compared to control.

Variation in single cane weight in response to drought and waterlogging stress: Single cane weight (SCW) reduced significantly in response to drought (39%) and waterlogging stress (23%). Under drought stress, the clones IND 85-490, GUK 14-30 and IK 76-166 showed lesser reduction in SCW while the clones IK 76-99, GUK 14-30, Oshima, Djantoer-1 and Awela Green Sport recorded better SCW under waterlogging stress as compared to control. Based on bi-plot analysis, the clones IND 85-490, Putli Khajee and IK 76-166 under drought and Djantoer-1, IND 85-490, Putli Khajee and IK 76-99 under waterlogging stress were identified in terms of exhibiting higher SCW values along with significantly lesser reduction under control (Fig. 70).

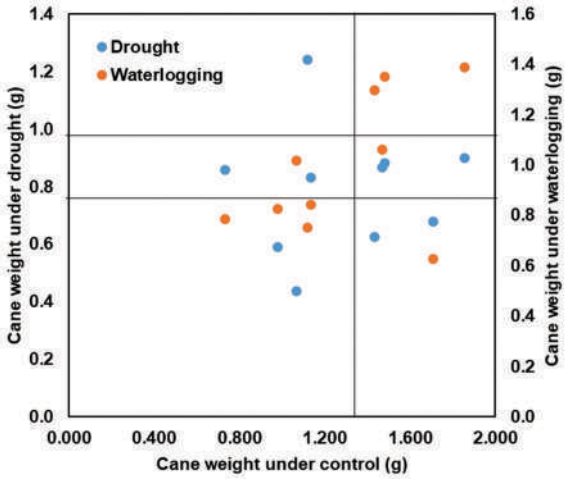


Fig. 70. Biplot of single cane weight of sugarcane germplasm clones in response to drought and waterlogging stress

(V. Krishnapriya)

5.2.3 SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Natural resource management for enhancing productivity and sustainable sugarcane production

Demonstration of Settling Transplanting Technology for sugarcane

Third ratoon crop of the demonstration plot was harvested on 23 March 2021. Trash shredding (rotavator) for Ratoon IV initiation was carried out on 14 April 2021. Urea was broadcasted @ 50 kg/ha and then *Trichoderma viride* @ 10 kg/ha mixed with 100 kg FYM to stimulate trash decomposition. Off-barring and stubble shaving were not done. Nutrient (N, P and K) requirement was calculated based on the STCR target of 125 t/ha. Fertigation started in the first week of ratooning with 55% N and 30% K till 12th week and remaining 70% N and K from 13 to 25th week. Application of single super phosphate, FYM@12.5t/ha, $FeSO_4$ (@100 kg/ha) and $ZnSO_4$ (@ 40 kg/ha) were carried out at full earthing up on 28 June 2021. Intercropping could not be taken up in Ratoon IV due to COVID 19 restrictions in May 2021. Clump-wise ratoon sprouting and tiller count was recorded on 06 July 2021. The average clump population and number of tillers in Ratoon IV was 48.98% and 50008 per hectare. Reordered NMC and biometric observations 240 days after ratoon initiation (DARI).

In Ratoon III, the number of tillers, cane diameter, number of millable canes (NMC), cane yield and CCS yield did not differ significantly (p=0.05) with the intercropping residual effect and the mean values were 82029/ha, 26.78 mm, 70332/ha, 99.61 t/ha and 12.52 t/ha, respec-

Table 21. Residual effect of intercropping on yield parameters, cane and sugar yield in Ratoon III

	Number of tillers/ha (75 DARI)	Cane height (cm)	Cane diameter (mm)	Inter-node nos.	SCW (kg)	NMC/ ha at 270 DARI	Cane yield (t/ha)	CCS yield (t/ha)
Blackgram	81127	246.17b	28.06	22.22b	1.56b	73870	115.19	15.6
Coriander	82415	235.39ab	26.83	17.44a	1.36a	72464	98.78	11.74
Greengram	77230	222.00a	25.33	19.14a	1.24a	60003	85.13	10.14
Sole sugarcane	87343	221.50a	26.91	19.06a	1.33a	74990	99.33	12.59
Mean	82029	231.26	26.78	19.46	1.37	70332	99.61	12.52
F test (p=0.05)	NS	*	NS	*	*	NS	NS	NS
CD 5%	-	19.32	-	2.61	0.18	-	-	-

* *Significant at p=0.05; NS – Not significant; Values with different letters in superscript within the column differ significantly*

tively. Residual effect of intercropping was significant with respect to cane height, number of internodes and single cane weight (SCW) in ratoon III. Residual effect of blackgram intercropping for cane height was on par with coriander intercropping, and was significantly higher than greengram intercropping and sole sugarcane. Residual effect of blackgram intercropping for number of internodes per cane and SCW was significantly higher than all others (Table 21). The residual effect of intercropping was not significant for the juice quality, and the mean Brix, sucrose, purity and CCS was 20.13, 18.20, 90.31 and 12.72%, respectively at 270 DARI in Ratoon III.

Soil samples were collected after the harvest of Ratoon III, and analyzed for organic carbon and physicochemical properties in the ridges and furrows separately. pH, EC, available N, P and K of postharvest soil did not differ significantly with respect to the residual effect of intercrops as well as ridge and furrow soils after four seasons of cropping (1 plant and 3 ratoons). The mean pH, EC, available N, P and K was 8.04, 0.60 dS/m, 224 kg/ha, 43 kg/ha and 688 kg / ha, respectively. However, soil organic carbon (SOC) varied significantly with respect to ridge and furrow. Ridges (1.08%) had significantly higher SOC than the furrows (0.91%). The ridges received mulched trash (after detrashing) and the shredded trash while the furrows received the shredded trash for the past four seasons may be the reason for higher SOC.

Severe lodging was observed with paired row planting (as proper earthing up could not be made), it was suggested to take up new planting in the next planting season with single row planting. Accordingly, new planting in the southern section was initiated and planted on 02 April 2021 with two genotypes (Co 14027 and Co 11015). Single bud settlings were planted at 1.5 x 0.6 m spacing with three intercropping treatments (black gram (VBN 6), coriander (CoCR 4) and sole sugarcane). Nutrient (N, P and K) requirement was calculated based on the STCR target of 150 t/ha. Basal application of single super phosphate, FYM@12.5t/ha, FeSO4 @100 kg/ha) and ZnSO4 (@40 kg/ha) were carried out. Weekly fertigation was started in the first week of planting with 30% N and K till 12th week on equal splits and remaining 70% N and K from 13 to 25th week. The number of tillers at 90 DAP, NMC and biometric observations at 240 DAP were recorded. Juice quality was analyzed at 240 DAP. Coriander was harvested for leaves and the blackgram for grain. The mean yield of intercrops was 2658 kg leafy coriander, and 952 kg blackgram per hectare.

(A. Vennila, S. Anusha, C. Palaniswami and Bakshi Ram till 30 June 2021)

Standardization of nutrient management package for sugarcane under wide-row planting in calcareous soil

Two budded setts of Co 11015 was planted on 11 February 2020 with eight treatments in RBD and harvested on 23 March 2021. The yield attributes and CCS yield did not differ significantly (p=0.05) among treatments at 360 DAP (Table 22). Mean single cane weight and CCS yield was 1.53 kg and 20.62 t/ha, respectively.

Table 22. Effect of nutrient management package on yield parameters, and cane and sugar yield of Co 11015 (Plant crop)

	Cane height (cm)	Cane diameter (mm)	Number of internodes per cane	Single cane weight (kg)	Cane yield (t/ha)	CCS yield (t/ha)
T1	238.56	26.32	24.00	1.35	118.59a	17.62
T2	250.11	25.87	25.00	1.51	137.43bc	20.53
T3	276.56	25.86	25.67	1.54	141.40bc	21.98
T4	244.33	27.37	25.44	1.53	135.01abc	19.83
T5	246.33	27.69	26.00	1.58	139.79bc	21.19
T6	270.67	27.86	26.22	1.62	147.77c	23.31
T7	257.78	27.14	25.22	1.56	128.49ab	20.69
T8	253.11	27.71	26.11	1.53	125.33ab	19.79
Mean	254.68	26.98	25.46	1.53	134.23	20.62
SEd	13.15	0.80	1.23	0.08	7.81	1.46
F test (p=0.05)	NS	NS	NS	NS	*	NS
CD (5%)	-	-	-	-	16.77	-

**Significant at p=0.05; NS – Not significant; Values with different letters in superscript within the column differ significantly T1: STCR 150 NPK + basal FYM @ 5 t/ha; T2: T1 +Soil application of $FeSO_4$ and $ZnSO_4$; T3: T1 + Foliar application of $FeSO_4$ and $ZnSO_4$; T4: Blanket NPK + basal FYM @ 5 t/ha; T5: T4 + Soil application of $FeSO_4$ and $ZnSO_4$; T6: T4 + Foliar application of $FeSO_4$ and $ZnSO_4$; T7: Basal FYM @ 5 t/ha; T8: Absolute control.*

However, cane yield varied significantly among treatments. The treatment, T6 (350:62.5:90 kg/ha $N:P_2O_5:K_2O$ + basal FYM @ 5 t/ha; entire P as basal, N and K in three splits) along with symptomatic foliar spray (5 sprays) of urea, $FeSO_4$ and $ZnSO_4$ till 120 DAP recorded on par yield with T2, T3, T4 and T5, and significantly higher cane yield (147.77 t/ha) than T1, T7 and absolute control (T8). The treatment, T1 (411:92:46 kg/ha $N:P_2O_5:K_2O$ (STCR 150 t/ha) + basal FYM @ 5 t/ha) recorded significantly lower cane yield than the treatments T2 and T3, implying nutritional imbalance in T1. Juice quality parameters did not differ significantly among treatments at 300 as well as at 360 DAP. Mean juice Brix, sucrose, purity and CCS was 23.12, 21.64, 93.62 and 15.37%, respectively at 360 DAP. N, P and K content in trash and N and K content (% dw) in cane at 360 DAP did not vary significantly among treatments. However, P content in cane varied significantly among treatments. The FYM only treatment T7 (0.088%) accumulated significantly higher P content in cane than all other treatments followed by the absolute control (0.078%). The total uptake of N, P and K did not differ significantly among treatments and the mean total uptake of N, P and K was 312.55, 54.05 and 210 kg/ha, respectively (Table 23). All the treatments including the ones which with foliar spray (Foliar spray up to 120 DAP) showed interveinal chlorosis in young leaves at 150 DAP onwards, which needs to be studied further.

Table 23. Effect of nutrient management package on nutrient content in trash and cane and total uptake (kg/ha) at 360 DAP

Treatment	Nutrient content (% dw)						Total uptake (kg/ha)		
	Trash			Cane					
	N	P	K	N	P	K	N	P	K
T1	0.71	0.13	0.74	0.51	0.063[a]	0.14	311.29	46.35	190.04
T2	0.67	0.14	0.79	0.38	0.060[a]	0.17	293.86	52.93	227.37
T3	0.78	0.12	0.77	0.41	0.057[a]	0.19	326.56	47.92	226.96

Treatment	Nutrient content (% dw)						Total uptake (kg/ha)		
	Trash			Cane					
	N	P	K	N	P	K	N	P	K
T4	0.85	0.14	0.66	0.34	0.060[a]	0.22	305.32	52.19	219.18
T5	0.81	0.14	0.68	0.39	0.064[a]	0.17	349.33	61.41	221.77
T6	0.83	0.13	0.67	0.48	0.056[a]	0.17	372.83	51.01	210.00
T7	0.80	0.14	0.69	0.30	0.088[c]	0.23	262.86	60.62	212.55
T8	0.64	0.14	0.57	0.36	0.078[b]	0.18	278.37	59.88	178.28
Mean	0.76	0.14	0.70	0.40	0.066	0.18	312.55	54.04	210.77
F test (p=0.05)	NS	NS	NS	NS	*	NS	NS	NS	NS
CD (5%)	-	-	-	-	0.0096	-			

**Significant at p=0.05; NS – Not significant; Values with different letters in superscript within the column differ significantly*

T1: STCR 150 NPK + basal FYM @ 5 t/ha; T2: T1 + Soil application of FeSO4 and $ZnSO_4$; T3: T1 + Foliar application of $FeSO_4$ and $ZnSO_4$; T4: Blanket NPK + basal FYM @ 5 t/ha; T5: T4 + Soil application of $FeSO_4$ and $ZnSO_4$; T6: T4 + Foliar application of $FeSO_4$ and $ZnSO_4$; T7: Basal FYM @ 5 t/ha; T8: Absolute control.

The nutrient treatments showed differential flowering behaviour and hence, the data on flowering was recorded. Flowering intensity in absolute control (10.14%) was at par with the FYM only treatment (6.82%) and significantly higher than other treatments (Fig. 71). Cane and trash samples were also collected for analysing the difference if any with respective to nutrient accumulation among flowered and non-flowered canes in the treatments showing more than 5% flowering intensity. Potassium content in trash of flowered cane (0.65%) was significantly lower than that of nonflowering cane (0.94%). N, P and K content of flowered cane was higher than the non-flowered cane (Fig. 72). The harvested cane (11.25 tonnes) was supplied for seed

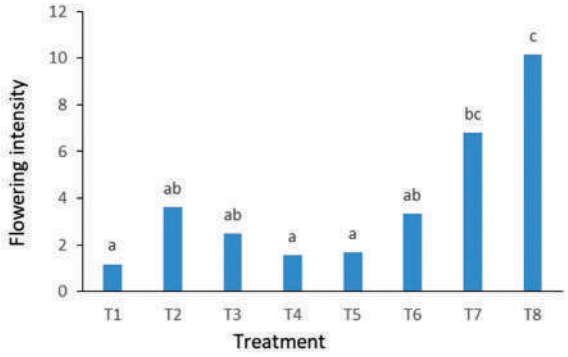


Fig 71. Effect of nutrient management package on flowering intensity (%) Bars with same letters did not differ significantly at p=0.05

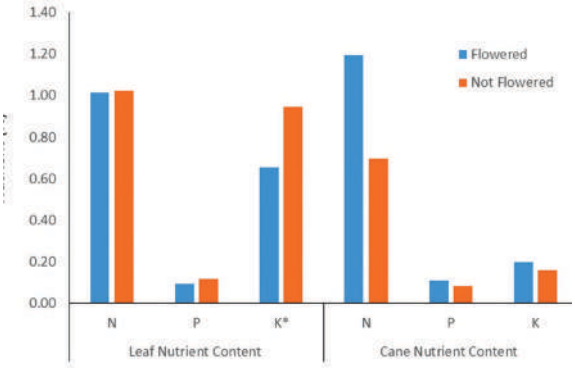


Fig. 72. Nutrient content of trash and cane of flowered and non-flowered canes

purpose worth Rs. 39,375 from this trial. Post-harvest soil samples were collected on 26 March 2021 and analysed for soil nutrient status and calcareousness.

Ratooning operations were initiated on 12 April 2021 by trash shredding using rotavator. Urea was broadcasted @ 50 kg/ha and then broadcast *Trichoderma* viride @ 10 kg/ha mixed with 100 kg FYM to stimulate trash decomposition. Other operations were not carried out till May 2021. The ratoon sprouted and the first dose (Basal SSP, 25% excess N, $FeSO_4$, $ZnSO_4$ and FYM) of nutrient treatments for ratoon crop was imposed as per the experimental design only on 02 June 2021 due to COVID 19 restrictions. Second dose of nutrient treatments (Top dressing I) was im-

posed on 29 June 2021 and the third by pocket manuring (Top dressing II) on 18 August 2021. Foliar application of 1.5% (0.6, 0.6 and 0.3% Urea, $FeSO_4$ and $ZnSO_4$) was carried out five times. After heavy rains in October 2021, very pale yellow appearance of the crop forced us to take up fifth foliar spraying at 200 DARI. T3 recovered from yellowness but T6 did not recover. Recorded SPAD reading on 27 July 2021. Collected TVD leaf samples at 6th month (07) and analyzed for chlorophyll and active iron, and recorded SPAD reading. Recorded yield parameters and analyzed juice quality at 240 DARI.

(A. Vennila, C. Palaniswami, I. Rajendran and G. Hemaprabha)

Development of simulation model for sugarcane production system

Series of incubation experiments were conducted for estimating thermal degree days (TDD) for germination with different temperatures up to 36^0 using the varieties Co 11015 and Co 14027. The base temperature for TDD was set as 20^0. The TDD for germination was 105. The TDD for flowering estimated using the date of ratoon initiation and flowering date of the clones flowered in the Arrowing Plot (Ratoon) during the flowering season in 2021 using the base temperature worked out in previous years (2019 and 2020). A total of 35 clones flowered in 2021. The base temperature ranged between 7 and 23^0. The TDD for flowering ranged between 1065.5 and 5566 among the flowered clones. The TDD required for flowering in ratoon crop was compared with that of plant crop flowering in the previous seasons which showed that ratoon crop required lesser TDD (200-300) than the plant crop flowering.

In the National Hybridization Garden (plant crop), out of flowered clones in 2021, 65 clones had base temperature worked out in previous years (2019 and 2020). TDD and Base temperature for the season 2021 was estimated for these 65 clones which ranged between 786 and 7576 TDD and 3 and 24^0, respectively. TDD required for flowering in the plant crop in 2021 was lower (200-300 TDD) than that of the previous two years. Hence, detailed investigation is required to elucidate the flowering behaviour in sugarcane.

(C. Palaniswami, G. Hemaprabha, A. Vennila, S. Vasantha, K. Hari, R. Gomathi, I. Rajendran, R. Karuppaiyan, A. Anna Durai, K. Mohanraj, A.S. Tayade, P. Geetha, S. Anusha, G.S. Suresha, R. Arun Kumar, V. Krishnapriya, R. Valarmathi and T. Arumuganathan)

Diagnosis of nutrient deficiencies and diseases, characterisation of canopy and estimation of biomass in sugarcane using drone based optical images

The projected was approved in IRC Meeting held during 20-24 September 2021. The necessary infrastructure and capturing optical images of sugarcane fields using drone has been initiated.

(C. Palaniswami, A. Vennila, I. Rajendran, T. Arumuganathan, R. Viswanathan, A. Anna Durai, K. Mohanraj, G. Hemaprabha, R. Raja (ICAR-CICR Research Center, Coimbatore), A.S. Tayade and R. Arun Kumar)

Pilot scale production of liquid jaggery

Sugarcane juice obtained in 12 lots was processed to get 200 litres of liquid jaggery from about 1000 litres of sugarcane juice and revenue was realized through sale. Further improvement in the facility for the production was done with additional procurement of evaporating pans. Registration work in FSSAI for liquid jaggery product was done with relevant documents. Final certificate for the product was obtained on 18.09.2021 with validity up to 17.09.2022.

(I. Rajendran, A. Vennila and C. Palaniswami)

Effect of soil calcareousness amendments on jaggery yield and quality on popular sugarcane varieties

Three popular sugarcane varieties Co 06022, Co 09004 and Co 86032 were selected for the experiments with two treatments of T2 (T1+ gypsum) and T3 (T1+ elemental S) with control of T1 (Soil Test Crop Response 150 t/ha target + micronutrients). Effect of soil calcareousness amendments on number of tillers (nos./ha) at 90 DAP was 47743, 52315 and 58584, respectively for three treatments. Effect of soil calcareousness amendments on SPAD values at 120 DAP was found to be 35.48, 34.29 and 34.73, respectively for three treatments.

Effect of soil calcareousness amendments on number of tillers (nos./ha) at 90 DAP				
	Co 06022	Co 09004	Co 86032	Mean
T1(STCR+MN)	51389	42708	49132	47743
T2(T1+gypsum)	53646	47917	55382	52315
T3 (T=1+elemental S)	65799	55787	54167	58584
Mean	56944	48804	52894	
Effect of soil calcareousness amendments on SPAD value at 120 DAP				
	Co 06022	Co 09004	Co 86032	Mean
T1(STCR+MN)	36.65	33.09	36.71	35.48
T2(T1+Gypsum)	36.51	32.78	33.58	34.29
T3 (T1+elemental S)	36.68	34.18	33.32	34.73
Mean	36.61	33.35	34.54	

(I. Rajendran, A. Vennila and C. Palaniswami)

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: Out of 3036 clones from different clonal trials, parents from NHG, germplasm and waterlogging tolerant clones from Kannur, ISH and IGH clones, transgenic clones, PZVT-2021 series, Indo-Australian clones screened for red rot resistance under controlled conditions, 1543 clones were identified as R/MR to red rot. About 107 parental clones from NHG were evaluated against CF12 pathotype of *C. falcatum* and 51 were R/MR (Fig. 73).

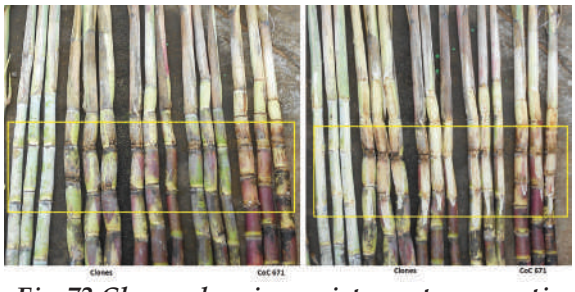


Fig. 73 Clones showing resistance to susceptible reactions to* C. falcatum *under controlled condition testing; Left-external symptoms, Right-disease progress inside the nodal and internodal tissues in susceptible clones and CoC 671 (Check). Pathogen inoculated nodes were marked in a yellow rectangle

Smut resistance in the parental clones: Out of 103 parental clones evaluated against sugarcane smut, 38 clones were R, 15 MR, 12 MS, 21 S and 17 clones were rated as HS.

Field tolerance to red rot: Twelve sugarcane varieties varying in red rot resistance were tested against soil borne inocula of 12 *C. falcatum* isolates collected from Tamil Nadu under field conditions to assess their field tolerance to red rot. All the varieties recorded reduced bud sprouting due to presence of *C. falcatum* inoculum in the soil as compared to their respective controls. The cultivars, Co 06031, Co 94012, CoC 671, Co 11015 and Co 10026 recorded relatively poor germination in that order, the new *C. falcatum* isolates Cf06022 Pennadam, Cf06031-Perambalur, CfC92061-NKM, and CfM0265-Palapatti exhibited severe impact on bud germination in the varieties. Among the varieties Co 10026, Co 12009, CoV 92102 and Co 09004 were free from disease infections, indicating tolerance to soil inoculum of *C. falcatum* isolates. Co 11015 picked up moderate infections from nine pathogenic isolates, whereas Co 86032 recorded relatively high disease incidences against 10 isolates. All the new isolates showed higher virulence than the designated pathotypes CF06 and CF12 and among them, the isolates Cf06022-Pennadam, CfM0265-Palapatti and Cf06031- Perambalur caused disease on ten, eight and seven varieties, respectively. The cv. Co 06031 exhibited 100% disease incidence without any plant survival, which indicated its high susceptibility over

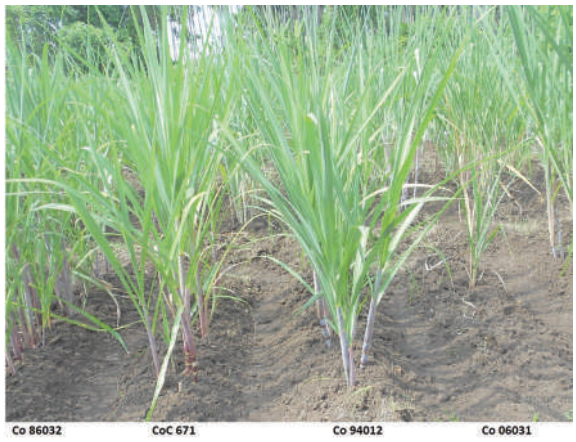


Fig. 74. Crop stand of sugarcane varieties to* C. falcatum *soil inoculum of Cf86027-Vellalapalayam (150 DAP)

standard susceptible checks used in the experiment (Fig. 74). Only the varieties Co 09004, Co 12009, CoV 92102 and Co 86032 maintained better crop stand in the presence of red rot inoculum in the rhizosphere region. Although the cv. Co 86032 recorded moderate incidences of red rot, it's crop stand was better than Co 10026 with no apparent red rot incidence.

(R. Viswanathan)

Yellow leaf disease (YLD)

Epidemiology

Yellow leaf disease severity on parental lines maintained at NHG, Coimbatore was assessed based on 0-5 scale season. Out of 431 parental lines, 24.36% recorded YL incidence and the remaining 75.63% (326 clones) were apparently free from YLD; 2.5% were HS scoring >4.1 *viz.*, Co 86032, Co 86010, CoV 92102, CoJ 85, LG 07595, Co 11015, Co 91010, CoSe 92423, CoV 09356, CoV 94101, CoP 14437, CoP 15441; 11.26% were MS scoring 2.1-3 *viz.*, Co 617, Co 976, CoS 91269, Co 87272, Co 7201, Co 0209, Co 6304, CoJ 46, BO 102, CoSe 96436, 97 R 401, Co 93020, Co 06033, CoPant 90224, CoS 96260, BO 92, Co 775, CoH 13, CoC 85061, CoH 70, CoH 56, CoH 99, CoP 18437, CoP 18436, 85 R 186, Co 93003, 69 A 591, CoH 98 , Co 8316, CoA 11323, Co 740, CoP 13436, CoS 767, Co 62198, ISH 101, CoN 91132, CoS 95255, CoSnk 03707, CoS 03261, BO 89, BO 32, Co 0209, CoJ 84291, CoS 98247, BO 109, 98 R 278, CoJ 85, CoSnk 05102, CoP 11436, LG 07595, Co 98007, Co 92005, CoOr 10346, VSI 08121, Co 85033 etc. and 10.44% were MR scoring 1.1 to 2.

Studies were conducted on YLD incidence and severity in the crop raised from seed canes of varying generations after tissue culture (T0 to T5) and YLD affected control. For germination and number of millable canes, there was a progressive decline in values from T1 to T5 and infected plants recorded further loss as compared to T5. Similar observation was recorded for flowering. Disease incidence was noticed at trace levels in T3 to T5 with severity grade 1 whereas, control exhibited severe disease incidence with severity grades of 4 and 5.

Impact of YLD on cane growth and yield: Detailed impact analyses of YLD on sugarcane (cv. Co 86032) were performed in larger plot trials by comparing tissue culture derived healthy plants with YLD-affected ones. One set of seed canes from each of the source canes were treated with fungicide, insecticide, urea, $ZnSO_4$ and $FeSO_4$ in mechanized sett treatment as recommended in AICRP on Sugarcane to manage sugarcane fungal diseases and to improve sett germination and crop vigour. Overall, YLD-free crop exhibited a healthy crop stand from germination onwards and in December 2021, the healthy plots still maintained a better crop growth with moderate flowering, whereas the diseased plot had a poor crop stand with pale canopy and nutrient disorders, no flowering and reduced cane height to an extent of nearly two feet as compared to the healthy plot (Fig. 75). Subsequent estimation of yield parameters revealed that the healthy plots recorded significantly better cane height, cane diameter, cane weight and juice volume than the diseased plots. However, juice quality parameters did not show any variation among the treatments. Canes from diseased-treated and untreated recorded 24 and 36% reductions

Fig. 75. Crop stand of YLD-free and YLD affected seed cane planted plots (Co 86032)

in cane height, respectively as compared to the healthy treated. The respective reductions for cane diameter were 21.2 and 36.4%, for cane weight 52.1 and 58.5% and for juice volume 64 and 65.5%. Between the treated and untreated plots of healthy canes, the former recorded higher yield parameters, indicating that sett treatment with various agro inputs resulted in a positive impact on cane growth and yield (Fig. 76, 77). Although treated canes of diseased plots exhibited better values than the respective untreated canes, reductions in cane and juice yields are very high in a plant crop. This data indicate severe degeneration of the variety Co 86032 due to sugarcane yellow leaf virus (ScYLV). Cane yield recorded at the time of harvest of the previous season crop in March 2021 revealed that the healthy plot recorded an estimated yield of 172 t/ha as compared to 108 t/ha in the diseased plots.

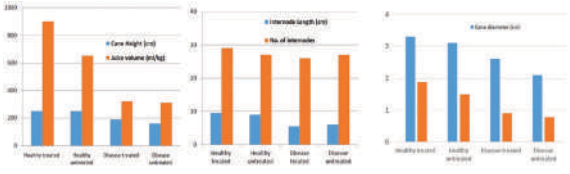


Fig. 76. Impact of ScYLV and sett treatment with agro inputs on various yield parameters (Co 86032)

Fig. 77. Robust and vigorous canes from YLD-free plot as compared to degenerated canes from YLD affected plot (Co 86032)

Detailed analyses of crop growth, yield and juice quality parameters of YLD affected canes were performed with the canes exhibiting 0 to 5 severity grades of the disease in the popular cv. Co 11015. Healthy canes did not show any variation for these parameters with the canes exhibiting YLD severity grade 1, whereas with increase in disease severity a reduction in the values with increasing trend was observed. Cane height was reduced to 25, 27.7, 25 and 25% in the canes exhibiting YLD severity grades 2, 3, 4 and 5 (Fig. 78). The respective figures for cane weight and juice volume were 31.4, 36.1, 39.5 and 31.4%, for 31.7, 26.6, 44.7 and 36.8%. With regard to juice quality parameters, only in case of grade 5 significant reductions in sucrose and CCS per cent were observed whereas in other severity grades, such impact was not found.

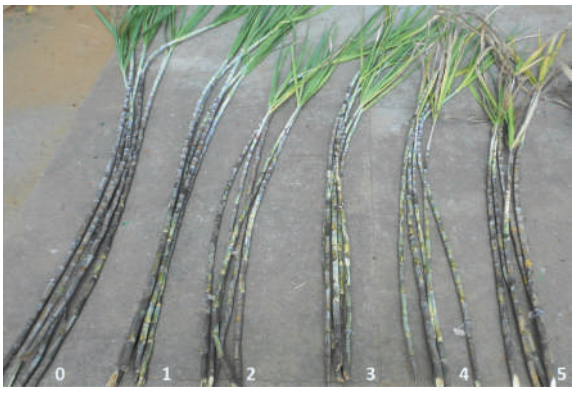


Fig. 78. Phenotypic features of canes exhibiting YLD scores of 0-5 (Co 11015)

Dynamics in aphid population: Periodical surveys for aphid colonization were undertaken to record dynamics in aphid population during the crop season. Unlike the previous seasons, aphid count declined from July onwards and thereafter the insect population was not detected in the trial plots. Continued rain during the season from July to December considerably reduced aphid population build up on sugarcane varieties.

(R. Viswanathan and K. Nithya)

Characterization of red rot pathotypes

Thirty-one *C. falcatum* isolates from tropical region, 20 of them from the state of Tamil Nadu were assessed for their pathogenic variation based on disease reactions on 29 sugarcane varieties, with an objective to ascertain relative and gain of virulence in the new isolates. Among

the isolates, CfM0265-Palapatti, CfSe95422-VPT, Cf11015-Pennaikuppam, Cf11015-Thiruvendhipuram, Cf06030-Pazhangur, Cf11015-Eraiyur, Cf11015-MPKM and Cf95020-G exhibited a higher virulence over the designated pathotypes and other isolates. Among the new isolates tested, the ones isolated from Co 11015 and CoM 0265 during the season maintained a higher virulence over the other isolates. Among the six isolates, all except Periasevalai isolate possessed a high virulence. The new Cf11015 isolates invariably caused susceptible reactions on the new varieties Co 2001-15, Co 0212, Co 09004, Co 10026, Co 11015, and Co 12009; Co 86032 and CoV 09356 also exhibited reactions to a range of S to MS to these isolates (Fig. 79). Further, CoC 24, CoSi 6, CoV 92102 and PI 1110 that exhibited less severe disease reactions to other isolates exhibited S reaction to Cf11015 isolates. Although the disease development was relatively less during the season, the three susceptible varieties, CoC 671, Co 94012 and Co 06031 showed maximum severity. Whereas, other known susceptible varieties Co 419, Co 997, Co 6304, CoC 24, CoSi 6, except Co 658 and Co 95020 exhibited a poor disease reaction. Further, among the new varieties, Co 11015 exhibited maximum susceptibility; apart from the self-isolates, it also succumbed to Cf86032-Srikandapuram, CfM0265-Palapatti, Cf419, Cf997, Cf06022-NATEM and Cf95020-G

Fig. 79. Exhibition of higher virulence by new* C. falcatum *isolates from Tamil Nadu on sugarcane cv Co 0212

Fig. 80. Behaviour of sugarcane cv Co 11015 to new* C. falcatum *isolates from Tamil Nadu

(Fig. 80). Seventeen Cf11015 isolates were assayed for their comparative virulence on cut canes of Co 11015 and CoC 671 along with Cf671 and Cf86032-Srikandapuram. Among the 17 isolates, Cf11015-Periyababusamuthiram, Cf11015-Periyasevalai (ML), Cf11015-Pannaikuppam, Cf11015-Mundiampakkam and Cf11015-Papanapattu exhibited a higher virulence than Cf671. In general, Co 11015 exhibited a higher disease development than CoC 671 in the evaluation experiments.

(R. Viswanathan and R. Selvakumar)

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

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

Nano formulations of Systemic Acquired Resistance (SAR) inducer molecules *viz.,* Benzothiadiazole (BTH) and Salicylic acid (SA) were tested for their efficacy against red rot, smut and wilt diseases of sugarcane in pot and field experiments.

Pot experiments: In first experiment, efficacy of nano formulations of BTH and SA was assessed and compared with efficacy of application of BTH and SA. For this, the setts of CoC 671 were treated with nano formulations of BTH and SA, challenge inoculated with pathogen and planted along with four controls *viz.,* BTH (125 µM) applied setts, SA (250 µM) applied setts, pathogen inoculated and mock-inoculated control. The disease incidence was recorded at fortnight interval till 360 days. When compared the progress of red rot from germination to harvest in SAR inducer nano formulation applied plants with their respective controls, i.e., BTH and SA application, the results clearly showed that nano formulation, especially BTH nano formulation could induce host resistance continuously and protect the crop from red rot till harvest (Fig. 81). Red rot incidence in BTH nano formulation applied plants were 11.1% at 60 days after planting (DAP) and no further incremental increase in disease was noticed till 330 DAP and at harvest (360 DAP) it showed only 33.3% red

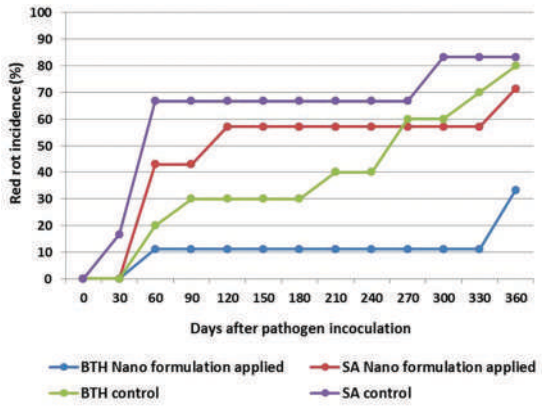


Fig. 81. Progress of red rot in SAR inducer nano formulation applied plants Vs their control

rot incidence, that too as mild symptom. On the contrary in the BTH control, the plants showed constant increase in red rot from 20% at 60 DAP to 80% at 360 DAP. Also, BTH nano formulation could reduce red rot incidence to a tune of 63% over pathogen inoculated control. These results reiterate that slow release of BTH from chitosan coated BTH nano formulation consistently induced the host resistance and effectively protects the crop till harvest. In second experiment, only BTH nano formulation was selected for testing its efficacy against red rot disease in two varieties *i.e.,* CoC 671 and Co 11015. The setts were treated with BTH nano formulation (T_1) and planted along with respective controls, *i.e.,* pathogen inoculated (T_2) and healthy control (T_3). The results showed that BTH nano formulation could control red rot incidence by 80.5% in CoC 671 and 100% in Co 11015.

Field experiments

Nano formulation Vs Red rot: Four treatments *viz.,* T_1 - BTH nano formulation, T_2 - Fungicide (Thiophenate methyl- Roko® - 0.1%, T_3 - Pathogen inoculated control and T_4 - Healthy control were imposed on two varieties CoC 671 and Co 11015. The pathogen *C. falcatum* isolate Cf671 was challenge inoculated during planting as grain inoculum and the disease incidence was recorded. In both the varieties, BTH nano formulation applied plants recorded the least incidence of red rot. Application of nano BTH formulation reduced red rot incidence by 50.1% in CoC 671 and 88.9% in Co 11015, and in fungicide treated plants, the reduction in red rot incidence was 48.3% in CoC 671 and 73.5% in Co 11015 (Fig. 82).

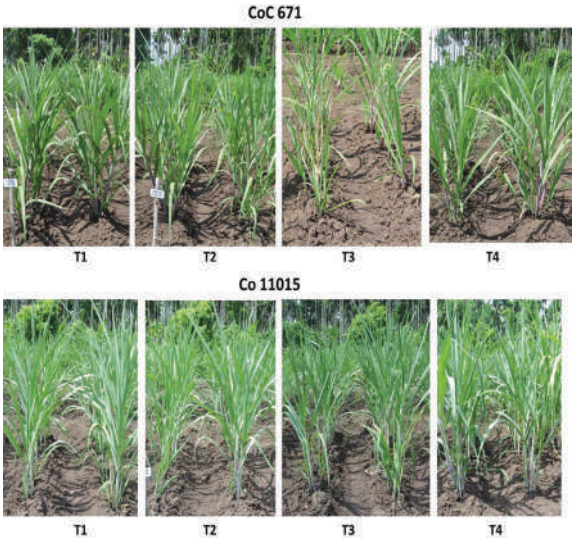


Fig. 82. Field stand of sugarcane varieties imposed with nano formulation and other treatments

Nano formulation Vs Smut: In set II of smut trial, four treatments were taken, *i.e.,* T_1 - BTH nano formulation, T_2 - SA nano formulation and T_3 - Fungicide (Propiconazole - Tilt® - 100ppm) were applied as 3 sprays and T_4 was pathogen inoculated untreated control and they were imposed on cv Co 96007 and Co 97009. The mixed inoculum of pathogen was inoculated by meristematic needle inoculation and the disease incidence was scored till harvest. The results showed reduction of smut incidence to the tune of 62.5% to 90.0% in BTH nano formulation applied plants, while it was 30.0% to 73.2% in case of SA nano formulation applied plants.

Nano formulation Vs Wilt: In set I, four treatments were taken, *i.e.,* T_1 - BTH nano formulation, T_2 - SA nano formulation and T_3 - Fungicide (Propiconazole - Tilt® - 100ppm) applied as sett treatment and two sprays and T_4 was pathogen inoculated control and the treatments were imposed on cv Co 86002. The pathogen (Fs86010) was applied as grain inoculum and disease incidence was scored till harvest. Screening for wilt incidence during harvest showed that BTH formulation could reduce wilt incidence by 68.6% and SA nano formulation reduced the wilt incidence by 62.3% over pathogen inoculated control. The treatments of set II trial were same as that described for the smut trial above. The cv. Co 86002 was inoculated with the pathogen (Fs86010) by

plug method and the wilt incidence was scored in 0-4 scale. The incidence of wilt in nano BTH and SA formulation applied plants was R, while it was MR in pathogen inoculated control and that indicated induction of resistance in host and reducing wilt intensity.

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

Molecular characterization of phytoplasma associated with sugarcane

Sugarcane grassy shoot (SCGS) incidence was observed to be 92.30% in the zonal varietal trial IVT, 25% in AVT I plant, and 60% in AVT II plant. Various phenotypic symptoms of SCGS samples are initial chlorosis, partial chlorosis with leaf dryness, complete chlorosis with creamy white colored leaves. The symptoms expressed only in spindle leaf from the cane, side bud germinated leaf. Leaves from the completely dried clump were collected along with its nearby asymptomatic apparently healthy cane samples from different varieties *viz.,* Co 14008, Co 14006, Co 86032, Co 14025, CoTI 14112, CoSnk 14102, CoC 671, CoSnk 14102, CoV 92101 to assess the minimum threshold limit of SCGS phytoplasma to express the initial symptoms. qPCR primers were designed from the 16S rDNA regions along with housekeeping SecA genes. Initially, nested PCR analysis was performed using the universal P1/P7 primers, with that more than 85% of the samples had shown the expected amplification of 1.8kb. qPCR diagnostic primers were standardized through gradient PCR assay from the CoC 671 samples.

The standard curve was obtained by using the pGEMT easy vector plasmid cloned with SCGS phytoplasma (1.2kb), serial dilution curve was prepared with five points and tenfold dilutions between points to determine the concentration of unknown samples in Step one plus Real time PCR System (Applied Biosystems, USA). Three technical replicates were used for each serial dilution of plasmid DNA. The sugarcane healthy leaf DNA without SCGS phytoplasma infection was used as a negative control and sterile water was used as a blank control. In qPCR assay, quantitative standard curve was constructed by relating the log of the initial number of templates in each standard to a fractional cycle number derived from each curve. The efficiency (slope) and the coefficient of determination (R^2) of the linear equation were determined to optimize the concentrations and conditions of the qPCR assay. A linear line with an equation of y = -3.4084x + 41.897 and a correlation coefficient of $R^2 = 0.998$ was obtained. The amplification efficiency was calculated as $E = 10^{(-1/slope)}-1 \times 100$. The quantity was measured by $10^{(Cq-b)/m}$, where b is the y-intercept and m is the slope of the linear regression. Unknown concentrations have been reported as determined by interpolation from the standard curves and the Ct value is a parameter reflecting the quantity of templates present in the reaction.

(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 sett treatment device with the provision of hot water treatment (STD-HWT) for disease management and to improve varietal performance

Varietal performance

Sett treatment of different varieties with STD-HWT at 52 and 54 ^{0}C individually or in combination with nutrients revealed that the higher temperature 54 ^{0}C along with nutrients significantly improved germination, number of millable canes and finally yield to 24.1% in Co 86032, 47.8% in Co 0238 and 100% in Co 11015 as compared to control plots. Regarding Co 0212, it performed well at 52 ^{0}C followed by other treatments as compared to control (Fig. 83).

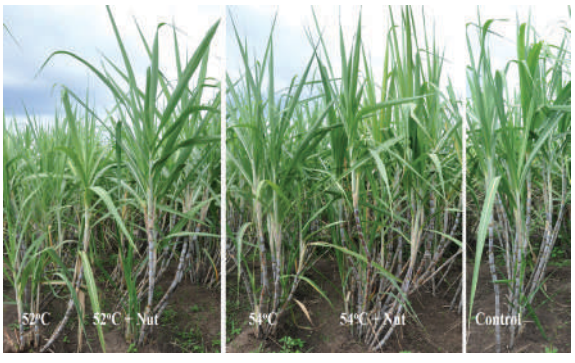


Fig. 83. Efficacy of STD - HWT and Nutrients on plant growth improvement - Co 11015

Disease management

Smut: Results on efficacy of hot water treatment at 52 and 54 ^{0}C individually and along with the fungicide propiconazole indicated that there was significant improvement in germination and improvement of yield attributes along with reduction in smut incidence as compared to infected control of the susceptible cultivar, Co 96007. Among the treatments, there was no disease incidence by combining hot water at 54 ^{0}C and propiconazole. However, yield was found to be reduced significantly as compared to other treatments due to lower germination. Instead, HWT alone at 54 ^{0}C was found to be best in improving the yield as compared to other treatments with hot water at 52 ^{0}C and propiconazole individually or in combination. In contrast, mechanized treatment with propiconazole was found to best in reducing smut incidence, however it failed to improve yield as hot water treatment (Fig. 84).

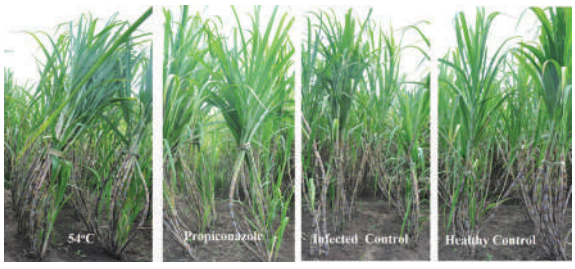


Fig. 84. Efficacy of STD - HWT and fungicides against smut in Co 96007

Grassy Shoot Disease (GSD): Based on our earlier standardization, STD-HWT unit for GSD management has been validated by using completely infected CoV 92101 stalks. From which, single bud setts were subjected to various treatments including recommended practice of hot water treatment at 50 ^{0}C for 1h and 52 ^{0}C for 30 min without vacuum were compared with STD-HWT with vacuum at 52 ^{0}C and 54 ^{0}C individually for 15 min and planted in pits. Results indicated that there was no significant difference on germination among treatments including control, while there was significant improvement in yield attributes *viz.*, NMC, cane height, internodal length and girth of stalks due to reduced GSD (Fig. 85). However, difference on number of nodes between control and treatments is insignificant. With significant reduction in disease incidence, an improvement in yield attributes

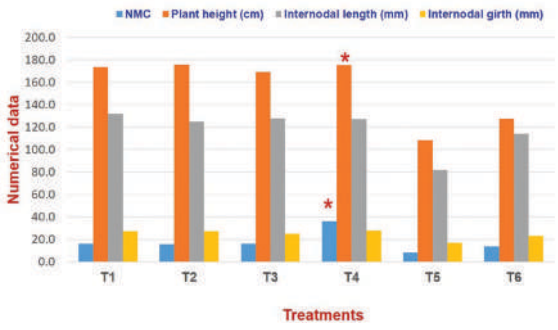


Fig. 85. Efficacy of mechanized sett treatment with hot water alone or in combination with vacuum against GSD incidence in CoV 92101

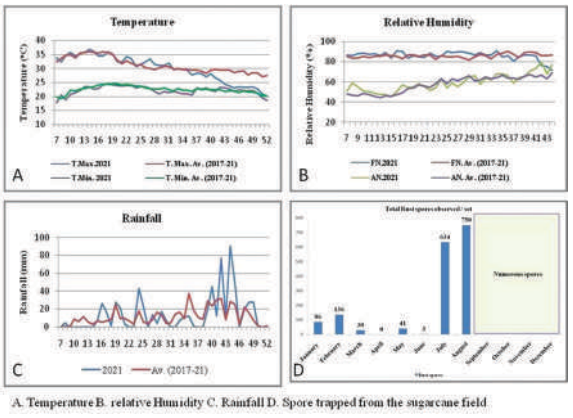
was recorded in all the treatments as compared to control and it is interesting to note that there was no phenotypic expression of disease in STD-HWT at 54 ^{0}C in pits. Under field conditions also, significant reduction in disease incidence (>80%) could be observed with increase in temperature level at 54 ^{0}C by vacuum based treatment in STD-HWT unit.

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

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

In peninsular India, the severity of sugarcane rust is determined by the weather factors like temperature, relative humidity and rainfall. In 2021, the maximum temperature was recorded in the range of 20 to 37 ^{0}C and the lowest maximum temperature (20 ^{0}C) was recorded in December and the highest maximum temperature of 36.8 ^{0}C was recorded in April. June to August 2021 recorded higher temperature than the mean average maximum temperature. The average mean maximum temperature (2015-2021) ranged between 27.48 ^{0}C and 36.07 ^{0}C at SBI farm. Until September, the maximum temperature was normal (28 ^{0}C) and there was decline @ 2 ^{0}C per month and it reached 20 ^{0}C in December and during that period the night minimum temperature was 18.5 ^{0}C. Throughout the crop season, the minimum temperature recorded was above 18 ^{0}C and maintained below 25 ^{0}C, which is similar to average minimum temperature range of 19 to 24.5 ^{0}C. In general, Coimbatore receives rain from March second week, but during 2021, there was no rain during March and the rain started in

last week of April. There was heavy rain fall in April and in June 2021 than the average. The relative humidity (FN) recorded was 91% in April, whereas the average was 85% only. But the lowest RH was recorded in November (71.5%) where the average RH was 81.6% which was mainly responsible for poor germination of rust uredospores in the field. During 2021, the afternoon RH recorded was in range of 45.8 - 82.2%, whereas the average RH (AN) recorded was between 44.3 and 69.2% (Fig. 86).



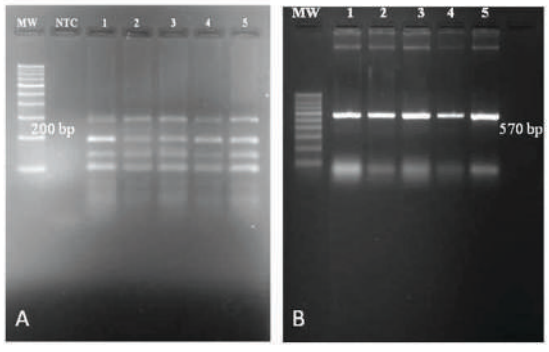
A. Temperature B. relative Humidity C. Rainfall D. Spore trapped from the sugarcane field

Fig. 86. Weather parameters recorded at ICAR-SBI farm during 2021

Presence of sugarcane rust spores was estimated using spore traps kept in the field. Vaseline coated microscopic slides were used to observe the uredospores in the air responsible for secondary spread of the disease. The slides were observed for presence of uredospores at fortnightly intervals and the spore numbers were correlated with the peak period for rust infection and severity till harvest. It was clear that rust spores are present during January to March, and in April and June the spores were not detected from the air, which can be correlated with heavy rainfall in 2021. During July and August onwards the spore numbers increase in the sugarcane field, which reach beyond counting from September till harvest. Although sufficient spores are present in the atmosphere, unfavourable temperature, relative humidity and maturity phase of the crop restricted the germination and infection of rust pathogens, thus limiting the spread of the rust in the field.

Occurrence of rust in parental clones of NHG and Arrowing plot: Out of 269 clones in Arrowing plot only 23 clones *viz.,* 2011-35, Co 0238, Co 0331, Co 11015, Co 1148, Co 12014, Co 13015, Co 15023, Co 15027, Co 740, Co 775, Co 8341, Co 86011, Co 87011, Co 89003, Co 94008, Co 94019, Co 99004, Co 99006, CoH 70, CoJ 83, CoPant 84212 and CoPant 97222 showed rust and the remaining clones were rust free. Out of 431 parental clones maintained at NHG, 69 clones expressed rust infection and other clones remained rust free. In zonal varietal trial, only 11 entries showed rust from traces to 5% severity, and only two entries namely 29 and 140 showed 5-10% rust severity. Unusually this year, the leaf spot was observed in many clones and 23 entries exhibited rust in traces and leaf spot together.

Status of rust resistant Bru gene among Indian sugarcane clones: To ascertain the presence of Bru gene in sugarcane parental clones, PCR reactions were performed with Bru1-specific markers, R12H16 and 9020-F4-PCR-Rsa1. The presence of *Bru1* was indicated by presence of an amplification by a product of 570 bp with the R12H16 marker and 200 bp with 9020-F4-PCR-Rsa1 marker. Based on literature, the clones Newra, POJ 2878, Co 419, Chin and Uba Naquin were known to harbour Bru gene and were confirmed (Fig. 87). Around 100 parental clones from NHG were tested with R12H16-PCR marker for the presence of Bru gene and around 20 clones showed 200bp product indicating the presence of Bru gene, which will be further confirmed with the second marker. Many clones, which are not carrying Bru gene, are showing resistance against rust pathogen indicating the availability of alternate rust resistant genes in our germplasm.



A. 9020-F4-PCR-Rsa1; B. R12H16-PCR
1. Newra 2. POJ 2878 3. Co 419 4. Chin 5. Ubanaquin

Fig. 87. DNA profiles of the two molecular diagnostic markers for Bru1 selected sugarcane clones

A. Rust affected plot B. Propiconazole sprayed plot

Fig. 88. Effect of propiconazole on sugarcane rust in the field

Management of sugarcane rust using fungicide: Propiconazole at 0.05% was tested for rust management in the field. When the fungicide was sprayed @ 0.05% (5 ml in 10 L water) immediately after appearance of initial symptoms, rust spread was controlled to the newly emerging leaves. In severe conditions, 2nd spraying with propiconazole @ 0.05% after 20 days of first spray spraying gave complete protection from the rust (Fig. 88).

(R. Selvakumar and T. Lakshmipathy)

Epidemiology and management of Fusarium diseases in sugarcane

Epidemiology of wilt: Impact of wilt in plant crop on bud sprouting in stools and ratoon crop establishment was studied after harvest of NHG (2020-21 crop), which had a severe wilt outbreak. Many of the wilt resistant parents *viz.*, BO 91, BO 130, Co 89029, Co 0235, Co 06035, CoH 13, CoH 56, CoH 110, CoH 167, CoJ 88, BO 155, CoLk 8102, CoLk 94184, CoM 6806, CoP 06436, CoP 9206, CoP 18437, CoPant 97222, CoPb 10183, CoS 87216, CoS 88216, CoS 96260, CoSe 92423, CoSe 01434, 97R401, ISH 176, HR 83-144, LG 01030, LG 01118, LG 02100, LG 05493, LG 05823, LG 06839, LG 08422, LG 14564 remained wilt-free with close to 100% flowering, exhibited a good ratoon establishment. Many of the susceptible parents recorded more than 50% wilt such as Co 86002, CoOr 03152, Co 419, Co 775, Co 1148, Co 62198, Co 8209, Co 8353, Co 85019, Co 86011, Co 88025, Co 91010, Co 94008, Co 94012, Co 97015, Co 98010, Co 2000-10, Co 0121, Co 0237, Co 0327, Co 06036, Co 06037, Co 11001, CoA 11323, CoC 671, CoC 90063, C 81615, CoM 9206, CoV 89101, CoVc 14062, CoPant 84212, CoC 8201, CoBln 05501, CoV 09356, CoT 8201, 85 R 186, MS 68/47, ISH 41, ISH 69, ISH 229, LG 72120, LG 72115, LG 99001, LG 05828, LG 06810 had exhibited poor flowering and a poor ratoon establishment (Fig. 89). This observation revealed that either severe wilt in plant crop reduces ratoon establishment or causes more severe wilt in the ratoon or both.

Fig. 89. Poor ratoon crop establishment in sugarcane varieties due to severe wilt in plant crop

Simulation of wilt: Studies were conducted on wilt and pokkah beong development from infected seed canes of 11 varieties under field conditions. Yellowing and drying symptoms of wilt were noticed in nine varieties during 120 and 240 days, respectively. Pokkah boeng symptoms appeared during early phase of the crop and not found later. As in the previous seasons, infected seed canes exhibited a poor crop stand (Fig. 90). In another trial, *F. sacchari* multiplied on sorghum grains and chopped canes of wilt affected canes were mixed and used as soil inoculum and observed for disease development. Overall, presence of both kinds of inocula reduced bud sprouting and crop stand in the plots, although typical disease development was not noticed as in sett borne infections of *F. sacchari.*

Fig. 90. Crop stand of wilt free and wilt affected crop of sugarcane cv Co 419

Molecular characterization of Fusarium isolates: Forty-four *Fusarium* cultures were recovered from infected sugarcane samples of cane stalks with wilt and top rot, leaves with pokkah boeng symptoms, wilted cane with knife cut & pokkah boeng and pokkah boeng with knife cut. The samples comprised sugarcane varieties from factory locations, germplasm, *Erianthus*, NHG, quarantine, VPT farm and pokkah boeng affected sorghum. The cultures exhibited typical characters of *Fusarium* in plates and the tissue bits have shown 100% recovery of the fungus in most of the cases (Fig. 91). Thirty *Fusarium* isolates recovered from wilt infected cane, leaf and cane tops of sugarcane plants were purified on OMA plates and subjected to molecular characterization by sequence analysis of partial genome of tef1α gene, after PCR assays. The results revealed that most of the isolates belonged to *F. sacchari.*

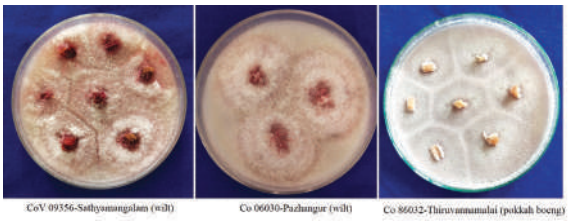


Fig. 91. Recovery of Fusarium cultures from sugarcane stalk and leaf samples

Morpho-physiological observations on wilted and healthy sugarcane: Impact of wilt on cane yield and juice quality parameters was studied with five varieties, Co 775, Co 7201, Co 87252, Co 2000-10 and Co 05010. Wilt affected canes exhibited significant reductions in the range of 24 to 50% in cane height and respective losses for the parameters, cane weight, juice volume and sucrose% were 16.1 to 57.5%, 17 to 66.6% and 5.1 to 33.6% (Fig. 92). Further, impact of wilt on cane yield and juice quality parameters of wilt

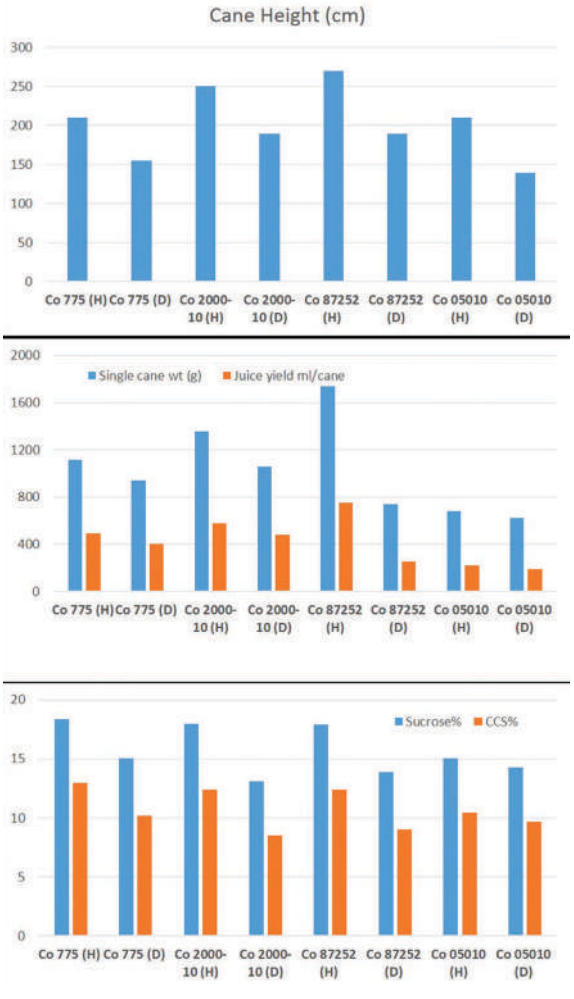


Fig. 92. Impact of wilt on various cane and juice yield parameters in sugarcane varieties (H-Healthy; D-Diseased)

affected canes of the popular cv. Co 11015 was assessed. Healthy canes were compared with wilt affected canes exhibiting chlorosis, partial wilt and complete wilt. The wilt affected canes recorded 35.7 to 53% reductions in cane height, 52.3 to 60.5% in cane weight, 52.6 to 60.5% in juice yield and 5.6 to 37.1% in sucrose %. The canes exhibiting complete wilt symptoms exhibited severe losses than the partially affected canes for all the yield and quality parameters. Further, total wilted canes recorded drastic reductions in juice quality parameters including Brix, sucrose%, purity% and CCS % probably due to systemic damages to the tissues. The results further revealed that those plants, which suffer from nutrient deficiencies especially micronutrients, quickly succumb to wilt.

Management: Sett treatment with fungicide (Propiconazole) has improved bud sprouting and crop stand in five of six varieties with *F. sacchari* infected setts under field conditions, whereas, in CoT 8201 such positive impact was not found. The treated plots showed an improved cane population, however, a clear variation in the varietal response was found, indicating pathogen preference to cane varieties resulting in a probable variable pathogen load in the setts.

SBIRC, Kannur: During 2021, Pokkah boeng was first recorded in the month of May in germplasm clones at SBIRC, Kannur. Barbados white sport, Chapina and Fiji B of *S. officinarum,* Q 61. B 41-248, H 54-1523, PR 1065, SW 111, CAC 87, 56-245, 56-397, LF 70-1153, LF 70-1154, LF 70-1155 of foreign hybrids and Co 62082 was found affected. For the first time, pokkah boeng was recorded in Chuk Che, Lalkhadi and Uba Reunion of *S. sinense* and IJ 76 491 of *S. robustum.* Only few clumps affected and only chlorosis phase was noticed in all diseased clones and all the clones recovered after sometime.

(R. Viswanathan, R. Selvakumar, P. Malathi, A. Ramesh Sundar, R. Gopi and R. Arun Kumar)

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

In order to maximize the ScYLV coat protein gene expression, yeast expression vector *Pichia pastoris (pPICZ aB)* was used in which the recombinant proteins are expressed as fusions to a C-terminal peptide containing the c-myc epitope and a polyhistidine (6xHis) tag. The vector allows high-level, methanol inducible expression of the gene of interest in *Pichia*, and can be used in any Pichia strain including X33 and GS115. It contains an AOX1 promoter for tightly regulated methanol induced expression of the gene of interest. The full length of ScYLV CP gene primers were designed with *PstI* CTGCAG and Not1 GCGGCCGC restriction enzyme sites. The primers were standardized through gradient PCR and the positive ScYLV amplicons obtained from Co 11015 and 57NG56 were cloned into pPICZ α B vector, the colony PCR followed by the restriction digestion with the same enzymes confirmed the insert size with 588bp (Fig. 93). Further standardization of methanol inducible gene expression and protein purification is in progress using Ni-NTA resin agarose column.

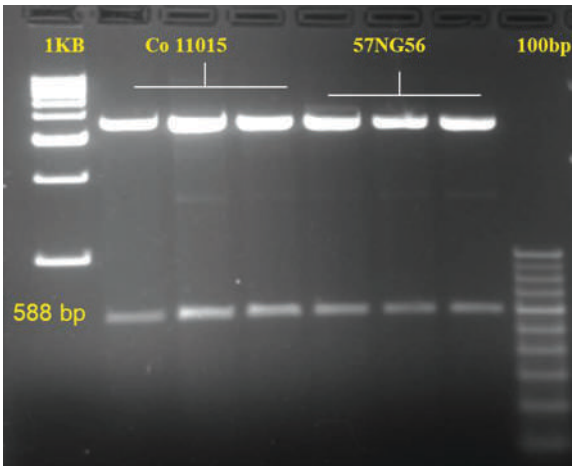


Fig. 93. Restriction digestion profile of pPICZ B vector for confirmation of ScYLV CP insert

Besides, sugarcane viral disease scenario across the varietal spectrum of Tamil Nadu from different places such as Paramathi and Mohanur (Namakkal), Sevur (Coimbatore), Sathyamangalam, Trichy and Thiruvannamalai were analysed for all the three major RNA viruses by RT-PCR. The results showed that ScYLV was predominant followed by SCMV and SCSMV. The varieties subjected into analyses were Co 86027, Co 86032, Co 0212, Co 06022 from Namakkal; Co 86032 (TC) from Sevur, Avinashi; 16G031, 16G032, C15632 from Sathyamangalam; Co 06022 from Trichy; Co 11015, Co 86032, CoG 6 and CoV 92102 from Thiruvannamalai.

In continuation of the new reports of sugarcane viruses on its closely related host species, sorghum and maize samples grown in sugarcane ecosystem were collected from Paramathi (Namakkal), Sevur (Coimbatore), Trichy and Thiruvannamalai. Of the 35 maize samples tested for three sugarcane RNA viruses, SCMV was diagnosed from three samples, two symptomatic and one asymptomatic from Paramathi, Namakkal district of Tamil Nadu but SCSMV and ScYLV were not diagnosed from any sample even with different genomic regions of primers tested. All the positive samples had shown the expected amplicon size of 894bp for the SCMV and their sequences were submitted to GenBank under the accession numbers of MW618112, OK358714 and OK358715. The pairwise multiple sequence alignment of SCMV sequences from *Zea mays* of this study has clearly shown highest nucleotide similarities of 100% among themselves and 98.1 to 97.8% with SCMV sequences from major cultivated varieties of sugarcane such as CoC 671, Co 740, CoV 94101, Co 86032 and Co 6304 from India.

In the 35 sorghum samples (mostly 'sencholam' types grown for grain and fodder) tested for three sugarcane RNA viruses, SCMV was diagnosed from four symptomatic and two asymptomatic samples from Coimbatore, Paramathi, (Namakkal Dt.) Thiruvannamalai, SCSMV from two asymptomatic samples from Kidaram, Trichy and Paramathi, Namakkal and ScYLV from four asymptomatic samples from Paramathi, Namakkal, Kidaram, Trichy and Thiruvannamalai. All the positive samples had shown the expected amplicon size of 894, 690, and 615 bp for the SCMV, SCSMV and ScYLV, respectively and their sequences were submitted to GenBank under the accession numbers, MW580397, MW618113, OK358711, OK358712, OK358713, OK358716, OK665790 (SCMV); MW654013, OK631531, OK631532, OK631533 (ScYLV); OK665791, OK665791 (SCSMV). The pairwise multiple sequence alignment of SCSMV sequences has clearly shown the highest nucleotide similarities of 99.8% among themselves and 96% identity with other SCSMV sequences of sorghum from India; 94.2 - 97.6% identity with other SCSMV sugarcane India, Thailand, Indonesia and China. However, they showed only 83-84% identity with sugarcane SCSMV isolates from Thailand and Brazil isolates (Fig. 94).

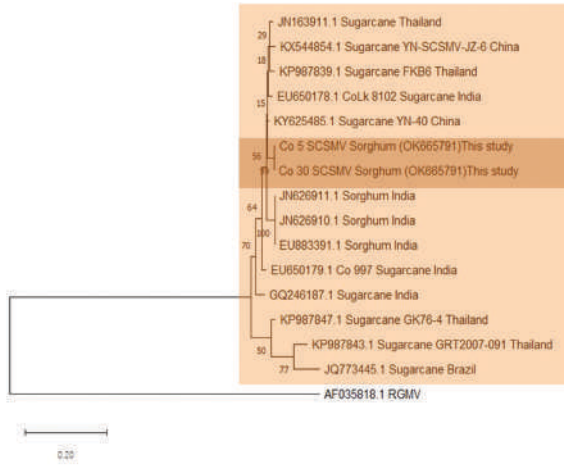


Fig. 94. Phylogenetic tree constructed by the maximum likelihood method using Tamura-Nei model with nearest neighbour joining interchange tree options (MEGA X v.10.1.6) with 1000 bootstrap replications showing the closest genetic relationship of SCSMV isolates of* S. bicolor *from this study with other SCSMV sequences of sorghum and* Saccharum *sp.

In addition, more than 300 sugarcane viral diseased samples of different varieties collected from different states during the previous seasons were subjected to variability analysis to assess genomic variation in the virus population. All the samples were processed for the RT-PCR assays using the SCMV, SCSMV and ScYLV diagnostic primers designed from the coat protein regions and the new genotype primers for ScYLV. More than 180 partial viral genomic sequences were submitted to NCBI.

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

Dissecting the molecular interface between the biotrophic pathogen *Sporisorium scitamineum* and its host - sugarcane

Whole transcriptome analysis of S. scitamineum in vitro developmental stages: Application of next-generation sequencing technology to decipher the molecular responses of distinct in vitro developmental stages of *S. scitamineum* has not been attempted in India. Hence, whole transcriptome sequencing of in *vitro* developmental stages *viz.,* haploid sporidia and dikar-

yotic mycelia was performed using a high-virulent isolate Ss97009 and a low-virulent isolate SsV89101. Reference-based assembly was carried out for the reads followed by differential gene expression analysis to compare the gene expression profiles between the different transition stages of these two isolates. When comparing infective dikaryotic mycelia to non-infective haploid sporidia, the higher percentage (79-87%) of genes up-regulated revealed significant differences in transcriptional reprogramming events occurring during the dimorphic transition. The differentially expressed genes (DEGs) were funtionally annotated using Blast2GO 5 PRO package. *S. scitamineum* was represented as the top-hit species, while the second top-hit species was a closely related-smut fungus *Sporisorium reilianum.* Mapping of all the DEGs to the biological pathways was performed using KEGG database, and the mapped DEGs mostly represented the pathways such as carbohydrate metabolism, amino acid metabolism and lipid metabolism, etc. (Fig. 95). Comparative analysis of the transcriptome data for virulence genes revealed the roles of carbohydrate-active enzymes (CAZymes - GH16, GH128, GH30, and GH45), transcriptional regulators (zinc cluster superfamily and homeobox-domain containing proteins), and membrane transporters, illuminating the transcriptional events occurring during the dimorphic transition of *S. scitamineum.*

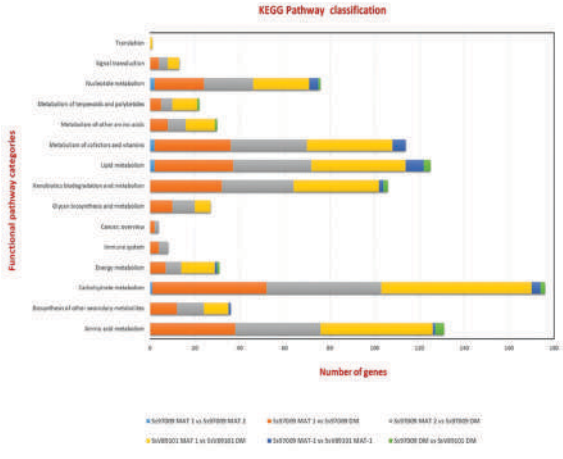


Fig. 95. Bar graph showing the KEGG pathway classification. Number of differentially expressed genes that are distributed in the respective KEGG pathway categories were plotted and compared within all the combinations

Whole transcriptome analysis of S. scitamineum *isolates during its interaction with sugarcane:* Molecular responses in *S. scitamineum* during early phase of infection and whip emergence stage were investigated using a high-virulent and a low-virulent isolate. Differential gene expression profiles of fungal transcripts recovered from Sugarcane x *S. scitamineum* samples of both isolates Ss97009 and SsV89101 at different time points (2 dpi, 5 dpi, and 60 dpi) were analyzed using OmicsBox version 1.4.11. A majority of genes showed down-regulation at earlier infection stages (2 dpi and 5 dpi) in both high and low virulent isolates, presumably representing the host defense, or circumventing the invasion strategy of the smut fungus. However, the sample of the high-virulent isolate Ss97009 recorded a higher number of up-regulated genes, indicating substantial transcriptional modifications during successful infection compared to the low-virulent isolate. Throughout all infection time points (2 dpi, 5 dpi, and 60 dpi), an arsenal of plant cell wall-degrading enzymes, aiding in penetration and acquisition of nutrients, were detected in both high-virulent and low-virulent isolates (Fig. 96). After the penetration into the host, *S. scitamineum* establishes a compatible biotrophic interaction by secreting pool of candidate secretory proteins. *In silico* secretome anal-

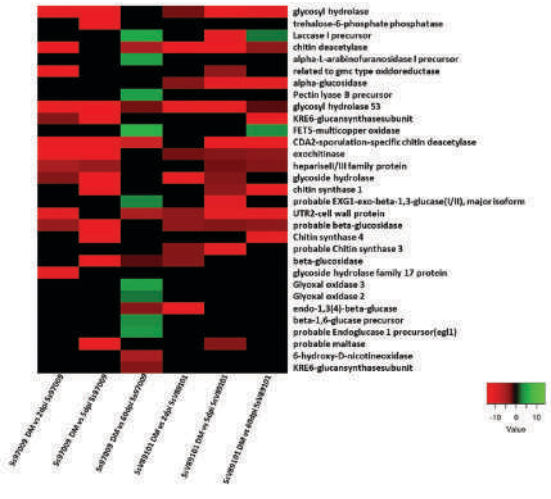


Fig. 96. Heatmap of the differentially expressed genes (DEGs) related to Cell wall degrading enzymes (CWDEs). Heatmap was constructed using the log2 fold change values, and the genes in green and red represent up- and down-regulated genes respectively

ysis revealed that majority of the effectors *viz.*, Mig1, Eff1, Pep1, Suc2 were consistently up-regulated at the time of pathogenesis by the isolate Ss97009, confirming its high virulence compared to SsV89101. This study highlighted the transcriptome alterations of *S. scitamineum* during its dynamic interaction with sugarcane.

Whole transcriptome analysis of sugarcane during interaction with S. scitamineum: To gain new insights into the defense responses in the host against *S. scitamineum*, we investigated the transcriptome of sugarcane - *S. scitamineum* interaction samples during early phase of infection and whip emergence stage using a high-virulent isolate Ss97009 and a low-virulent isolate SsV89101. The differential gene expression results indicated that there were significant transcript changes in sugarcane in response to both high- and low-virulent isolates. Comparatively, differential gene expression was higher in the early stages (2 dpi and 5 dpi) than in the later stage (60 dpi) with both the isolates suggesting a stronger response during initial colonization. At 60 dpi, DEGs were more abundant in plants inoculated with Ss97009 as compared to SsV89101 indicating that the responses against the high-virulent isolate was more intense than that of the low-virulent isolate.Analysis of the biological functions of the sugarcane DEGs revealed that the genes and pathways induced in Ss97009 and SsV89101 inoculated plants at 2 dpi and 5 dpi were similar, while those involved in defense responses were differentially expressed only in Ss97009 inoculated plants at 60 dpi. DEGs associated with hormones like auxin, ethylene, gibberellin, and jasmonic acid, which act as critical signals for regulating disease resistance in plants, were differentially expressed (Fig. 97). Up-regulation of transcription factors viz., NAC, bHLH, MYB, and WRKY, and genes involved in the flavonoid biosynthesis pathway *viz.*, flavonoid 3'-hydroxylase and chalcone synthase was found to be associated with both the early phase and the whip emergence stage of infection, while up-regulation of many pathogenesis-related proteins like pathogenesis related protein 1, thaumatin-like protein and beta 1,3 glucanase were observed only during the early stage. The reduced number of PR-proteins in the whip incident sample indicated the susceptibility of the sugarcane cultivar to the high-virulent isolate Ss97009. Quantitative real-time PCR analysis was done to validate the differential expression profiling obtained from Illumina RNA-seq and the expression patterns obtained by qPCR were similar to those observed with the Illumina sequencing re-

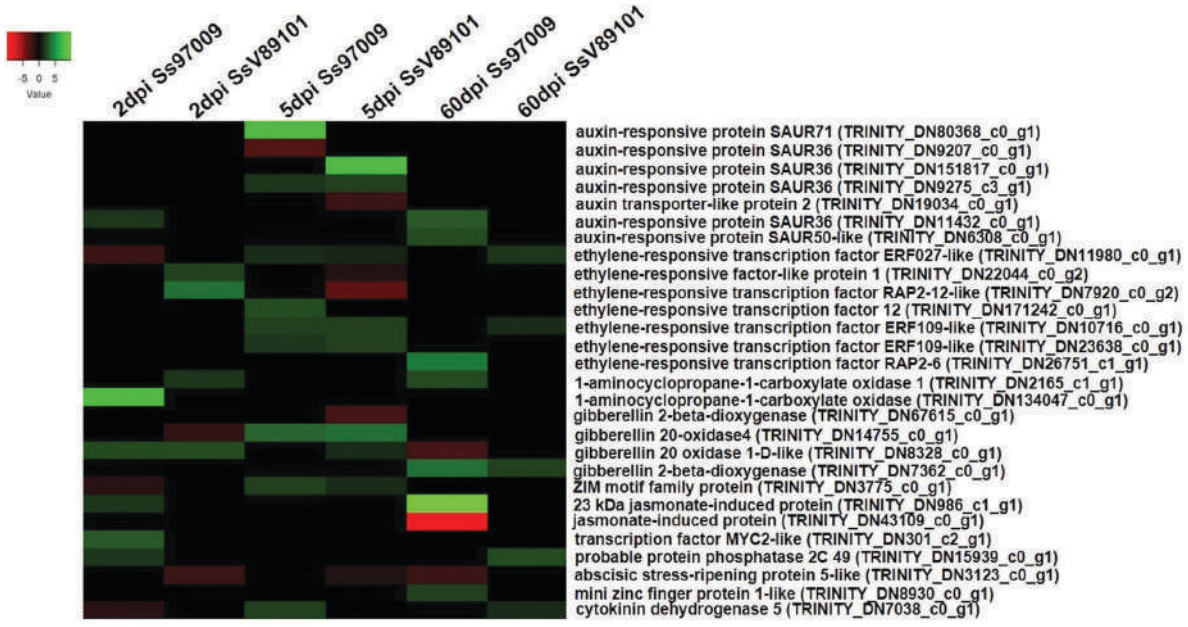


Fig. 97. Heatmap of the differentially expressed genes (DEGs) related to hormone biosynthesis in sugarcane cultivar Co 97009 inoculated with the* S. scitamineum *isolates Ss97009 and SsV89101. Heatmap was constructed using the log2 fold change values, and the genes in green and red represent up- and down-regulated genes respectively

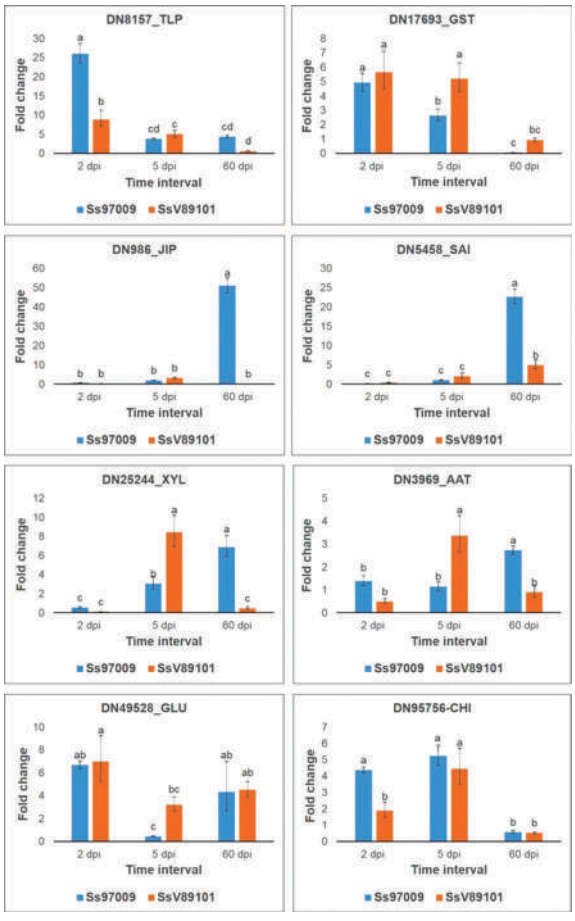


Fig. 98 Validation of differentially expressed genes identified in Illumina sequencing by qPCR. DN8157_TLP, thaumatin like pathogenesis related protein 4; DN17693_GST, glutathione S-transferase; DN986_JIP, jasmonate induced protein; DN5458_SAI, soluble acid invertase; DN25244_XYL, endo 1,4 beta xylanase-1 like; DN3969_AAT, amino acid transporter AVT6A-like; DN49528_GLU, beta 1,3-glucanase; DN95756-CHI, chitinase. The x-axis represents the sugarcane buds inoculated with the S. scitamineum isolates Ss97009 and SsV8901 sampled at different intervals: 2 dpi, 5 dpi and 60 dpi, and the y-axis represents the fold change of the respective genes. Error bars represent the standard deviation based on three biological replicates

sults (Fig. 98). Altogether, the complex networks of plant-pathogen interaction pathways as well as the differences in the defense responses in sugarcane against *S. scitamineum* with varying virulence behaviour were deciphered.

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

Deciphering in *planta* secretome of *Sporisorium scitamineum* x sugarcane interaction

Qualitative analysis of the extracted apoplastic proteins for contamination of cytoplasmic proteins from *Sporisorium scitamineum* infected sugarcane meristems

The results of qualitative assessment of extracted apoplastic wash fluids using the cytoplasmic marker - Glucose-6-phosphate dehydrogenase (G6PDH) biochemical assay indicated that all the extracts have relatively less than 30% of cytoplasmic protein contamination, except the extracts collected using sodium phosphate buffer which recorded around 20-50% of contamination. Similarly, the qualitative analysis of another cytoplasmic marker - malate dehydrogenase (MDH) assay also indicated 10-40% cytoplasmic contamination. Overall, the prelusive works on the extraction methodology of apoplastic wash fluid by biochemical estimations suggested that the syringe method of extraction with $CaCl_2$ + Sodium acetate buffer may serve as an ideal buffer for extraction. However, before selecting an appropriate buffer, the quality of extraction was also evaluated by a more stringent method by western blot using cytoplasmic marker-specific antibodies like Rubisco large subunit and UDP-glucose pyrophosphorylase (UGPase). Results of western blot with Anti-UGPase indicated that none of the extracts had detectable amount of cytoplasmic protein contamination as compared to whole cell extract. On the other hand, we could not detect Rubisco proteins, even in the whole cell extract against Anti-Rubisco, presumably due to their absence in the meristematic tissues. Hence, from the overall observations with different assays and estimations, $CaCl_2$ + Sodium acetate buffer-based extraction using syringe method was selected for further proteomic analysis of apoplastic protein extracts.

Apoplast protein identification through iTRAQ based LC-MS/MS analysis

Comparative proteomic analysis of apoplastic proteins of healthy and infected meristematic tissues (during compatible interaction) using iTRAQ labelled LC-MS/MS method resulted

in identification of 1453 and 1601 peptides that accounted for 56 and 67 proteins, respectively. Notably, 49 proteins presented in both healthy and infected meristem. Out of 67 proteins in infected sample, 54 were from the host, Co 97009 and 13 represented *S. scitamineum*. Out of 13 *S. scitamineum* proteins, 11 proteins (around 84.6%) were identified as secreted proteins using SignalP and TargetP tools. Venn diagram (Fig. 99) shows the number of up-regulated (A) and down-regulated (B) DAPs identified in iTRAQ results. The numbers indicate the DAPs in 24 hpc and 48 hpc while comparing with *MAT-1* and *MAT-2* (representing the distinct opposite mating types) (Fig. 99).

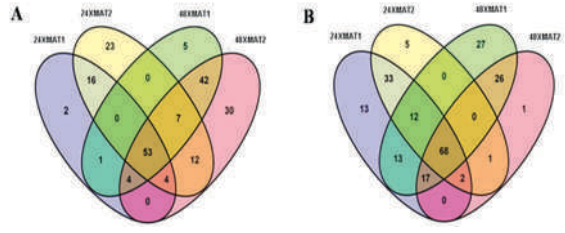


Fig. 99 Venn diagram showing the up-regulated (A) and down-regulated (B) DAPs identified in iTRAQ results. The numbers indicate the DAPs in 24 hpc and 48 hpc while comparing with MAT-1 and MAT-2.

However, due to the absence of full-length proteins and complexity in *Saccharum* specific amino acid database, the percentage of secreted proteins from the host of both samples could not be identified/distinguished. The differentially abundant proteins detected in this comparative analysis are being analyzed further by means of a protein-protein interaction network, using STRING data. For this purpose, appropriate time intervals for sampling were identified for different developmental stages in *planta* which includes 2 dpi (infection peg and primary hyphae formation), 5 dpi (intercellular colonization) and 60 dpi (sporogenesis and teliospore formation at meristem), besides others, through critical histopathological analysis using light and electron microscopy. Accordingly, samples were collected at different time points *viz.*, 2 dpi, 5 dpi and 60 dpi samples from both compatible and incompatible interactions in triplicates. RNA extraction from the collected samples is also under progress for further transcriptomic analysis.

Comparative expression analysis of potential pathogenicity-associated genes of high- and low-virulent *Sporisorium scitamineum* isolates during interaction with sugarcane

The expression of few significant and differentially expressed protein candidates were transcriptionally validated at different developmental stages of compatible and incompatible interactions. Temporal transcriptomic expression of potential pathogenicity-associated genes of two distinctly virulent *S. scitamineum* pathotypes, *viz.*, SsV89101 (low virulent) and Ss97009 (high virulent) were analyzed during interaction with a smut susceptible sugarcane cv. Co 97009 at six different time intervals. The pathogenicity-associated genes profiled in this study comprise of 14 plant cell wall degrading enzymes (PCWDEs) and 10 candidate secreted effector protein-coding (CSEPs) genes. Absolute quantification of pathogen biomass and comparative expression profiling analyses of these pathogenicity-associated genes during host-pathogen interaction indicated that there was a significant variation between low and high virulent isolates (Fig. 100).

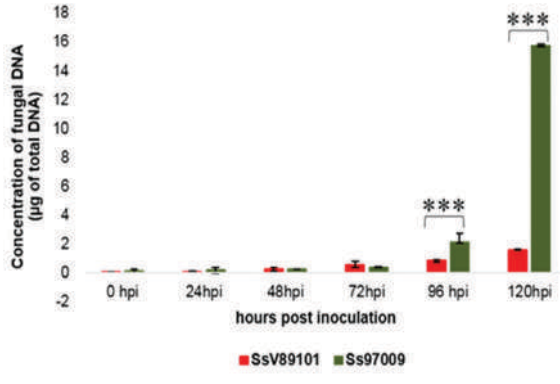


Fig. 100.* Sporisorium scitamineum *biomass quantification assay - Biomass quantitation of low (SsV89101) and high virulent (Ss97009)* S. scitamineum *isolates in the susceptible cultivar (Co 97009) at different time points. Values indicate the mean concentration of pathogen DNA in µg of total DNA of six replicates. Error bar represent standard error of the mean. Statistical significance level P value ≤ 0.01 (***) using t-test

More precisely, the higher and early expression of certain PCWDEs, *viz.*, Laccase and Chitinase, and the CSEPs, *viz.*, SUC2, SRT1 and CMU1 during the colonization of high virulent isolate suggested that they might possibly play a major role in facilitating faster and successful pathogen ingress, and tissue colonization than the less-virulent isolate. The expression profiles of CSEPs coding genes analysed by quantitative reverse transcription PCR at distinct time points is depicted in Fig. 101. Dikaryotic mycelium grown in axenic cultures and used as control compared with low virulent isolate (SsV89101) and highly virulent isolate (Ss97009) inoculated in susceptible genotype (Co 97009).

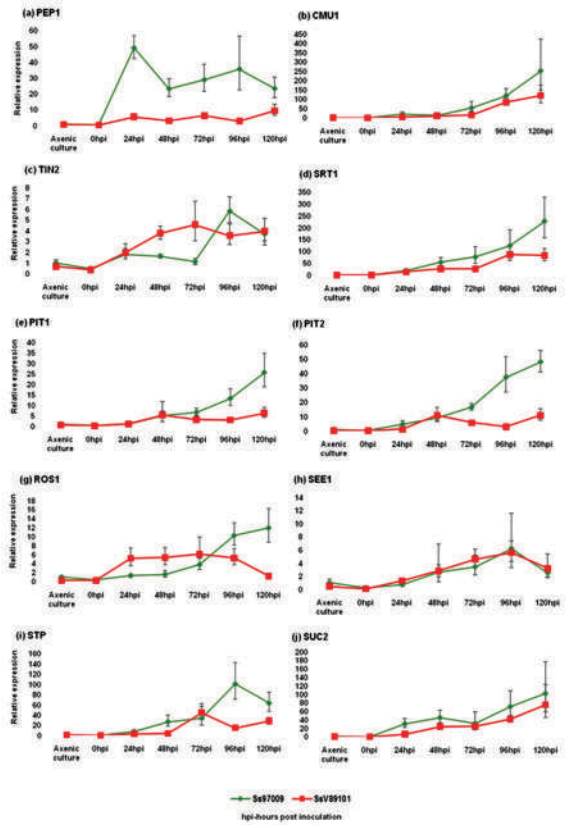


Fig. 101. Expression profiling of CSEPs coding genes - Expression profiles of Candidate Secretory Effector Proteins coding genes analysed by quantitative reverse transcription PCR at 0, 24, 48, 72, 96 and 120 hpi. Dikaryotic mycelium grown in axenic cultures and used as control compared with low virulent isolate (SsV89101) and highly virulent isolate (Ss97009) inoculated in susceptible genotype (Co 97009). Error bar represent standard error of the mean.PEP–Protein essential for penetration; CMU1–Chorismate mutase; TIN2–Tumour inducing gene; SRT1–Sucrose transporter; PIT1 and PIT2–Protein important for tumour; ROS1–Regulator of sporogenesis; SEE1–Seedling efficient effector; STP–Sugar transporter; SUC2–Secreted invertase

Comprehensively, this quantitative temporal expression analysis has provided critical insights into the early expression of pathogenicity-associated genes and their putative role in attributing more virulence. The obtained results would be useful to compare the candidate differentially expressed apoplastic proteins expressed during compatible interaction. The study provides valuable clues for the screening of candidate virulence determinants for further functional characterization of the test pathogen isolates used for evaluation of smut resistance in breeding clones.

(A. Ramesh Sundar, R. Viswanathan, G.S. Suresha)

Deciphering interacting partners of PAMPs/Effectors of *Colletotrichum falcatum* that trigger innate immunity in sugarcane

Transcriptional profiling of defense related genes in agroinfiltrated leaves of tobacco: The project envisages to understand the intricate mechanism of red rot resistance in sugarcane by dissecting the functional role of putatively identified pathogen associated molecular patterns (PAMPs)/ effectors of *Colletotrichum falcatum viz.,* EPL1 and PDIP1 that induce PAMP-triggered immunity (PTI)/Effector-triggered immunity (ETI), henceforth identifying its interacting partners (PRR/R/S genes) in sugarcane. In order to examine the defense inducibility of the candidate genes in agroinfiltrated leaves of tobacco, expression of defense related genes was monitored through quantitative real-time PCR. NtL23 was used as internal control. Transcriptome analysis clearly depicted the defense induction ability of these two proteins with the upregulation of SAR marker genes viz., PR-1 & PR-5, salicylate pathway genes PAL-1 & CHN-50, jasmonate pathway gene PR-4a, ETI- signalling pathway related genes PAD-4 & EDS-1, and few defense-related transcription factors of WRKY & MYB families (Fig 102). Transient expression of the candidate genes has also triggered H2O2 accumulation and hypersensitive response in tobacco.

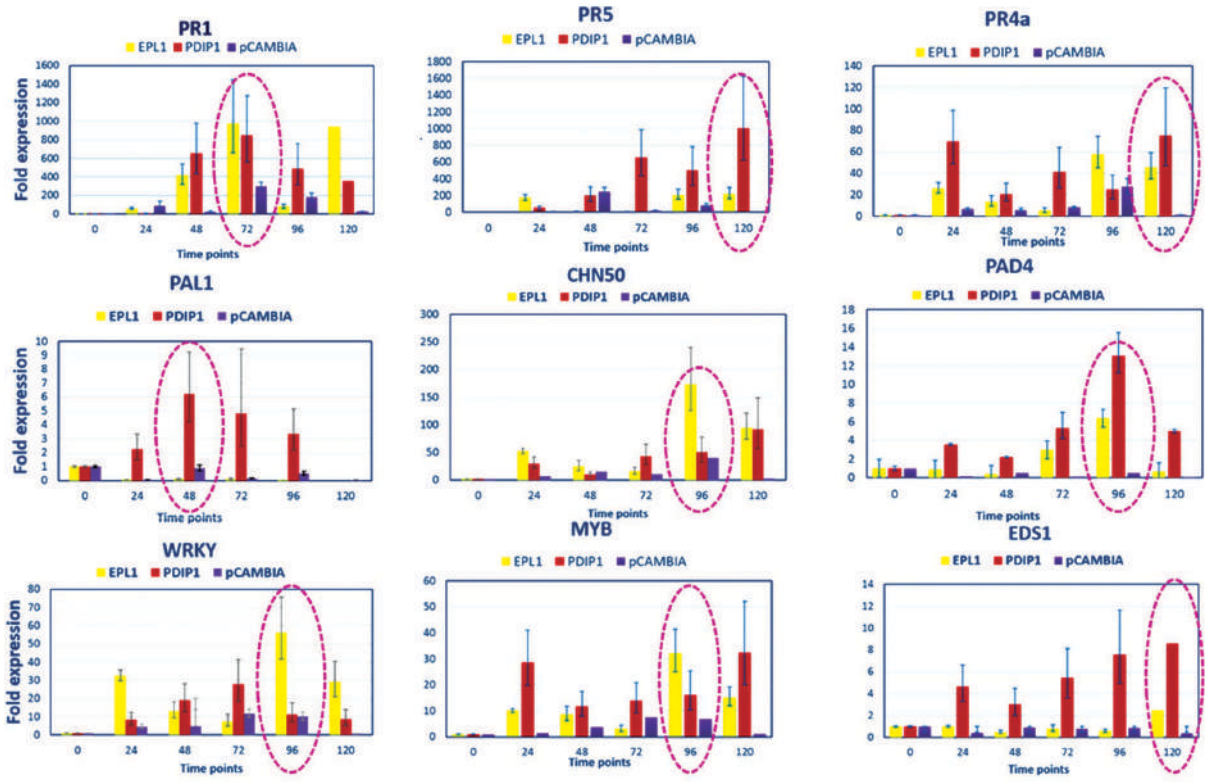


Fig. 102. Transcriptional profiling of defense-related genes in **N. tabacum** *leaves infiltrated with pCAMBIA1302 EPL1::GFP, pCAMBIA1302 PDIP1::GFP & pCAMBIA1302 (Empty vector). Leaves infiltrated with empty vector were used as control for relative quantification of gene expression. NtL23 was used as internal control*

Verification of inducibility, stringency and dosage dependence of novel DEX- inducible vector-pC-1302DEX: For ectopic expression of C*f*EPL1/ C*f*PDIP1 in sugarcane, dexamethasone inducibility and stringency of GVG cassette in the customized inducible vector, pC1302DEX vector was assessed by agroinfiltration in *N. tabacum* using agrobacteria harboring pC1302DEX vector. GFP fluorescence was observed only upon foliar spray of dexamethasone on agroinfiltrated leaves whereas no fluorescence was observed in leaves without DEX application (Fig. 103). Hence, it was inferred that the expression of transgene in pC1302DEX vector is regulated and induced only upon dexamethasone spray. Transcriptional profiling of GFP was also carried out in agroinfiltrated *N. tabacum* leaves upon induction with different concentrations of dexamethasone. The expression of GFP increased proportionately with increasing concentration of DEX and scored maximum with a potency of 5µM dexamethasone, which exhibited the dosage

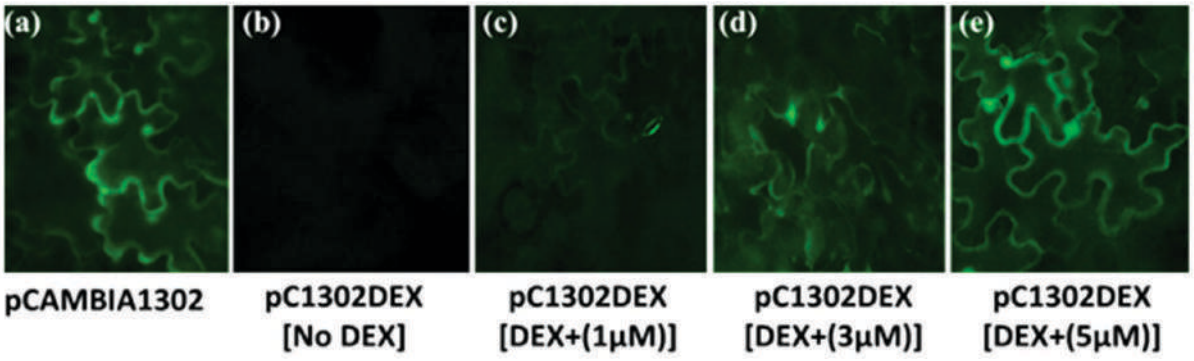


Fig. 103. GFP fluorescence in agroinfiltrated leaves upon 60 hpi using (a) pCAMBIA1302 vector (under CaMV 35S constitutive promoter); (b) pC1302DEX vector without dexamethasone spray; (c-e) pC-1302DEX vector with 1 µM , 3µM and 5µM dexamethasone spray respectively

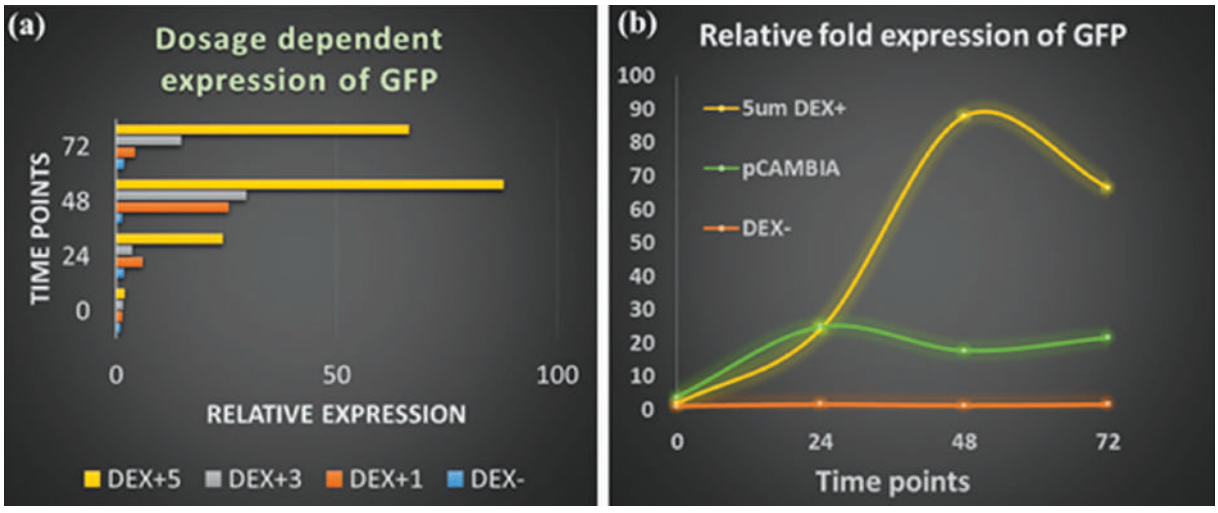


Fig. 104. Transcriptional profiling of GFP in agroinfiltrated N.tabacum leaves upon induction with different concentrations of dexamethasone: (a) Dosage dependent expression of GFP at different time points (0, 24, 48, 72 hrs) and different concentrations (1µM, 3µM, 5µM); (b) Relative fold expression of GFP with a potency of 5µM was exceptionally high, when compared to that of the constitutive promoter of pCAMBIA1302

dependence of the inducible system (Fig 104). Subsequently, *Agrobacterium* mediated transformation and particle bombardment of embryogenic calli of sugarcane was carried out for candidate gene constructs, pC1302DEX::EPL1 andpC1302DEX::PDIP1. Screening and selection of the transformants is under progress.6-8 month old transgenic lines will be induced using DEX-spray prior to pathogen challenge in order to study PTI/ETI (PAMP/Effector triggered immunity) mechanisms in sugarcane.

Development of EPL1 and PDIP1 mutants by protoplast mediated transformation of C. falcatum 671*:* Site directed mutagenesis of *C. falcatum* genes would delineate their role in fungal pathogenicity and loss or gain of virulence in sugarcane. In order to generate C*f*EPL1 fungal mutant, protoplast mediated transformation of *C. falcatum* 671 was carried out using the customized gene replacement vector, pUC19_mut_EPL1 vector. A total of 115 putative mutants were screened, out of which only 12 colonies were complete gene deletion mutants of EPL1. Growth and mitotic stability of transgene integration was examined in the 12 gene deletion mutants. Except for their slow growth and reduced sporulation ability under hygromycin selection, EPL1 mutants had no discernible morphological changes. Stable integration of hygromycin cassette and mitotic stability was confirmed by PCR upon repeated subculturing of mutants. Screening of the mutants for loss/ gain of pathogenicity by detached leaf bioassay and in field cane by plug inoculation method is in progress.

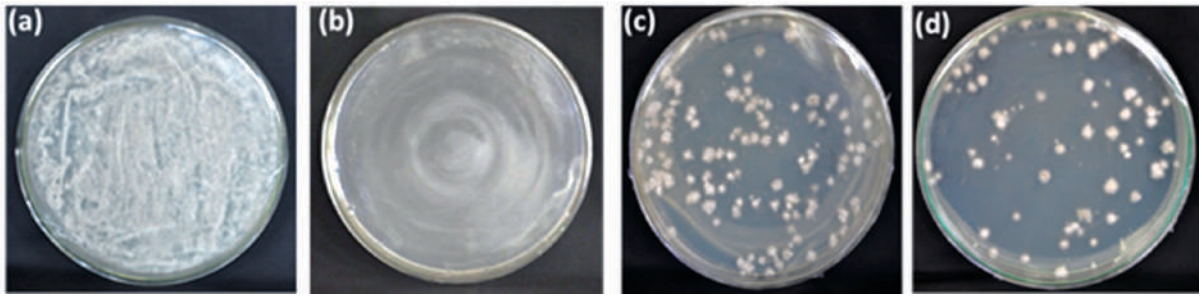


Fig. 105. Protoplast mediated transformation of* C. falcatum *using pUC19_mut_EPL1 vector and pUC19_mut_PDIP1 vector: The transformants were selected on Hygromycin-supplemented media (50µg/ml). (a & b) Transformation controls; (c) pUC19_mut_EPL1 transformation plate: (d) pUC19_mut_PDIP1 transformation plate

For development of CfPDIP1 fungal mutant, protoplast mediated transformation of *C. falcatum* 671 was carried out using pUC19_mut_PDIP1 vector (Fig. 105). Screening of 395 putative mutants for a homologous recombination event of gene with hygromycin cassette delineated the colonies to be partial gene deletion mutants, which in contrary cannot be used to study the loss/gain of function of a gene. Further experiments need to be conducted to generate complete gene deletion mutants to investigate its role in pathogenicity, pathogen virulence and its essentiality for growth and survival.

(A. Ramesh Sundar, R. Viswanathan, P. Malathi, C. Appunu, ICAR-SBI & Dr. Rajeev Sukumaran, NIIST, Trivandrum)

Development of sugarcane bacilliform virus (SCBV) based VIGS vector for functional genomics in sugarcane (DST-SERB)

SCBV genetic variability: In the SCBV genetic variability study, 57% of *Saccharum* hybrid varieties and 48% germplasm clones were observed to be PCR positive for SCBV with an amplicon size of 794bp. Contigs derived from the partial sequencing of RT/RNaseH region of all SCBV isolates showed 80-99% similarity with existing SCBV sequences in NCBI. All the contigs derived from the present study were submitted to NCBI-GenBank. Evolutionary analysis using the maximum likelihood method revealed the segregation of sequences into three major monophyletic groups where most of the isolates clustered in the third monophyletic group. Broadly, the phylogenetic tree classified the isolates into 25 genotypes; five genotypes from the study SCBV-U, V, W, X and Y and 20 genotypes reported from all over the world (SCBVA-T). Fifty-nine isolates from the study were grouped into a separate cluster forming a new genotype SCBV-U. Another 17 isolates formed a branch of SCBV-L genotype. The isolate CBJ 46 showing <88% similarity to the neighbouring N genotype SCBV-FJZZ3 from China, formed a distinct branch (SCBV-W) outside the 3rd monophyletic tree. Further, the isolate CBJ 46 is the only isolate that showed no similarity to any of the existing whole-genome sequences. Five genotypes that were already established in other sugarcane growing countries SCBV-G (France and China), SCBV-Q (China), SCBV-R (China), SCBV-S (China) and SCBV-T (China) were first time reported from India *viz.,* SCBV-G from *S. officinarum* Poona, SCBV-Q from CoC 24, *S. spontaneum* IND 81-157, IND 81-086; SCBV-R from *S. spontaneum* SES 954, IND 85-535, IND 81-003, IND 84-426; SCBV-S from *S. spontaneum* 07-1488, IND 85-512; SCBV-T from *S. spontaneum* IND 84-432 and *S. officinarum* Khajuria. SCBV-U, a novel genotype from the present study can be considered as the most frequently occurring genotype in India, especially in case of isolates from *Saccharum* hybrids and interspecific hybrids.

Recombination events in SCBV: RT/RNase H region of badnaviruses is considered as the species demarcation region with greater than 20% variability. Greater differences in nucleotides generally present in SCBV lead to the emergence of numerous genotypes, thus making recombination and genomic re assortment possible inside the genome. Exploring a dataset of 124 nucleotides with seven methods using RDP4 revealed the presence of inter-SCBV recombination. Out of 68 recombination events detected, a total of 9 events were found to be significant, where the p-value was 0.05. Fifty-eight isolates from the SCBV-U genotype showed trace evidences of recombination, suggested them as a recombinant genotype. The SCBV isolates CBJ 46, ISH 101 and SB Pathri from the current study with the proposed genotypes of SCBV-W, U and X, respectively were established as recombinants. SCBV-W variant CBJ46 became a recombinant with SS IND 81-003 (genotype R) as a major parent and PR 1062 (genotype U) as a minor parent. SS IND 81-003 is a recombinant isolate from SCBV-BRU (major parent) and CB622 (minor parent). SCBV-CHN2 (genotype G) with SS IND 81-157 (genotype Q) contributed to the evolution of SB Pathri isolate (genotype X). SS IND 81-003 (genotype R) and SCBV Thiruvalla (genotype M) with a significant p-value of $1.15x10^{-02}$ add to the recombinant ISH 101 (genotype U). Exchange of genetic fragments took place between the following isolates- SCBV GD-YT2361 (genotype R), CBSe 95436 (genotype L) and CBC 24 (genotype Q) to form SCBV-R, SCBV-L and SCBV-Q genotypes. From the analysis, SCBV-U

and SCBV-R genotypes played a key role as major or minor contributors of recombination events. The genetic material exchange must have happened through germplasm materials across provinces/ countries that led to new variants, which is evident from the recombination plot. Breakpoint distribution plot of 124 isolates with 603nt sequence established 250-550 (position in the alignment) as a probable hot spot inside the RT/RNase H region. Characterization of recombination events and gene assortment within these genotypes of SCBV will offer insight into the evolution of the species over the generation. The breakpoint distribution plot aided in, finding out the frequent variation sites within the RT/RNase H region of the genome.

Construction of pSCBV-VIGS vector: Whole genome amplification of SCBV-Baragua (~7.8kb) was achieved by following the RP-SP-RCA procedure. It was cloned into modified pUC19 vector (2.7kb) with *NCoI* restriction enzyme site and single release of the insert was confirmed by *Hae II* restriction enzyme digestion from the plasmids. Further, the SCBV-Baragua whole genome sequence was revealed by primer walking from Delhi University. The full genome of pUC19-SCBV (~9.5kb) was sub cloned into binary vector pCAMBIA 1302 (10.5kb) using ACC 651 and Sal I restriction enzymes and the insert was confirmed by restriction digestion of the plasmid and SCBV 750 RT-RNase H primers. The pSCBV-PDS-pCAMBIA 1302 was transformed into *A. tumefactions* strain LB 4404 by electropo-

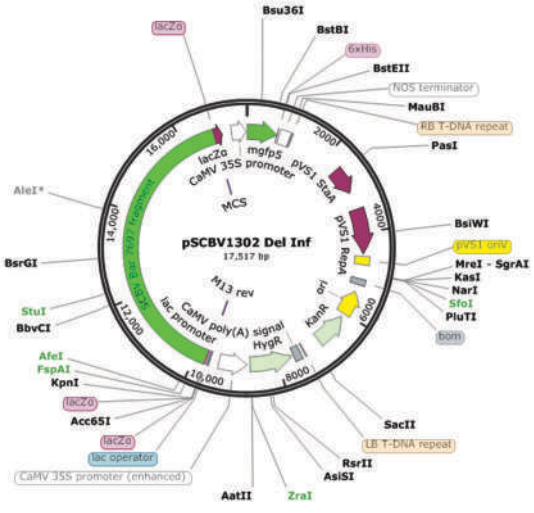


Fig. 106 a. Map of pSCBV 1302-Del-Inf construct

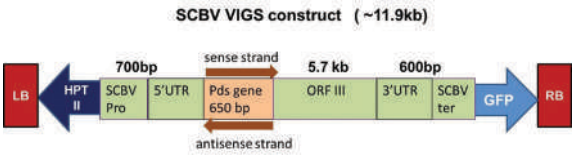


Fig. 106b. SCBV-VIGS construct

ration (2.5KV) (Electroporator, Eppendorf) and the obtained colonies were confirmed by RCA and restriction digestion of plasmids. VIGS construct was developed by deleting the ORF I and ORF II regions of pUC19-SCBV Baragua clone (~ 1200 bp) (pSCBV-Del-Inf) (Fig. 106a). The hairpin construct of PDS gene will be prepared and the silencing efficacy of pSCBV-PDS- pCAMBIA 1302 construct will be evaluated through agro infiltration into Nicotiana seedlings (Fig. 106b).

(R. Viswanathan, B. Parameswari, C. Appunu, and K. Nithya)

Biogenesis of nanomaterials from effective *Trichoderma* spp. for the management of red rot disease in sugarcane

Standardization on synthesis of nanoparticles: Extracellular and intracellular metabolites were prepared from the *Trichoderma* spp. after growing the culture in Molasses broth, Czapek's Dox broth, Complete medium, Oats broth, Potato Dextrose Broth. Extracellular metabolites obtained from culture broth and extracellular sterile water metabolites are used to prepare zinc oxide and chitosan/zinc oxide nanoparticles usingmicrowave mediated method and magnetic stirrer method with different concentration of Zinc nitrate as precursor. In the same way, synthesis of nano material from the Intracellular metabolites was also performed. Results showed that the extracellular metabolites found to be effective in the synthesis of nanoparticles when compared to intracellular metabolites. After comparing extracellular metabolites from media and water extracts, extracellular metabolites using Czapek's Dox broth has been selected. Among the methods tried for synthesis, magnetic stirrer method was found more effective.

Characterization of nanoparticles: The particles size was determined using Dynamic Light Scattering (DLS) device and Zeta potential. Then, their stability was assessed by measuring the mean droplet diameter and size distribution at 4-week

intervals. The strong and broad peak at 317 nm and 364 nm in UV-vis spectra, attributed to the surface plasmon resonance of ZnO nanoparticles. The chitosan-ZnO synthesized using extracellular metabolites of *T. harzianum* were found to be stable after 4 months also.

Screening of synthesized zinc oxide and chitosan/zinc oxide nanoparticles: The synthesized nanoparticles were screened against sugarcane red rot pathogen, *C. falcatum* isolates *viz.*, Cf94012 and Cf671 under in *vitro* condition by poisoned food technique. In particular, 2.5 mM zinc oxide and chitosan/zinc oxide nanoparticles effectively reduced the growth of red rot pathogen under in vitro conditions.

(P. Malathi, SBI as Mentor; V. Bhuvaneshwari, KASC as PI, TARE)

Virus indexing service

About 106 tissue culture raised plants from different tissue culture production units *viz.*, M/s EID Parry, Pugalur 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 20,400 was generated under virus indexing charges from the private tissue culture labs.

(R. Viswanathan)

Sugarcane quarantine

The clones CoLk 14201, CoLk 14204 (Lucknow), CoPb14185 (Gurdaspur), CoH 17261, CoH 17262 and CoH 19261 (Uchani) were handed over to NAG after quarantine. The clones LG 14436, LG 14450 and LG 14568 (Lucknow) were received for NHG and are in quarantine. The clones CoSe 11453 (Kushinagar), CoPb 14181, CoPb 18211, CoPb 18212, CoPb 18213, CoPb 18214 (Gurdaspur), MS 14082 (Padegaon), CoP 11438 (Pusa), CoS 14233 (Shahjahanpur), CoLk 15201, CoLk 15207, CoLk 15466 (Lucknow), CoPant 12221, CoPant 12226, CoPant 13224 (Pantnagar) and CoN 15071 (Navasari) were received for NAG and are in quarantine.

(R. Viswanathan)

5.3.2 ENTOMOLOGY

Studies on sugarcane pests and their management

Standardization of mass production of scarabaeid specific *Bacillus thuringiensis* using agro-industrial by products for white grub management

Evaluation of agro-based by-products for production of Bt-62: Six different agro-based by-products, namely jaggery, wheat bran, molasses, sago, groundnut cake, rice bran and castor cake were evaluated as media material. The bacterial population produced was considerably different among the treatments, the highest spore count being in wheat bran 3% followed by jaggery 3%. When these media were supplemented with five different ingredients namely defatted soybean, magnesium sulphate, sodium nitrate, calcium chloride and yeast extract in order to enhance the bacterial output, maximum spore production was observed in the medium containing yeast extract followed by calcium chloride.

Fermentor based mass production of Bt-62 strain: Bt 62 was mass produced in 1000 litres of standard media in large scale fermentor at M/s T. Stanes Company, Coimbatore, using 1% seed inoculum. The samples were collected at different intervals for assessment. At the end of 72 h, the media was found to contain 10^8 CFUs/ml.

Evaluation of cell protectants on the survival of liquid formulation of Bt-62: Liquid formulations of Bt cultured in fermentor were prepared using different preservatives and their shelf-life examined at different intervals by plating technique. Survival of these formulations varied significantly at different days after storage. Among all treatments, DMSO-0.5% produced higher bacterial output at 3 months storage. The observations are being continued.

Field evaluation of Bt 62 formulation against white grub in sugarcane

a. Curative application: Bt-62 culture multiplied on standard T3 media in fermentor was evaluated in white grub endemic Sathyamangalam area in a 200 sq m plot with 7-month old crop. Grub number was assessed in 10 random spots before imposing treatment. Bt-62 was applied at 4.0 x

10^{14} CFUs/ha as soil drench near the root zone. Another plot of the same size served as control. Post-treatment white grub incidence assessed 30 days later showed a significant 60.0% decrease in grub number in treated plot whereas it remained same in the control plot.

b. Prophylactic application: Bt-62 culture mass produced in fermentor (1000 lit), was evaluated in about 50 acres of white grub endemic Sathyamangalam area of M/s Bannari Amman Sugars, to examine the feasibility of using Bt 62 as a prophylactic measure. The product was applied as drenching, sett soaking, and through drip irrigation at the time of planting in 35 fields comprising 31 plant crops and 4 ratoon crops. Corresponding untreated controls were maintained for comparison for each trial. Post-treatment data were recorded in the first week August. Among the 35 experimental plots, nine plant crops and four ratoon crops were affected whereas 22 other treated fields showed no attack.

Prophylactic evaluation of Bt-62 against white grub in citrus: In an ongoing experiment, Bt-62 multiplied in fermentor was applied prophylactically against white grub in a grower's citrus farm in Anaikatty at 1.0 x 10^{11}, 1.0 x 10^{10} and 1.0 x 10^{9} CFU/tree. For each treatment, plots of 20 cents each with 5-year-old trees were demarcated. In each plot, soil around 25 trees was excavated for about 15 cm depth in the root zone and Bt-62 was applied at the base of tree. Trees treated with water are maintained as control.

(P. Mahesh, B. Singaravelu, J. Srikanth and K. Hari)

Isolation of novel Bt isolates from biodiversity hot spots and functional validation of indigenous crystal toxin genes against sugarcane insect pests

Soil samples were collected from Western ghats of Karnataka, Tamil Nadu (Valparai) and Kerala (Mallakapara forest). From 404 soil samples, 31 Bt isolates were identified (Fig. 107). PCR Screening revealed *cry1* and *cry 8* genes in some of the isolates. Two hundred and fifty nine and 197 soil samples have been collected from Tripura and Odissa forest area, respectively with the help of forest department personnel for isolation of Bts. For functional characterization of Bt isolate SBI-KK 27 which has seven toxin genes, initiated and successfully cloned two novel *cry1* genes *viz., cry1D* and *cry1E* for expression in acrystalliferous Bt HD73- isolate. Spore crystal mixture from these recombinant Bt isolate was tested against first instar internode borer, fall army worm and second instar cotton pink boll worm. Initial bioassay results suggested for the both gene were less active than the parent isolate SBI-KK27 for Internode borer and fall army worm.

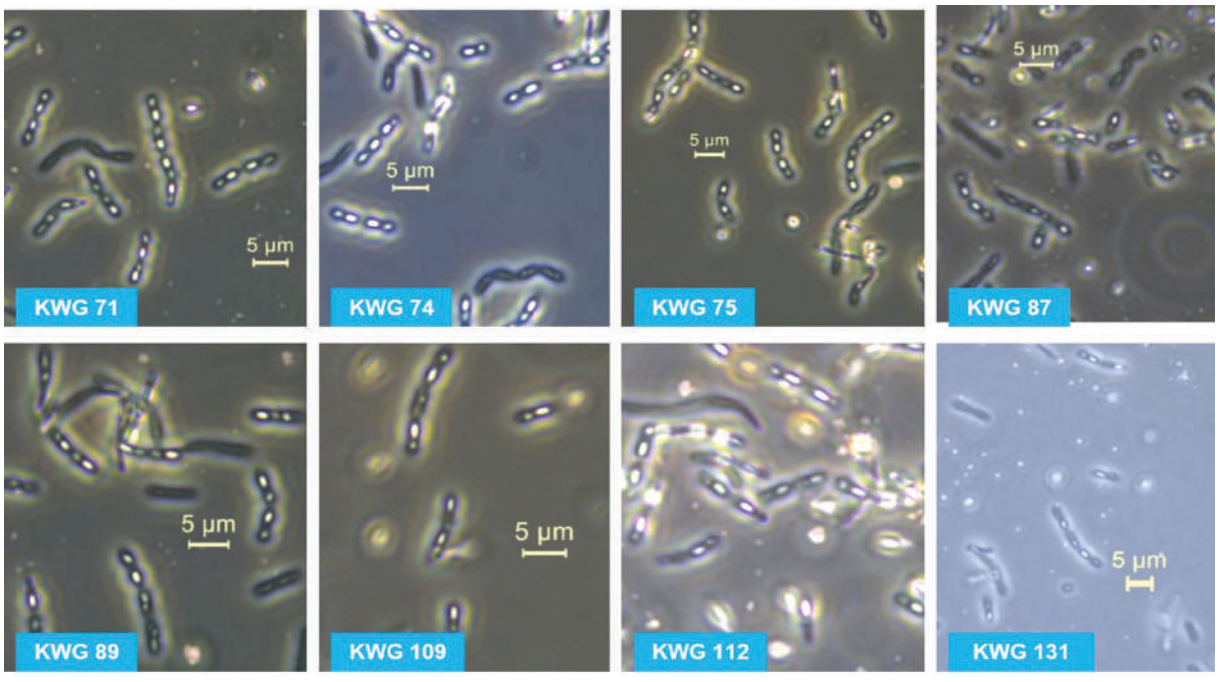


Fig. 107. Bt isolates from soils of Western ghats in Karnataka

The experiment has to be further corroborated with diet incorporation method as at present observations were based on diet surface contamination experiment. The *Cry1D* was observed to have growth and developmental retardation of 90% for pink boll worm resistant to Bollgaurd II cotton. Further confirmation with diet incorporation method is needed.

Bioassay of Bt 721 and Bt 723 possessing *cry3* genes against 1st instar white grubs revealed that it is not toxic as *cry8* gene found in Bt62 isolate. *cry8* genes *cry8Ea, cry8Ga, cry8Ha* and a *cry8* like obtained from Dr. Jie Zhang, from State Key Laboratory for Biology of Plant Diseases and Insect Pests, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Bejing China under MTA was bioassayed against 1st instar *H. serrata.* It was found that *cry8Ha* alone was active like Bt 62 against the 1st instar white grub.

(B. Singaravelu, C. Appunu, G.S. Suresha, C. Sankaranaryanan, K. Deva Kumar and P. Mahesh)

Screening for novel genes in the transcriptomes of cane Crambids for RNAi-mediated control

De novo transcriptome sequencing of internode borer and early shoot borer has been completed. The total number of transcripts assembled for the INB were 258457. Functional annotation analysis revealed that a total of 98027 transcripts were mapped with UniProt database and all the transcripts had the e-value of 0 - e^{-150}, indicating a good match. Further, around 15000 transcripts were observed to be matched with the lepidopteran pest *Heliothis virescens* followed by around 8000 transcripts with *Bombyx mori.* The gene ontology-based annotation revealed the number of transcripts associated with important molecular functions in insects *viz.,* chitinase activity (26), chitin synthase activity (23), ecdyson activity (1), PTTH activity (1) and voltage-gated sodium channel activity (23). Differential expression analysis of transcripts showed the up-regulation of important transcripts *viz.,* chitinases, P450 enzymes and glutathione-s-transferases in the advanced instars of INB. The juvenile harmone suppressible protein was observed to be up-regulated only in the sixth instar. *De novo* transcriptome sequencing of ESB has also been completed and the clean reads were in the range of 35.8 – 55.4 million. The clean reads were observed to be good as the PHRED score was more than 30% (Q30%) in 93% of the reads. The number of transcripts were in the range of 66002 – 87381 across the six instars involved in the study. It was observed that around 27% of the transcripts were annotated with NR database of NCBI followed by around 19% in the Swissprot database. In the KEGG pathway, the number of transcripts associated with cholinergic and GABAergic synapses were 76 and 53, respectively for the sixth instar as against 47 and 30 for the first instar. The FPKM values revealed that around 75% of the transcripts expressed at low level, 15-20% of the transcripts expressed at moderate level and another 5-10% of the transcripts expressed at high level (FPKM value of more than 15).

(T. Ramasubramanian, S. Mohankumar (TNAU) and P.T. Prathima)

Prospects for conjunctive use of *Telenomus dignus* and *Cotesia flavipes* against internode borer

Improvisation of INB culture: Improvements were made in INB culture to enhance egg production. Different oviposition containers such as wooden and glass cages, and plastic boxes of different sizes were used. Depending on the size of the container, moths were released in suitable numbers of equal male: female ratio provisioning with leaf bits as substratum. Fecundity recorded every day until the death of moths. Preliminary observations indicated that small plastic boxes yielded higher number of eggs per female moth.

Laboratory tests with field-release station: The field-release station standardized for the larval parasitoid *Cotesia flavipes* has been tested in preliminary laboratory tests for egress of the egg parasitoid *Telenomus dignus.* Parasitized egg masses of INB with at least 20 eggs at ready-to-emerge stage were placed in a station which was then covered with a thin polyethylene bag punched with holes. The station was examined 24 h later for parasitoid emergence and collection in the polyethylene bag. Nine tests indicated 25.0-94.7% egress of parasitoids on the basis of number of emergence holes with more than 50.0% emergence in four tests.

Field evaluation of Telenomus dignus: In an augmentative field trial, *T. dignus* was released at 5000 parasitoids per ha over a two-week period in a 6-month old grower's farm (cv. Co 62175) after recording pre-release incidence and intensity of internode borer. Post-release INB counts were made at 60 and 90 days after release. INB incidence and intensity, which were higher in release plot, showed a decline over the two observations. On the other hand, INB incidence in control plot increased over the 90-day period.

INB sentinel eggs to trap Telenomus: In order to use INB eggs as sentinel eggs to trap *Telenomus dignus,* field tests were continued. Leaf bits bearing fresh egg masses of INB obtained from laboratory cultures were kept in grown-up crop of sugarcane, collected 24 h later and maintained in the laboratory. In two such field tests with 10-12 egg-bearing leaf bits, parasitoid emerged from a few egg masses with low adult emergence. Some egg masses could not be recovered apparently due to predation in the field.

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

Formulation and field application of *Metarhizium anisopliae* (Metchnikoff) Sorokin (1883) as a mycoinsecticide

Field trial: The pre-treatment count ranged from 6.33 to 7 per m row while the post treatment count ranged from 0.25 grub/m (plots applied with *M. anisopliae*+ *B. brongniartii* and /or Lesenta) to 3.25 grubs in untreated plots. Post treatment, the grub population was lower in all treatment plots. The % reduction in the treatments ranged from 69.23 *(B. brongniartii)* to 92.30 (*M. anisopliae*+*B. brongniartii* as well as Lesenta) while it was 69.23 in plots treated with *B. brongniartii.* Recovery of *B. brongniartii* and *M. anisopliae* could be made from the soil samples retrieved. A new trial with *M. anisopliae* (SBIMa-16) and Lesenta at the time of planting as sett application is under progress.

Mass production for formulation and field application: A new jaggery based media (ICAR-SBI liquid medium) was developed and found to be economic and extremely suitable for production of several EPF of sugarcane ecosystem, specifically *M. anisopliae* being on par or better than standard broths. In the experiments to compare newly developed jaggery based liquid media namely ICAR-SBI 5, 10 and 15%, it could be observed that the spore yield was 11.8, 23.2 and 14 x 10^7/ml, respectively while it was 10.4 and 14.8 x 10^7/ml in the standards YpSs and SD broth, respectively. Among the liquid media developed SBI-5% has been standardized and the effect of the quality of jaggery (main ingredient) sourced from 36 outlets have been found to be significant in the mass production output of *M. anisopliae.*

Mass production of SBIMa-16 on grain media: An increased spore yield of SBIMA-16(10 fold) could be achieved on grains through solid fermentation in comparison to grain extracts (liquid fermentation), though there were slight changes in virulence.

Whole grains: In continuation with the last year's studies on mass production of EPF in grain extracts for liquid fermentation, mass production of *M. anisopliae* (SBIMA-16) through solid fermentation was achieved on different grains. Among the sources, the spore production ranged between 0.7 (Finger millet) to 2.03 (wheat) X10^9/g and the % spore germination ranged from 60 (Finger millet) - 82.6 (Rice). The virulence of the spores was found to vary between 63.33 (Finger millet) to 96.67 (oats) on the laboratory host, *G. mellonella.*

When sugarcane trash was used as an additive with the grains to improve the texture and avoid caking, similar pattern of spore production was observed. The lowest sporulation rates were obtained in Finger millet mixed with trash (0.73x 109/g) and the highest sporulation rates were observed in both wheat and sorghum grains mixed with trash (0.97 and 0.99x 10^9 /g respectively). The spore germination ranged between 59.33 (Finger millet + trash) to 71.33% (Wheat/ Rice + trash). Virulence ranged between 66.67 (Oats + trash) to 100 %(rice + trash) on *G. mellonella.*

Addition of protein supplements and salts as pre-mixture to the grains, in general improved the spore production but did not influence the high spore producers such as rice and wheat but provided a significant boost to finger millet and Oats which showed better spore production of 1.39 and 2.34 x 10^9/g which was either on par or

better than the rice and wheat media. The virulence ranged between 63.33 (Finger millet) to 90 % (rice). The spore germination ranged between 63 (Finger millet + supplements)-76 % (Rice + supplements).

Broken grains: Spore production on broken grains resulted in differential performance ranging from 0.69 (finger millet) to 1.73 x 10^9/g (pearl millet) with only the latter (Pearl millet) showing dramatic improvement over whole grain of the same species. Germination rates ranged between 57.67 (finger millet broken) to 73.67 (oats broken). Virulence ranged between 63.33 (finger millet broken) to 93.33%(oats broken) on *G. mellonella.* When trash was added to broken grains, the production of spores ranged between0.84 (rice broken) to 8 x 10^9/g (wheat broken +trash). Germination of the spores ranged between 59.67 (Finger millet broken + trash) to 71.33% (oats broken + trash). The virulence ranged from 66.67 (rice broken + trash) to 90 % (in oats broken + trash) on *G. mellonella.*

Protein supplements to the broken grains mixed with trash produced 1.021 x 10^2 (Maize broken + supplement + trash) to 8.93 x 10^9/g (wheat + supplement + trash). Germination rates were 56.67 (maize broken + trash + supplement) to 71 % (oats broken + trash + supplement). Virulence due to *M. anisopliae* was the highest when produced on wheat and pearl millet (96.67%) compared to 73.33 % (finger millet broken + supplement + trash) on *G. mellonella.*

Pilot scale fermenter system: In a fermentor (assembled) system of 20 l capacity, production of *M. anisopliae* (SBIMA-16) could be achieved with saving in time and high sporulation rates (10^8/ml) on ICAR-SBI-5% liquid medium.

(N. Geetha, K.P. Salin and T. Ramasubramanian)

Early detection of mechanism of resistance operating in sugarcane intergeneric hybrids against shoot borer, *Chilo infuscatellus* (Snellen) and internode borer, *Chilo sacchariphagus indicus* (Kapur) (Lepidoptera: Crambidae)

Observation of internode borer incidence on the Erianthus arundinaceus *derived intergeneric sugarcane hybrids:* Eighteen *E. arundinaceus* derived intergeneric sugarcane hybrids were screened under field conditions to study their relative degree of resistance against *Chilo sacchariphagus indigus* and the incidence ranged between 0 and 70%. Among the entries, nine, six and two genotypes were graded as least susceptible, moderately susceptible and susceptible category, respectively. Three IGHs clones recorded absolutely nil internode borer incidence *viz.,* CYM 06-212, CYM 09-167 and CYM 07-981. The IGHs clones, CYM 09-565, CYM 08-922, CYM 07-678 and CYM 07-678 recorded 10 to 20% incidence. Similarly, INB intensity of attack was minimum in the clones, CYM 09-565 (0.39%) and CYM 04-388 (0.73%), whereas maximum intensity of attack was observed in the clones CYM 09-1369 (3.71%), CYM 07-649 (4.65%) and CYM 09-521 (10.81%).

Internode borer incidence on the progenies of E. arundinaceus *with* Saccharum*:* A total of 22 progenies of *E. arundinaceus* including 5 selfing, 2 BC_1 and 15 BC_2 along with a cultivated variety CoC 671 were evaluated for their resistance against sugarcane internode borer (INB). Among the entries, selfed and BC_1 progenies of *E. arundinaceus* were free from INB attack. Similarly, INB incidence on the BC_2 progenies of *E. arundinaceus* ranged between 0.00 and 80% and the borer intensity varied from 0.00 to 4.35%. Among BC_2 progenies, 14, 3 and 1 were graded as least susceptible (LS), moderately susceptible (MS) and highly susceptible (HS), respectively.

Internode borer incidence on the progenies of E. procerus with Saccharum: Thirty-nine *E. procerus* progenies comprising selfed (2), BC_1 (31) and BC_2 (6) were screened to study their degree of resistance against internode borer (INB) and the incidence varied from 0.00 to 50% and 10 to 50% in BC_1 and BC_2 progenies of *E. procerus,* respectively. In the BC_1 entries, 23, 5 and 1 were graded as least susceptible (LS), moderately susceptible (MS) and highly susceptible (HS), respectively. Among BC_1 progenies, Gu 12-15, Gu 12-20, Gu 12-21, Gu 12-22, Gu 12-26, Gu 12-29, Gu 12-31 and Gu 12-34 were free from INB attack. However, INB incidence was considerably higher in BC_2 progenies of *E. procerus* than BC_1 progenies. In the BC_2 progenies, only one entry, GU 15-4 was least susceptible to INB. With respect to the borer intensity, it was significantly higher in BC_2 progenies (2.08%) as compared BC_1 progenies (0.72%).

Comparative observation of internode borer incidence on the progenies of E. arundinaceus *and* E. procerus*:* Internode borer incidence and intensity was compared among three groups of intergeneric hybrids (IGHs) *viz., E. arundinaceus* (BC_1 and BC_2), *E. procerus* (BC_1 and BC_2) and CYM genotypes. In the three groups, INB incidence and intensity was higher in the order of *E. procerus* (BC_2) > CYM genotypes >*E. arundinaceus* (BC_1) >*E. procerus* (BC_1) progenies. However, INB infestation was absolutely nil in the selfed and BC_1 progenies derived from *E. arundinaceus*.

Profiling of silicon in the feeding sites of tissue borers in sugarcane and E. arundinaceus*:* Silicon was estimated from the different plant parts of popular sugarcane varieties (Co 86032, Co 06030, Co 06022, Co 0212, Co 11015, Co 09004 and Co 0238) and *E. arundinaceus* (IJ 76 370 and IJ 76 166) *viz.,* leaf, leaf sheath, midrib and rind which are preferential feeding sites of the tissue borers in sugarcane. Silicon content was higher among the plant parts in the order of leaf > leaf sheath > midrib> rind invariably in all the selected genotypes. In the popular varieties, the silicon content was ranged from 24.6 to 50 mg/g of leaf, 21.38 to 40 mg/g of leaf sheath, 9.56 to 21.37 mg/g of midrib and 11.36 to 16.96 mg/g of rind, respectively. However, it was significantly higher in the leaf (68 mg/g), leaf sheath (50 mg/g), midrib (35 mg/g) and rind (19 mg/g) of the selected *E. arundinaceus.* The silicon content was significantly higher in the genotypes, Co 06030, Co 0212, Co 06022 and Co 86032 with 40 mg/g leaf, 15 mg/g rind 19 mg/g midrib, respectively as compared to other popular varieties. Silica content in the different feeding sites of borers was considerably higher in the *E. arundinaceus* genotypes, IJ 76 370 and IJ 76 166 as compared popular sugarcane varieties and these elite groups could be used as genetic stocks for the future breeding programme for insect resistance in sugarcane.

(M. Punithavalli, K.P. Salin and K. Mohanraj)

Evaluation of entomopathogenic fungi against white grub, *Holotrichhia serrata* and whitefly, *Aleurolobus barodensis* infesting sugarcane

In the product evaluation (contractual research), a field trial at Sathyamangalam under the aegis of Bannari Amman Sugars, *M. anisopliae* and *B. bassiana* of VSI, Pune were evaluated against white grub. The pre-treatment population of white grubs *(H. serrata)* in the experimental plots varied from 6.5 -7.3 per m row and the post-treatment count showed a population of 0.75 (Lesenta) to 2.25 *(M. anisopliae)* in the treatment plots while it was 3 grubs per m on untreated plots. The per cent reduction of grubs ranged from 25 *(M. anisopliae)* to 45.83 % *(M. ansiopliae* + *B. bassiana)* over the untreated plots. The population of whitefly was high during a pilot survey but due to COVID-19 incidence, the trial could not be taken up. Later on the population was too low to take up the trial. Currently a new trial is laid at Sathyamangalam.

(N. Geetha and K. P. Salin)

5.3.3 NEMATOLOGY

Basic and applied studies of sugarcane phytonematodes and entomopathogenic nematodes

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

Vertical movement of EPN in soil and its efficacy against white grub: Two experiments were conducted to study the vertical movement of EPN in soil and its efficacy against 2nd instar white grub. In first experiment, eight EPN *viz., Steinernema glaseri* (SBILN1), *S. siamkayai* (SBITNT1), *S. abbasi* (SBIUP81). *S. thermophilum* (SBIH1), *S. carpocapsae* (SBIP2), *S. surkhentense* (SBIP3), *Heterorhabditis indica* (SBITND78) and *H. bacteriophora* (SBITNLN2) were tested under laboratory condition with five dosages *viz,* 500, 1000, 1500, 2000, 2500 IJs/grub in plastic vials (10 cm height with diameter 2.5 cm). All the EPNs caused mortality of the grubs and *S. glaseri* (SBILN1) recorded quicker mortality of the grubs. The mortality of the grubs ranged between 40 and 100%.

In another experiment, different dosages of (500, 1000, 1500, 2000, 2500 IJs/grub) *S. glaseri* (SBILN1) was tested against 2nd instar white grub at different soil depth (PVC pipe at the various height of 5, 10, 15, 20, 25, 30 cm and diameter 3.6 cm) under laboratory condition. It was observed that all the dosages caused mortality of white grub up to 25 cm and it ranged between 0 and 100%. There was no mortality of the grubs in 30 cm soil depth.

Monoxenic and liquid culturing of EPN: Liquid culturing of ten EPN isolates (four *Steinernema spp.; S. surkhentense* SBIP3, *S. abbasi* SBIUP81, *S. siamkayai* SBITNT1, *S. glaseri* SBILN1 and *six Heterorhabditis* spp., two *H. indica* isolates; SBITND78, SBIBNR, Four *H. bacteriophora* isolates; SBILN8, SBITNV46, SBITNTH3, SBILN2) were attempted by Monoxenic culturing method. Monoxenic culturing of *Heterorhabditis* spp. was done on petriplates. Successful nematode mass production of *Steinernema* spp. was observed in the liquid media.

ICAR-SBI EPN *biopesticide formulation:* Three novel ICAR-SBI EPN formulations containing *Heterorhabditis bacteriophora* strain SBILN8, *Steinernema siamkayai* strain SBITNT1 and *Steinernema surkhetense* strain SBIP3 were developed with long shelf life with viable infective nematode juveniles (IJs). The formulation containing *Heterorhabditis bacteriophora* strain SBILN8 has a shelf life of ten months; *Steinernema siamkayai* strain SBITNT1 has a shelf life of 12 months and *Steinernema surkhetense* strain SBIP3 has a shelf life of 12 months.

Commercialization of ICAR-SBI EPN Biopesticide Formulation: ICAR-SBI EPN Biopesticide formulation technology has been commercialized to five companies (Coordinated by Agrinnovate India, New Delhi) with a license fee of Rs. 10 lakhs.

Maintenance of EPN & symbiotic bacterial cultures: Seventy-eight EPN strains belongs to tropical (49) and subtropical (29) are being maintained in the culture collection & 45 symbiotic bacteria belongs to *Photorhabdus* spp. (26 Nos.) and *Xenorhabdus* spp. (19 Nos.) are also being regularly sub cultured and stored in glycerine.

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

Establishment of native entomopathogenic nematodes as potential bio-pesticide to tackle the exotic invasive pest fall armyworm menace (DST-SERB-TARE)

Survey, isolation of EPN from fall army worm Spodoptera frugiperda infested fields of sugarcane and maize: Survey was conducted in fall army worm (FAW) infested fields of maize and sugarcane from different districts of Tamil Nadu and fourteen numbers of EPNs naturally occurring in maize fields were isolated. Based on the Sequence analysis of the 18s rDNA and morphological examination, the isolates 1 and 13 were identified as *Heterorhabditis bacteriophora;* isolates, 2, 4, 5, 6, 9 and 10 were identified as *Steinernema siamkayai;* isolates, 3, 7, 8, 11 and 12 were *Heterorhabditis indica;* isolate 14 was *Heterorhabditis sp.*

NCBI GenBank submission of ITS sequences of EPN: ITS sequences of 13 EPNs (*Heterorhabditis* and *Steinernema* spp.) isolated from fall army worm (FAW) infested fields have been submitted to GenBank with accession numbers from MZ507532 to MZ507544.

Standardization of EPN bio-assay method against FAW Spodoptera frugiperda: Different bioassay methods were tested to standardise a suitable bioassay method for testing EPN *Steinernema siamkayai* against FAW 3rd instar larva. It was observed that, the mortality of FAW ranged from 33.3 to 100% and differed significantly among treatments. Leaf bit with IJ inoculation (Diet 24 h later) bio-assay method recorded 100% mortality of 3rd instar FAW larva at 48 h incubation and would be suitable bioassay method in vitro evaluation of EPNs against FAW.

Dose response assay to evaluate the native EPN against 2nd and 3rd instar of FAW Spodoptera frugiperda: FAW *S. frugiperda,* 2nd and 3rd instar larvae were exposed to IJs of *Steinernema siamkayai, S. glaseri, H. indica, H. bacteriophora.* Results of the *in vitro* bio-assays revealed that 100% mortality of 2nd instar FAW was observed in 10 IJs of *H. indica* at 36 h, 10 IJs of *S. siamkayai* at 72 h, 40 IJs of *S. glaseri* at 36 h and 40 IJs of *H. bacteriophora* at 48 h. LC_{50} of tested EPN ranged from 1.47 to 7.01 IJ/larva. The LC_{50} was lowest for *H. indica* (1.47) followed by *S. siamkayai* (2.81). Hence, the *H. indica* and *S. siamkayai* are considered as more virulent against 2nd instars of FAW larvae.

Results of the *in vitro* bio-assays revealed that 100% mortality of 3rd instar FAW was observed in 6 IJs of *H. indica* at 36 h, 40 IJs of *S. siamkayai* at 72 h, 40 IJs of *H. bacteriophora* at 48 h. The maximum mortality (87.5) of FAW observed for 35 IJs of *S. glaseri*. LC_{50} of tested EPNs ranged from 1.80 to 8.45 IJ/larva. The LC_{50} was lowest for *H. indica* (1.47) followed by *S. siamkayai* (6.09). Hence, the

H. indica and *S. siamkayai* are considered as more virulent against 3nd instars of FAW larvae.

Bio efficacy of EPNs against FAW in sugarcane in potted condition: Bio efficacy of three EPN (*H. indica, H. bacteriophora* and *S. siamkayai*) was tested against 2nd instar FAW under laboratory condition with sugarcane cv. Co 86032. EPN was sprayed on sugarcane leaves @ 5000 IJs /plant. It was revealed that, all EPN caused mortality of the FAW and it ranged between 40 and 50%.

Insecticidal activity of symbiotic bacteria Photorhabdus *and* Xenorhabdus *against 2nd instar to 6th instar FAW:* Insecticidal activity of cell culture and cell free culture of two *Photorhabdus* (strains-SBIPLTN46 and SBIPLLLN8) six *Xenorhabdus* (strains SBIXSP3, SBIXIUP81, SBIXSTNT1, SBIXIH1, SBIXP2, SBIXP1) was tested against 2nd to 6th instars of FAWin cell well plates. All the culture filtrates caused mortality of all the instars of FAW and it ranged between 20 and 100 per cent.

(C. Sankaranarayanan, N. Seenivasan (TNAU, CBE) and B. Singaravelu)

5.4 STATISTICS AND ECONOMICS SECTION

An economic analysis on sugar recovery in different states in India

Decade-wise sugar recovery improvement was estimated and it was seen that sugar recovery improvement was comparative in the major cane growing states of tropical India up to first decade of the 21st century. However, in the current decade, sugar recovery improvement is fluctuating in the tropical states due to drought, fluctuations in the rainfall and labour scarcity (Fig. 108). On the other hand, sub-tropical India has recorded significantly higher recovery

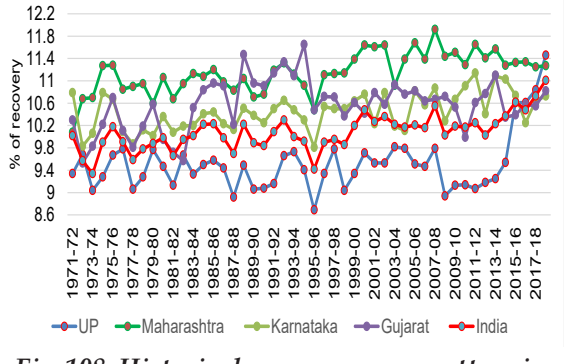


Fig. 108. Historical sugar recovery pattern in major sugar recovery states in the country

which has overweighed the reduction of sugar recovery in the hitherto medium and high sugar recovery states of India.

High sugar recovery in the sub-tropical states has led to overall sugar recovery improvement in the country despite instability. Recovery of sugar was analyzed since 2013-14 to know the impact of the variety Co 0238 in Uttar Pradesh (UP) (Fig. 109).

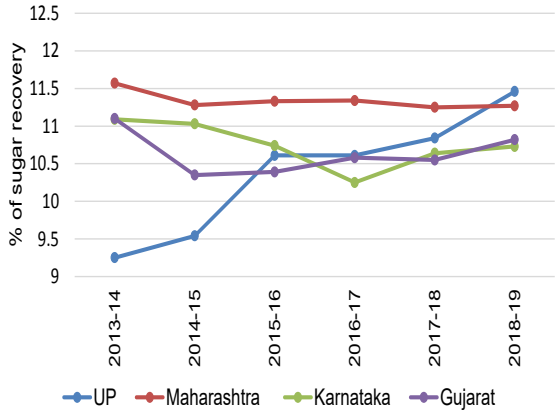


Fig. 109. Sugar recovery in Uttar Pradesh after introduction of Co 0238

Sugar recovery was just 9% during 2013-14 and has increased in correspondence with adoption of the new cane varieties in UP. Sugar recovery has crossed more than 11.5% in 2019-20 due to more than 80% of the cane area in the state has cultivation of Co 0238. Nonetheless, recovery of major leading states is fluctuating and marginally downward was estimated during this period. Significant sugar recovery improvement in UP has compensated the reduction in sugar recoveries of tropical states. Sugar recovery improvement of more than two units in UP was responsible for surplus sugar production in the country since 2017-18.

The changed recovery pattern has necessitated to reclassify the states and new sugar recovery category was delineated. Sugar recovery in correlation with adoption of improved varieties was analyzed. The study has documented historical sugar recovery pattern of different states, sugar recovery improvement, fluctuations and reductions in sugar recovery in different states and India were estimated.

(P. Murali, D. PuthiraPrathap, V. Venkatasubramanian)

Economic impact and climate smartness of variety Co 0238 in sub-tropical India

Variety Co 0238 has revived sugarcane cultivation in Uttar Pradesh, Bihar, Haryana, Punjab and Uttarakhand. Area of sugarcane cultivation was fluctuating and downward trend was observed in India since 2014-15 especially 2016-17. However, steady and increasing trend of cane area with cultivation of Co 0238 has greatly helped to revive and sustain the cane area cultivation. During 2019-20, 24.14 lakh ha out of 27.11 lakh ha in sub-tropical India was cultivated by Co 0238 undoubtedly establishing that Co 0238 occupies 52.4% of the total area in India.

Traditionally, yield in sub-tropical India is low compared to tropical states due to agro climatic factors. Cane yield was stagnant with 55-60 t/ha till the introduction of Co 0238 in North Western India. After introduction of this variety, the average yield substantially increased without adding any extra inputs. The average yield was 60.3 t/ha during 2013-14 in the sub-tropics which increased to 79.4 t/ha during 2019-20 only due to cultivation of the variety Co 0238 (Fig. 110).

Of late, sugarcane production system faces yield fluctuations due to climatic change. It was reported that the yield level of rest of the India was increasing up to 2013-14 and afterwards it was showing decreasing trend. From a cane yield level of 83.3 t/ha during 2013-14, it has decreased to 78.5 t/ha during 2018-19. However, it was well balanced by the variety Co 0238 in the sub-tropics. It not only improved the yield level of the sub-tropics but also improved the average yield of the country from 70.5 t/ha (2013-14) to about 80.5 t/ha during 2019-20. India could surpass the yield level of the world's largest producer of Brazil (74.5 t/ha) only because of the cultivation of the wonder variety with more than 50% of the cane area in the country.

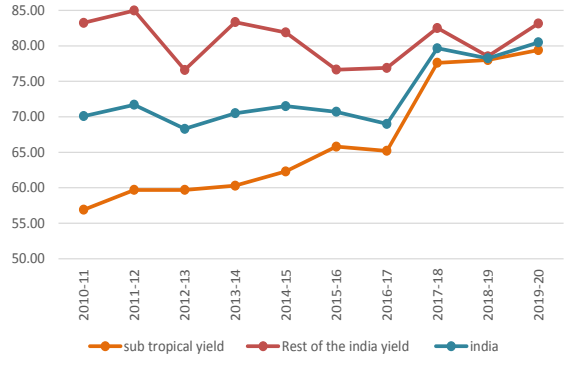


Fig. 110. Yield improvement by Co 0238 in sub tropics versus rest of the India

Research on sugarcane had substantially improved the yield and it was almost doubled since introduction of the first hybrid in the country. But, similar kind of improvement was not achieved in sugar recovery due to inverse relationship between yield and sugar recovery as well as improvement in sugar recovery needs favourable weather parameters during crop maturity. The sugar recovery is majorly shared by tropical states as depicted in Fig. 111.

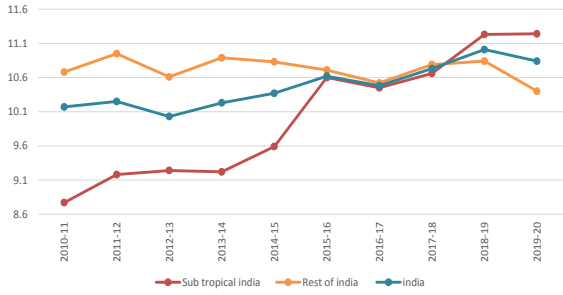


Fig. 111. Sugar recovery improvement through variety Co 0238

The sugar recovery was lower in the sub tropics due to unfavourable weather factors and cultivation of traditional varieties up to 2013-14. However, sugar recovery has attained vertical growth due to adoption of the variety Co 0238 with 11% in 2018-19. The average sugar recovery improved by 2.2 units i.e., from 9.21% during 2013-14 to 11.29% during 2018-19 in the five sub-tropical states was responsible for historical sugar recovery achievement in the country.

(P. Murali, V. Venkatasubramanian, D. Puthira Prathap, Ravinder Kumar)

Sugarcane based Agri-Business Incubator (ABI)

Sugrcane Edge, ICAR-SBI-ABI is continuously supporting technology commercialization and incubation activities. Currently, three incubates are actively developing new products as well as licensed technology commercialization. One of our incubate has successfully produced Cane-Jam in his farm on commercial scale and the product is sold under the brand name of 'DU-SUCRE' in the value chain marketing (Fig. 112).

Fig. 112. Commercial sale of Cane Jam in a farmer producer company at Erode

Similarly, another incubatee Mrs. Priyadarshini Krishnamurthy who produces and sell fresh organic sugarcane juice and jaggery products at Erode. The incubatee could sell about 100 litres of fresh cane juice during regular season in their outlet. In addition, they are operating mobile van to supply fresh sugarcane juice to other places and events with 1500–2000 litres of cane juice per occasion and earns profit. Though COVID-19 has slowed down expansion of their business, they are planning to have more juice outlets at different locations to optimize juice-based value chain marketing.

Sugarcane Edge has established pilot scale facility for dietary fiber-based food products such as bread, biscuits, cookies, cakes with life cycle study facilities for these products.

(P. Murali, V. Venkatasubramanian, K. Hari, A.J. Prabakaran, G. Suresha and D. Puthira Prathap)

5.5 EXTENSION SECTION

Transfer of Sugarcane Technologies

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

Sugarcane Research and Development workers' meetings

The 51st sugarcane R&D Workshop of Tamil Nadu and Puducherry was held during 26-27 February 2021 (Fig. 113). The workshop was hosted by Ponni Sugars (Erode) Ltd. About 200 delegates comprising scientists from ICAR-Sugarcane Breeding Institute, Coimbatore and Tamil Nadu Agricultural University, Cane Development personnel from various sugar factories, officers from the Department of Agriculture, Directorate of Sugar and other Cane Development organizations in Tamil Nadu & Puducherry participated in the workshop. The main topics discussed were ratoon management in sugarcane and enhancing the agronomic performance of Co 11015.

Fig. 113. Release of Compendium in R&D Workshop

Short term training programs

Organized a two-days training for 50 farmers from Nambiyur block, Erode district on 'Sustainable Sugarcane Initiative' during 29-30 July 2021 (Fig. 114).

Fig. 114. Two days training (29 - 30 July 2021)

One-day training programs

Conducted the following 13 one-day training programs (Fig. 115):

7 January 2021

21 January 2021

21 January 2021

4 February 2021

16 February 2021

18 February 2021

22 February 2021

26 February 2021

25 August 2021

29 September 2021

29 September 2021

Fig. 115. One-day training programs

- For 29 farmers and one staff from Sankagiri, Salem district on 06 January 2021.
- For 40 farmers and one staff from Bhavanisagar, Erode district on 07 January 2021.
- For 50 farmers and one staff from Madathukulam block, Tirupur district on 21 January 2021.
- For 40 farmers and two staff from Perambalur on 21 January 2021.
- For 40 farmers and one staff from Villupuram district on 21 January 2021.
- For 36 farmers and two staff from Krishnagiri on 04 February 2021.
- For 28 farmers and two staff from Papanasam block, Thanjavur district on 16 February 2021.
- For 24 farmers and two staff from Thanthoni block, Karur district on 16 February 2021.
- For 50 farmers and one staff from Kankayam block on 18 February 2021.
- For 24 farmers and two staff from Papanasam block, Thanjavur district on 21 February 2021.
- For 40 farmers and two staff from Thindivanam district on 26 February 2021.
- For 40 farmers and two staff from Chennimalai, Erode district on 25 August 2021.
- For 41 farmers and two staff from Tiruchirapalli on 29 September 2021.

Exposure visits

Conducted the following 14 exposure visits (Fig. 116):

22 July 2021

28 July 2021

31 July 2021

30 September 2021

27 October 2021

6 November 2021

27 November 2021

30 November 2021

1 December 2021

3 December 2021

13 December 2021

15 December 2021

Fig. 116. Exposure Visits

- For eight B.Sc. Agriculture students from Jagannath University, Jaipur on RAWE program on 30 April 2021.
- For 15 Board of Directors of The Malegaon Sahakari Sakhar Karkhana Ltd. Baramati on 22 July 2021.
- For 305 third year B.Sc. (Agriculture) students of University of Agricultural Sciences, Dharwad on 27 July 2021 (online).
- For five third year B.Sc. (Agriculture) students from Gandhigram Rural Institute on 28 July 2021.
- For 10 third year B.Sc. (Agriculture) students from Gandhigram Rural Institute on 31 July 2021.
- For 21 III B.Sc. (Agri) students of Karunya Institute of Technology, Coimbatore on 22 October 2021.
- For 11 Board of Directors, Meham Coop Sugar Mill on 6 November 2021.
- For 103 students and three staff from College of Agriculture, Hassan on 27 November 2021
- For 31 students and three staff from UAS, Bengaluru on 30 November 2021.
- For 32 students and three staff from UAS, Bengaluru on 01 December 2021.
- For 32 students and three staff from UAS, Bengaluru on 2 December 2021.
- For 32 and three staff from UAS, Bengaluru on 03 December 2021.

- For 40 DASEI students and one staff from ICAR-KVK, Chamrajnagar on 13 December 2021.
- For 40 DASEI students from MYRADA-KVK, Erode on 15 December 2021.

Demonstration on sugarcane technologies

- A demonstration on the variety Co 11015 was planted in Varapalayam village of Coimbatore district in February 2020 with the planting material provided from the Technology Park. The crop was grown under organic cultivation for jaggery making. Cane yield realized was 82.65 t/ha and obtained 10.20 t/ha organic jaggery. Demonstrations on Co 11015 ratoon and Co 0212 are being conducted in farmers field.
- Planted three demonstrations of Co 11015 in Kuttypalayam village, Bhavani block, Erode district.

Feedback on performance of sugarcane technologies

Survey based study with 60 sugarcane farmers from Villupuram, Tamil Nadu revealed that they had varied levels of adoption of sugarcane technologies. All the respondent farmers adopted new sugarcane varieties, thorough land preparation with cultivator, ridges and furrows making, basal application of organic manure and top dressing with nitrogen and potash fertilizers. Major constraints encountered in adoption were fear of taking risk while growing new sugarcane varieties soon after release, new varieties needed more inputs, increased rodent menace in trash mulching, occurrence of new pests and diseases and lack of labour to do ratoon management operations in time. In spite of these constraints, all the farmers favoured the continued adoption of advanced sugarcane technologies.

Study on 60 sugarcane farmers adopting drip irrigation from Kallakurichi, Tamil Nadu revealed that the water saving/ drought management measures apart from drip irrigation adopted included trash mulching, application of additional potash and alternate furrow irrigation. All the respondents after adopting drip irrigation realized water and labour saving and 98.33% obtained higher cane yield than conventional flood irrigation with reduced impact of drought. On an average, the respondents got 29.75% increase in cane yield compared to normal irrigation methods. The constraints encountered in adoption were clogging of drippers, damage of lateral tubes during harvest, rat damage and poor after sales service.

Publications

- Printed ICAR-SBI Annual Report 2020 (English)
- Printed ICAR-SBI News January 2020, April 2020, October 2020, January 2021, April 2021.

Technology Park: Technology Park was planted in February 2021 with 19 sugarcane varieties (Co 86032, Co 0212, Co 11015, Co 09004, Co 0238, Co 2001-13, Co 2001-15, Co 10026, Co 05011, Co 06022, Co 99006, Co 99004, Co 0232, Co 0237, Co 92005, Co 06030, Co 0118, Co 15007, Co 0233) and maintained.

Interaction with Krishi Vigyan Kendras: Participated in the Scientific Advisory Committee meeting of Shri Avinashilingam KVK on 29 January 2021, Dharmapuri KVK on 11 February 2021, MYRADA KVK on 30 November 2021 and offered suggestions for implementation of programs. Varietal demonstrations on Co 0212 and Co 11015 are being conducted in farmers' fields in collaboration with KVKs. On-farm training programs are also being organized with KVKs.

Visitors program

Entertained 1249 visitors to the institute comprising students (535), farmers (652) & cane development staff (62).

(T. Rajula Shanthy and D. Puthira Pratap)

Evaluating the effectiveness of state-level sugarcane R & D workshops: A cross-state assessment

The state-level sugarcane research and development workshop is a unique outreach initiative of the Institute having a history of over three decades. This project was formulated to evaluate these workshops to know the extent to which the outcomes implied from the workshop objectives have been realized. The locations of study are Tamil Nadu/Puducherry, Southern Karnataka and Northern Karnataka.

A questionnaire was constructed, displayed during the previous IRC and feedback was obtained. Subsequently, a preliminary refinement of the questionnaire was carried out with the help of experts using Google Forms. The refined questionnaire consisted of three parts *viz.*, face-sheet information, evaluating the impact and solicit suggestions. The questionnaire was evaluated against aspects such as validity, appropriateness for the sample, understandability, comprehensiveness and unambiguity. The questionnaire was administered to the participants of the 51st Sugarcane R&D Workshop of Tamil Nadu and Puducherry with 61% survey response rate. Among the 61 respondents, 31% belonged to the co-operative /public sector factories, 66% belonged to private sugar factories while 3% belonged to research/educational institutions.

The preliminary observations of the study are:

- Opportunity to interact with scientists/experts, opportunity for networking with colleagues and updating knowledge and skill were the predominant factors that influence the decision of the respondents to attend the workshop, besides the nomination of employers.
- 'Varieties' was the major topic in which the respondents were most interested in the workshops
- Respondents had rated the pre-R&D workshop correspondence to be understandable, accurate and with appropriate level of detail.
- Respondents were 'satisfied' with the clarity of correspondence, feasibility/practicality of workshop recommendations and the opportunity to express opinions during the workshop.
- Respondents had rated the Compendium of research articles and status papers, general interactive sessions and varietal display at the R&D workshops to be very helpful.
- Respondents had cited varietal percentage improvement in the factory area and taking up Big Mill Tests as major instances of action taken on the R&D workshop recommendations.
- Respondents had effectively used the written materials received from the workshop in their work.
- Among the various parameters of the compendium, the respondents had rated 'understandability' and 'ability to hold interest' as 'high'.

(D. Puthira Prathap and P. Murali)

Need based technological interventions under Tribal Sub Plan in selected tribal villages

Tribal Sub Plan is being implemented in 21 tribal villages in Coimbatore district of Tamil Nadu and Palakad district of Kerala since 2015 in four hill ranges.

Technological interventions in tribal villages

Beneficiary villages in Mettupalayam range

Surveys were conducted in Mettupalayam forest range and eight tribal villages namely Kunjapana, Kunjapanapudhur, Mantharai, Thuthikarai, 10 line, 23 line, 40 line and Puliyamaram Oor were selected as beneficiary villages. There are 165 families in these eight tribal villages and the major crops grown are coffee and tea. Based on the observations made using participatory rural appraisal techniques, transect walks, discussions held with the Tribal Head and other tribal people in the respective villages, technological interventions were identified for the two villages and a tribal school.

Items for the eight villages are coffee de-pulper (8), umbrella (200), lantern cum torch (100), raincoat (60), plastic tarpaulin sheet (100), power sprayer (10), blankets (165), jamukaalam (165), tiffin box with handle and small container (165), led 20 w solar street lights (10), bush cutter (7), agricultural operation kits (digging fork heavy, 5 feet crowbar, pick axe, bill hook with wooden handle, tata spade, plastic pan, tea bottom pruner, sword, trowel, hand hoe) (30), sewing machines with steel stool and starter kits (22), tea plants UPASI 1 (24950), lemon plants (150), nutmeg plants (2585), clove plants (2160), coffee plants (11500), 2 kg nutrient mixture packets (325), silver oak plants (120), village board (1), cap with SBI logo (170), bone meal packets (60),

aluminium basin with lid for coffee pulper (16), ghamela plastic pan (170), small spade (140), health and hygiene kit for children (107).

For Tribal Residential School- blankets (83), jamukaalam (55), garden tool set, solar water heater 200 lpd, 6x3 feet steel door (4), cap with SBI logo (220), SS tea drum (1), SS bowl (120), set of ladle and spoons (20), SS tumbler (120), mixer (1), induction cook top with utensils (2), chopping boards (3), multipurpose container (5 sets), fan (4), planters (10), garden plants, color charts (300), white board (4), duster (10), chalk (18 boxes), marker pen (40), flask (8), container (4 sets), steel cupboard (2), aluminium basin with lid (2), serving buckets medium (8) and water jug (4).

On-Farm Trials in tribal villages

- Planted a demonstration with ADT 45 paddy variety in a tribal farmer's field at Ookaiyanoor and the yield obtained was 1800 kg/ acre.
- Demonstration plots with tomato PKM 1 in three fields in Ookapatti gave fruit yield of ~6000 kg per acre.
- Demonstration plots with cowpea VBN 3 in four fields in Ookapatti and Neelampathi gave fruit yield of ~2800 kg per acre.
- Demonstrations on tea (UPASI 1), Lime (Balaji) and Coffee (Robusta variety) were planted in the eight adopted tribal villages in Mettupalayam range and is being monitored.
- Demonstration on banana G naine and Quintal nendran in four plots in Ookaiyanoor is in progress.

Spread and acceptance of new technologies

Four villages *viz.,* Neelampathi, Ookaiyanoor, Ookapatti and Mottiyoor in Periyanaickenpalayam range with over 140 acres of cultivated area were adopted in 2020 as beneficiary villages and various demonstrations and field trials were conducted, the results being encouraging. Based on the prevailing crops cultivated in the tribal area under rainfed conditions and demand for seeds of improved varieties, they were supplied with seeds of blackgram (VBN 8)-248 kg, greengram (Co 8-248 kg), cowpea (VBN3-248 kg), castor (YRCH1-300 kg), ragi (Co 15-250 kg), thinai (Co7-35 kg), varagu (Co 3-20 kg), kudhiraivaali (MDU1- 100 kg), samai (150 kg), paddy (ADT 45-240 kg), moringa PKM 1(2 kg), vegetable seeds of chilli Co 1 hybrid (500 g), tomato PKM 1 (8 kg), brinjal Co 2 (7 kg), Bhendi Co 4 (4 kg), cluster bean MDU 1 (9 kg), papaya Co 8 (100 g), 360 coconut (TxD), banana (Quintal nendran - 820 & G naine - 1525), lemon Balaji variety (285) along with fertilizer kits.

The preference of tribal farmers and the desirable attributes as told by them are: Ragi (Co 15) due to its suitability for rainfed condition, bold grain and non-lodging; Chillies (Co 1) for its high yield with long fruits and resistance to fruit rot; Tomato (PKM 1) for its non-stacking nature with round heavy fruits; paddy (ADT 45) due to high grain yield and straw yield. The establishment of all the crops was good due to adequate rain.

Success Stories

Paddy cultivation: Mr. Selvam is a tribal farmer from Ookaiyanoor, a tiny tribal hamlet in Karamadai range of Coimbatore district of Tamil Nadu well away from the main land. He owns over six acres of land and grows banana, mango, vegetables, coconut, lemon, ornamentals etc. which could sustain the needs of his family of six. We could see paddy cultivation for the first time in Selvam's field. Paddy is not cultivated every year due to water shortage and less demand for rice. He has both upland and lowland, paddy being raised only in lowlands and was getting very poor yield with the local variety he had used. Required quantity of paddy seeds of ADT 45, a paddy variety of 110 days duration was supplied by us. It's a medium slender semi-dwarf erect white rice variety and has resistance to gall midge and brown plant hopper, the common pests of paddy. He was guided to raise a seedling nursery using 15 kg seeds in eight cents for transplanting in one acre once the seedlings attained four leaf stage. The crop was raised using organic manures in puddled soil using a stainless steel country plough supplied by us earlier. In a complete pest and disease free crop growth, the field was harvested after 110 days. He could reap a bumper harvest of 1800 kg of paddy per acre which he says, is double the normal yield he used to get. Being a semi-dwarf variety, he could also store the hay for his herd of cattle (Fig. 117).

Seedling nursery

Paddy soon after transplanting

Demo on paddy field nearing harvest

Expecting a good harvest

Fig. 117. Paddy being grown by a tribal farmer

Tailoring unit: Sixteen sewing machines were supplied to 16 tribal women from the eight beneficiary villages of Mettupalayam range who were certificate holders in tailoring. The machines are kept in the community hall of the village and is being used by them. Training is also given to women who are interested in taking up tailoring. Christened as 'Savithri Bhai Phule Tribal Women Tailoring Unit', these tribal women have geared up to make this a successful venture, with additional support from us.

Prototypes developed / Technology assessment and refinement

- Developed a prototype of country plough along with Ramkumar Industries, Coimbatore for use in hilly terrain areas and 20 stainless steel country plough were fabricated and supplied to four adopted tribal villages. Feasibility testing of the SS plough is being done.
- Coffee de-pulper for processing fresh robusta coffee berries grown by tribal people was fabricated for tribal people, which is to be supplied and the feasibility of use in tribal areas to be studied.
- Garden tools best suited for hilly terrain were tailor-made as demanded by the tribal villagers and is being put to use for cultivation, practicality analysis pending.

Training / awareness programs / Visits organized in tribal villages

- Training on improved agricultural practices and value addition for 38 tribal villagers of Neelampathi on 06 January 2021 and provided a flour mill (Fig. 118).

Fig. 118. Training on improved agricultural practices (06 January 2021)

- 'Tribal Farmers Meet' at Kunjapana and nearby six tribal villages and distributed plants (lime, nutmeg, clove) on 19 January 2021. They were given a training on the Importance of scientific cultivation practices of lime (Fig. 119).

Fig. 119. Training on the Importance of scientific cultivation practices (19 January 2021)

- 'Awareness camp on health and hygiene' in Domanur and Sembukkarai tribal villages for 80 tribal children on 29 January 2021 (Fig.120).

Fig. 120. Awareness campaign on health and hygiene at Domaur and Sembukkarai (29 January 2021)

- Door-to-door awareness campaign on 'Basic hygiene for a healthy living' to eight tribal villages in Kunjapana and supplied blankets and jamukkaalams on 5 February 2021 (Fig. 121).

Fig. 121. Door-to-door awareness campaign on basic hygiene (05 February 2021)

- Monitoring visit to six tribal villages on 12 February 2021 to see the solar lights installed and appraised them about the drawbacks of tree felling for their sustenance.
- Awareness Campaign on Clean cultivation and healthy surroundings in Kunjapana tribal village and other seven tribal villages with the participation of over 123 tribal villagers and distributed bush cutter (7), agricultural operation kits (30) on 19 February 2021 (Fig. 122).

Fig. 122. Awareness campaign and distribution of agricultural operation kits (19 February 2021)

- Training on 'Tree spices and their cultivation' to 117 villagers from Kunjapana and other seven tribal villages and distributed nutmeg, clove, lime, silver oak and nutrient mixture on 20 February 2021 (Fig. 123).

Fig. 123. Training on tree spices and distribution of plants (20 February 2021)

- Training on 'Improved tea cultivation' to over 120 tribal villagers of Kunjapana and other seven tribal villages and distributed 24950 UPASI 1 tea plants on 24 February 2021 (Fig. 124).

Fig. 124. Tea plants for distribution to tribal villagers (24 February 2021)

- Training on 'Improved package of practices for coffee cultivation' to over 130 tribal villagers of Kunjapana and other seven tribal villages and distributed coffee plants Robusta variety (11500) on 27 February 2021. Also conducted awareness camp on health and hygiene (Fig. 125).

Fig. 125. Awareness camp on Health and Hygiene (27 February 2021)

- Awareness campaign on 'Avenues for income generation' to 39 tribal women and sewing machines (16) were distributed on 27 February 2021. The meeting was headed by Shri Vinu Dhas, Headmaster of Tribal School, Kunjapanai (Fig. 126).

Fig. 126. Distribution of sewing machines to tribal women (27 February 2021)

- Monitoring visit to Kunjapana and nearby tribal villages on 17 March 2021 and visited the plants distributed earlier.

Monitoring of the ongoing developmental activities in the beneficiary tribal villages and feedback on the impact is being studied.

(T. Rajula Shanthy, C. Jayabose, C. Sankaranarayanan, R. Arunkumar and R. Karuppaiyan)

5.6 ICAR- SUGARCANE BREEDING INSTITUTE REGIONAL CENTRE, KARNAL

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

Breeding elite clones suitable for North West Zone (NWZ)

Hybridization, progeny evaluation and selection

Sugarcane variety notified for commercial cultivation

Co 15023 (Karan 15), an early sugar accumulating variety was notified (vide Gazette Notification No. SO 500 E dt 29.01.2021) for commercial cultivation in NWZ comprising the states of Delhi, Haryana, Punjab, Rajasthan, Uttrakhand and Uttar Pradesh (Central and Western parts) (Fig. 127, Table 24).

Fig. 127. Field veiw of variety Co 15023

Co canes accepted for inclusion in Zonal Varietal Trial (ZVT): Three early maturing 'Co' canes *viz.*, Co 21012, Co 21013 and Co 21014 were accepted for inclusion in ZVT trials for NWZ.

Raising fluff in mist chamber: The fluff of 40 bi-parental, 16 GCs and four PC combinations was sown in the mist chamber, of which 14 bi-parental and 13 GC/PC combinations produced good number of seedlings.

Table 24. Comparative performance of Co 15023 in AICRP trials for cane yield and juice quality with the standard varieties

Entry/Standard	CCS (t/ha)	Cane yield (t/ha)	Sucrose (%)	Pol % in cane
Co 15023	12.20	89.49	19.41	14.93
Standards				
CoJ 64	10.42	82.22	18.35	14.09
Co 0238	11.92	95.32	18.10	14.06
Co 05009	10.45	84.80	17.87	13.70
Percent improvement over standards				
CoJ 64	16.99	8.64	5.81	6.02
Co 0238	2.35	-6.11	7.27	6.20
Co 05009	16.51	5.32	8.62	9.00

Seedling selection in ratooned ground nursery (2020-21): A total of 244 good performing clones were selected from the ground nursery based on HR Brix, NMC, cane diameter, cane height and other desirable morphological traits after assigning selection number K19-01 to K19-244, and were field transplanted in augmented design under C1 evaluation stage along with four standards (Co 0238, CoJ 64, Co 05011 and CoS 767). Performance of major cross combinations for HR Brix, selection intensity and other morphological traits is given in Fig. 128.

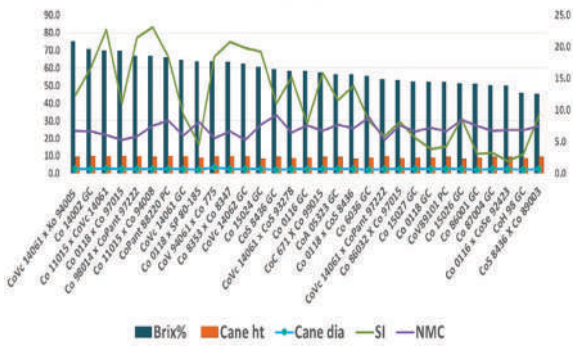


Fig. 128. Performance of major cross combinations for selection intensity, yield and quality traits

First clonal trial (2021-22): One hundred and eight clones of K18 series were evaluated for cane quality at 8th month. Co 0238 was the best among the standards with 20% HR Brix and 17 entries were numerically superior to Co 0238. Among them, three clones *viz.,* K18-002 (20.1), K18-066 (20.1) and K18-082 (20.1) tested MR against mix inoculum of red rot pathogen (CF 08 and CF13).

Red rot: In C1 trial, out of 108 clones screened against mixed inoculum of CF08 and CF13 red rot pathotypes, six clones exhibited R, 15 MR, 9 MS, 37 S and 39 HS reactions to red rot.

Preliminary trial (2020-21): Based on cane yield, juice quality parameters, red rot reaction 23 entries were selected from 108 K 16 series to PZVT.

Preliminary trial (2021-22): Among the 38 test entries of the trial, K17-116 (130560) produced higher NMC over best standard CoJ 64 (109260), whereas eight other entries had on par performance. Among them, K17-118 (118060), K17-115 (115740), K17-108 (114350), K17-107 (111570) and K17-039 (110650) produced numerically higher NMC over CoJ 64, the top performer. For sucrose content at 8 months, the entry K 17-050 (19.16%) performed better, whereas six entries *viz.,* K17-008, K17-034, K17-037, K17-072, K17-110 and K17-111 had on par performance with Co 0238.

Red rot: Of the 38 clones evaluated, nine were found to be MR, four MS, nine S and 15 HS against the mixed inoculum of CF08 and CF13 isolates of red rot.

Pre-Zonal Varietal Trial (2020-21)

Out of 55 test entries along with five standards (CoJ 64, Co 0238, CoS 767, Co 05011 and Co 12029) evaluated in PZVT, four clones *viz.,* K15-367, K15-521, K15-588 and K15-609 were assigned 'Co' status under early category, one clone K15-136 was assigned under mid-late group (Tables 25 and 26).

Table 25. Performance of early maturing clones in PZVT

Clone	Parentage	CCS (t/ha)	Yield (t/ha)	Sucrose (%)		Red rot reaction	
				8 months	10 months	CF08	CF09
Co 21012 (K15-367)	Co 88013 x Co 97015	17.82	138.73	17.07	18.27	MR	MR
Co 21013 (K15-521)	Co 0240 x CoT 8201	18.34	140.93	17.81	18.61	MR	MR
Co 21014 (K15-588)	CoS 8436 x Co 89003	18.10	136.43	16.66	18.95		
Co 21015 (K15-609)	Co 0403 x Co 1148	18.85	140.49	17.34	19.09		
Standards							
CoJ 64		9.96	80.06	17.16	17.70		
Co 0238		16.13	128.31	16.74	18.21		
CD		1.39	11.31	0.50	0.21		
CV		6.00	8.25	2.07	2.15		

Table 26. Performance of mid-late maturing clones in PZVT

Clone	Parentage	CCS (t/ha)	Cane yield (t/ha)	Sucrose (%)		Red rot reaction	
				10 months	12 months	CF08	CF09
Co 21016 (K15-136)	Co 98008 x Co 1148	18.38*	120.29	18.10	20.97*	MR	MR
Standards							
CoS 767		7.91	60.02	17.11	18.70		
Co 05011		14.34	104.26	17.07	19.48		
CD		1.71	11.31	0.21	0.54		
CV		6.28	8.25	2.15	1.67		

PZVT trial (2021-22): The overall mean of the trial for sucrose in juice at 8th month was 15.41%. Test entry WL06-182 (18.85%) recorded significantly higher sucrose over the best standard CoJ 64 (17.64%), whereas three test entries, WL04-72 (17.86%), WL06-85 (17.66%) and WL 10-85 (17.27%) were on par with the best standard CoJ 64.

*Red rot:*Among the 32 clones evaluated, nine were R, 12 MR, five MS and six S with CF08 isolate, while with CF13 isolate, 10 were MR, five MS, 10 S and seven HS to red rot.

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

'Co' canes maintenance (2020-21): The ratoon trial consisting of 68 entries including standards (Co 0118, Co 0238, Co 05011 and Co 12029) was evaluated for cane yield and juice quality traits at harvest. The experimental mean for CCS (t/ha) was 10.23 and Co 12029 (13.53) performed best among the standards. Fourteen of the 'Co' canes had on par performance; among them, Co 15023 (14.70), Co 15027 (14.01), Co 14035 (13.91), Co 17018 (13.91), Co 14036 (13.57) and Co 16030 (13.56) had higher value over the best standard. For cane yield as well, Co 12029 (112.54 t/ha) was the best standard. Co 14036 (129.21) was the superior performer test entry, whereas Co 18022 (120.92), Co 14035 (118.13), Co 15027 (114.52) were the other promising entries among the nine on par performer test entries with the best standard. For juice sucrose content at harvest, Co 0118 (19.54%) was the best standard. Test entries Co 15023 (20.87%), Co 17016 (20.50%) and Co 12027 (20.33%) were significantly superior over it.

Enhancement of sugarcane germplasm and development of pre-breeding material

Evaluation of sugarcane germplasm, ISH and IGH Clones under sub-tropical conditions

ISH trial (Plant crop): Twenty-four ISH clones were evaluated along with four standards (Co 0238, CoJ 64, Co 05011 and CoS 767) for drought tolerance. Drought stress was imposed by with-holding irrigations during the formative stage. The average reduction for numbers of tillers under drought at 120 DAP was 13.95% and it was 1.34 and 1.08 lakhs/ha, respectively under normal and drought conditions. Minimum reduction for tiller numbers observed in clones 14-161(1.6%), 93 CBE (6.2%) and 14-131 (7%) was lesser than the best standard Co 0238 (7.64%). Similarly, percentage reduction for plant height under drought stress at 150 DAP recorded was 13%. Co 0238 had 26% reduction in plant height under drought whereas, four ISH entries *viz.*,14-131, 14-94, 14-38, and 14-34 recorded the least reduction (<2%) for plant height at 150 DAP. Leaf area measured after imposing drought and the mean reduction for leaf area under drought was 9.23 cm^2. Entries 14-161, 14-34, 14-59,14-94 and 14-90 had performed good and had less reduction for leaf area <3% under drought. Among the standards, Co 05011 had the least reduction for leaf area of 8 cm^2. The average NMC for normal and drought stress was 99.7 and 93.86 lakhs/ha respectively, with 5.9% reduction under drought conditions. Cane height recorded under normal and drought was 246 and 235 cm respectively, with 6% reduction under drought; Clones that showed the least reduction and were also on par with the best standard (Co 0238) were 14-16, 14-83, 14-38 and 14-144. For numbers of internodes, there was 4.8% gain under drought compared to normal, and entries 14-83, 14-131, 14-95, 14-125, 14-144 exhibited more numbers of internodes under drought. Mean reduction was 2.83% for single cane weight and test clones 14-131, 14-83, 14-59, 14-144, 14-94 and 2012-124 showed least reduction and on par with the best standard Co 0238 (0.98%) under drought stress. Juice analysis at 8^{th} month revealed 14-111 (16.36%) and 14-59 (15.58%) as better performers and on par with the best standard Co 0238.

ISH trial (ratoon crop): Thirty-one ISH entries were ratooned in February 2021 and drought stress was imposed during the formative stage. Mean tillers before earthing up (BEU) under normal and drought were 1.12 lakhs/ha, 0.80 lakhs/ha respectively. The mean reduction for tillers BEU under drought stress was 38.8% whereas, it was 26.12 % after earthing up (AEU). Co 05011 was the best among the standard in BEU and AEU. Mean reduction of 18.75% for plant height and 6% for numbers of internodes was observed under drought stress. Cane height at 8^{th} month recorded under normal and drought conditions were 220 cm and 197 cm respectively, and the mean reduction was 10% under drought conditions. ISH clones 14-56, 14-144, 14-49, 14-42, 14-170 had on par cane height with the best standard Co 12029 under drought. For single cane weight, entries 14-147, 14-56, 14-144, 14-188 and 14-49 were on par with Co 0238 under drought. Juice analysis was carried out in 10^{th} month and Co 0238 (18.24%) was the best among standards for pol % in juice and ISH entries 14-192 (18.75%), 14-171 (19.28%), 14-127 (18.01%) and 14-63 (17.86%) were on par with it.

Screening of ISH clones and 'Co' clones under salinity stress: Five ISH clones *viz.,* 14-49, 14-61, 14-42, 14-52, 14-147 and three 'Co' clones *viz.,* Co 14034, Co 15025 and Co 16030 with standard Co 0238 were planted in March 2021 in pots with three replications to screen them under different salinity level. After 60 DAP, chloride-dominated saline irrigation water with different electrical conductivity (EC) *i.e.* 4, 8 and 10 dS m^{-1} was applied. Data were analyzed with CRBD design. At 90 days after salinity stress, a gradual decrease was recorded in all the studied parameters with a progressive increase of salinity stress from 4 dS m^{-1} to 10 dS m^{-1}. Average plant height was 100.82 cm under normal irrigated control which was reduced up to 14.9%, 20.0% and 27.80% in 4, 8 and 10 dS m^{-1}, respectively. ISH clones, 14-42, 14-49, 14-147 showed less reduction than average reduction while 14-61 showed the highest reduction at all the salinity treatments. Among 'Co' canes, Co 14034 (15.10, 19.72 and 22.0%) and Co 16030 (7.19, 16.45 and 29.23%) showed less reduction than average reduction in all the treatments. Standard Co 0238 also showed less reduction than the average reduction in all treatments. The average chlorophyll content was 44.2 µg/cm^2 in normal irrigated control. Mean chlorophyll content reduced to 11.76 %, 22.72% and

31.71% under 4, 8 and 10 dS m-1level, respectively as compared to normal irrigated control (Fig. 129). ISH clones, 14-52 and 14-147 and Co 14034 and Co 16030 maintained better chlorophyll content in all the treatments. Average plant population was 3.7/clump in normal irrigated control whereas EC of 4 dS m^{-1} caused 8-39% reduction, 13-55% in 8 dS m^{-1} and 27-64% in 10 dS m^{-1}. ISH clone, 14-42, 14-49 and 14-61 had maximum tillers/clump in all the treatments and showed less reduction than average reduction. At 8 dS m^{-1} and 10 dS m^{-1} salinity level, Co 16030 had the maximum number of tillers but reduction was minimum in Co 14034 (21% and 29%) as compared to respective control values.

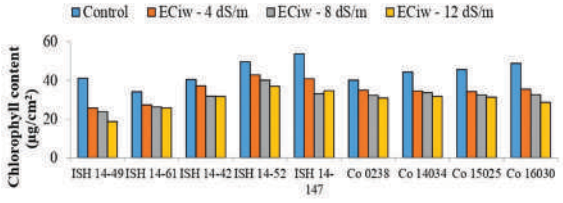


Fig. 129. Effect of different levels of saline irrigation on chlorophyll content of ISH clones and Co-clones

Red rot: Out of 19 ISH clones evaluated, two were MR, five MS, four S and eight HS to red rot.

Insect pests: Nineteen sugarcane germplasms /species clones (ISH & IGH) were evaluated against ESB and TB and incidence was <15.0%. For top borer, 18.0 germplasms/species *viz.*, 14-161, 14-131, 14-83, 14-125A, 14-94, 14-195A, 14-111, 14-38, 14-55, 14-144A, 93CBE, 14-90, 14-95, 14-191, 14-140, 14-109, 20-12 and 14-104A showed least susceptible reaction, whereas, one clone 14-34 was moderately susceptible to top borer.

(M.R. Meena, Ravinder Kumar, S.K. Pandey, M.L. Chhabra and Pooja)

All India Coordinated Research Project (Sugarcane)

Subtropical zone

Crop season 2020-21 (January to March 2021)

IVT (early): Seven test entries and three standards were evaluated for cane yield and juice quality traits. At harvest, for sugar and cane yield, Co 0238 (15.01 t/ha, 116.66 t/ha) was the best standard and none of the test entries could perform better. CoJ 64 (18.93%) was the best standard for sucrose and none of the test entries was better over it, however, the performance of entry CoS 17231 (18.49%) was on par with it.

AVT early plant I: Five test entries and three standards (CoJ 64, Co 0238, Co 05009) were evaluated for cane yield and juice quality traits. Co 0238 was the best standard for CCS yield (17.39 t/ha), cane yield (136.19 t/ha), sucrose content (18.35%), pol in cane (14.27%), etc. Test entry Co 15025 with 18.69 t/ha CCS yield, 142.37 t/ha cane yield, 18.78% sucrose and 14.91% pol in cane was found promising.

AVT early plant II: At harvest (10^{th} month), for cane and sugar yield, Co 0238 (110.73 t/ha cane yield & 14.95 t/ha sugar yield) was the best standard. Test entries Co 15023 (135.87 t/ha cane yield and 20.31 t/ha sugar yield) and Co 15027 (147.29 t/ha cane yield and 19.99 t/ha sugar yield) had superior performance over Co 0238. Co 15023 with 21.15% sucrose and 16.59% pol in cane was the best performing entry, which was significantly superior to Co 0238 (19.31% sucrose and 14.93% pol in cane).

AVT early ratoon: For cane and sugar yield, Co 0238 (124.24 t/ha cane yield & 16.89 t/ha sugar yield) was the best standard. Test entries Co 15023 (18.75 t/ha sugar yield and 133.16 t/ha cane yield) and Co 15027 (18.13 t/ha sugar yield and 139.92 t/ha cane yield) had superior performance over Co 0238. Co 15023 with 20.09% sucrose and 15.9% pol in cane was the best performing entry, as compared to Co 0238 (19.29% sucrose and 14.97% pol in cane).

AVT midlate plant I: Five test entries and three standards (CoS 767, CoPant 97222, Co 05011) was evaluated for cane yield and juice quality. At harvest, CoPant 97222 was the best standard for sugar yield (14.37 t/ha), cane yield (107.36 t/ha) and pol in cane (14.70%), whereas for sucrose content Co 05011 (18.97%) was the best performing standard. Co 16030 with 20.2 t/ha CCS yield, 146.16 t/ha cane yield, 19.65% sucrose and 14.97% pol in cane was the best performer, which produced significantly higher cane yield over the best standard.

Crop season 2021-22

IVT midlate: Eleven test entries and three standards (CoS 767, Co Pant 97222, Co 05011) were evaluated for cane yield and juice quality traits.

For NMC population (000/ha), CoPant 97222 (118.89) was the best standard and test entries CoLk 18203 (122.56), CoPb 18214 (111.11), CoPant 18221 (113.12), CoS 18232 (116.67) and CoS 18233 (115.28) had on par performance with it. For sucrose at 10th month, CoS 767 (16.52%) was the best standard and test entries, Co 18021 (17.23%), Co 18022 (17.19%), CoLK 18204 (18.49%), CoPb 18214 (17.98%), CoPant 18221 (18.26%), CoS18231 (17.37%) and CoS 18232 (18.0%) had better performance over it.

AVT early plant II: Five test entries and three standards (CoJ 64, Co 0238, Co 05009) were evaluated for cane yield and juice quality traits. For NMC (000/ha), Co 05009 (98.61) was the best standard and test entry CoLk 16202 (109.18) had better performance over it. At 8th month, CoJ 64 (17.41) was the best standard for juice sucrose% and test entry Co 15025 (16.86) had on par performance with it.

AVT early ratoon: Five test entries and three standards (CoJ 64, Co 0238, Co 05009) were evaluated for cane yield and juice quality traits. Co 0238 was the best standard for cane yield (132.86) and CCS yield (16.75). None of the test entries was found superior over it, however entry CoLk 16202 with 118.58 t/ha cane yield and 14.91 t/ha sugar yield had on par performance. For juice sucrose %, CoJ 64 (18.1) was the best standard and test entries Co 15025 (18.88) and Co 16029 (18.81) was superior over it.

AVT midlate plant II: Five test entries and three standards (CoS 767, CoPant 97222, Co 05011) were evaluated for cane yield and juice quality traits. For NMC (000/ha) and sucrose % at 240 days, Co 05011 was the best standard. All the test entries were on par for NMC population, whereas only one test entry, Co 16030 (17.47) had a superior performance for juice sucrose content over Co 05011.

AVT midlate ratoon: Five test entries and three standards (CoS 767, CoPant 97222, Co 05011) were evaluated for cane yield and juice quality traits. CoPant 97222 (99.6) was the best standard and test entry, CoLk 16204 (148.5) produced a significantly higher NMC (000/ha) population over it.

(Ravinder Kumar and M.R. Meena)

Evaluation and identification of climate resilient ISH and IGH genetic stocks against drought

Eighteen ISH clones along with three standards *viz.*, Co 0238, CoJ 88 and Co 98014 were planted in alpha design with two replications to assess the drought tolerance efficiency. Plot size was 6m x 2R x 0.9m and seed rate of was 12 buds/m. A reduction of 20.99%, 35.62%, 46.64% and 18.72% was registered for tiller population at 90 and 120 DAP, plant height and number of internodes formation respectively, under drought stress. Leaf rolling under drought was observed and seven clones expressed high intensity of leaf rolling, another seven clones exhibited partially leaf rolling, whereas, five clones had no leaf rolling after imposition of drought at the formative stage of the crop (60-140 DAP). Plant height till the top visible dewlap (TVD) was measured at 150 DAP after imposing the drought. Mean reduction per cent for plant height under the drought recorded was 37% and Co 98014 (43%) was the best among standards. The better performing ISH clones for plant height under drought stress were *viz.*, ISH-585, ISH-590, ISH-584, ISH-534 and ISH- 502. Similarly, mean reduction for leaf area at 150 DAP after imposing drought stress was 24.9% and Co 0238 was the best among standard with 28.8% reduction in leaf area. Eleven test entries performed better and had less leaf area reduction than Co 0238. The top performing ISH entries for leaf area were *viz.*, ISH-534, ISH-585, ISH-833, ISH-536, ISH-567 and ISH-524. Numbers of tillers at 150 and 180 DAP in normal and drought trial recorded was 1.47, 1.07 lakhs/ha and 1.38, 1.02 lakhs/ha respectively. There was 27.39% reduction at 150 DAP whereas it was 24.69% at 180 DAP. Six clones, ISH-501, ISH-584, ISH-594, ISH-590, ISH-519 and ISH-585 were at par with best standard, Co 0238 at 150 DAP, whereas ISH-594, ISH-519, ISH-501 and ISH-534 were recorded at par tillers numbers at 180 DAP. The average reduction for NMC at 8th month under the drought was 29.3% and Co 98014 (13%) had least reduction among the standards. Entries, ISH-584 (4.5%) and ISH-534 (9.6%) had least reduction for NMC under drought stress. At 8th month, average cane height under normal and drought condition recorded was 232 cm and 197 cm, respectively

with 15% reduction under drought. Co 0238 was the best among standards and seven ISH clones, ISH-585, ISH-676, ISH-833, ISH-545, ISH-501 and ISH-823 had at par value with it. Similarly, for single cane weight, there was 2% reduction under the drought stress (0.7 kg) as compared to normal (0.8 kg). CoJ 88 (3%) had the least reduction among the standards and six ISH clones were on par.

(M.R. Meena, Ravinder Kumar and Pooja)

Identification of pathotypes /races of red rot pathogen

Fifteen red rot isolates comprising eight reference pathotypes and seven isolates collected from Co 0238 (4), Co 89003), CoS 8436 (1), and CoLk 94184 (1) were inoculated independently on a set of 21 sugarcane differentials *viz.,* Co 0238, Co 975, Co 997, Co 1148, Co 7717, Co 89003, Co 62399, BO 91, Khakai, Co 86002, Co 419, Baragua, CoS 767, CoS 8436, CoJ 64, CoV 92102, CoSe 95422, CoS 86032, CoC 671, Co 7805 and SES 594 by plug method of inoculation. Pathogenic reaction on differential hosts showed that reference pathotype, CF11 was found to be the most virulent followed by CF07, CF01, CF08, CF13, CF02, CF09, and CF03. Among the four, CF0238 isolates (Afjalgarh, Ajbapur, Faridpur and Khumbi) found to be more virulent and exhibited susceptible reactions on seven to ten host differentials indicating a different origin in the region. The isolate Cf8436 (Karnal) succumbed to differential CoS 8436 with intermediate to susceptible reactions to 11 differentials, whereas, Cf89003 (Karnal) was also too virulent, showed susceptible reactions on 12 host differentials, suggesting the possible emergence of another new pathotype in sub-tropics. Further, isolate CfLk94184 (CoLk 94184) showed susceptibility on eight host differentials. The differential, SES 594 exhibited complete resistance to all the test isolates (Table 28).

(M.L. Chhabra)

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

Survey for sugarcane diseases was done in the reserved areas of 13 sugar mills of NWZ *viz.,* Mukarian (Punjab), Jind, Shahabad, Sonipat, Kaithal, Karnal, Bhadson (Haryana), and Khatauli, Sabitgarh, Milak Narayangarh, Rani Nangal, Chandanpur, Deoband (UP).

Red rot: In Co 0238, red rot was recorded in Mukarian (Punjab) by 10.0 to 50%, whereas incidence was noticed up to 10.0% in Karnal and 10-20% under Palwal (Haryana) area. Similarly, in Uttar Pradesh, red rot incidence was observed up to 50% (Sabitgarh: traces-10.0%, Milak Narayanpur: 10.0-40.0%, Rani Nangal: traces-50.0% and Chandanpur: 10.0%). In Co 89003, incidence was recorded in Jind (traces-10.0%), Sonipat (traces-20.0%), Karnal (10-30%), Bhadson (upto 20.0%), and Shahabad (5.0%). However, in varieties, CoJ 85 and CoH 160 mild incidence was noted in Kaithal Sugar Mill Area.

Pokkah boeng: Pokkah boeng was prevalent in most of the cultivated varieties in the zone. In Haryana, disease was observed up to 20% in varieties, Co 0238, Co 0118, Co 89003 and CoH 160, whereas, in Uttar Pradesh, maximum incidence was up to 30.0% in variety Co 0238.

Smut: Trace incidence of smut was recorded on variety Co 0238 in Haryana, Punjab, and UP.

Wilt: Mild incidence of wilt was observed in CoH 160 (Sonipat, Haryana), Co 0118 (Chandanpur, UP) and Co 0238 (Deoband, UP). Wilt incidence was also reported by the scientists of KVK, Jammu in CoJ 85.

(M.L. Chhabra)

Evaluation of IET/Zonal varieties for resistance to red rot

Thirty-nine IVT entries along with eight standards were evaluated for red rot resistance by plug and cotton swab methods of inoculation with CF08 and CF13 isolates. Among the IVT (early) entries, CoPant 18221 expressed susceptibility to both CF08 & CF13 isolates by plug and cotton swab methods, whereas, CoPb 18212 exhibited MS reaction to CF08 by plug method and, susceptible reaction to CF13 by plug and cotton swab methods of inoculation. Of the test IVT(Mid-late) entries, CoLk 18203 and CoPant 18222 showed susceptibility to CF13 isolate by plug method only. One AVT (Mid-late- I plant) entry CoH 17262 was susceptible to Cf13 isolate by both the inoculation methods. The remaining entries exhibited R or MR reactions with both the inocula and methods (Table 29).

(M.L. Chhabra)

Table 28. Pathogenic behaviour of *C. falcatum* pathotypes on host differentials

Isolate	Source	Reaction on host differentials																			
		Co 0238	Co 975	Co 997	Co 1148	Co 7717	Co 62399	Co 89003	Bo 91	Khakai	Co 86002	Co 419	Baragua	CoS 767	CoS 8436	CoJ 64	CoV 92102	CoSe 95422	CoS 86032	CoC 671	Co 7805	SES 594
CF01	Co 1148	R	I	S	S	I	S	R	R	R	I	S	R	R	R	S	I	R	R	S	R	R
CF02	Co 7717	R	R	S	S	S	S	R	R	R	S	S	R	R	R	S	R	R	R	I	R	R
CF03	CoJ 64	R	R	S	S	R	R	R	I	R	S	R	R	R	R	I	I	R	R	S	R	R
CF07	CoJ 64	R	I	S	S	S	R	I	R	R	S	I	R	S	R	S	R	R	R	S	S	R
CF08	CoJ 64	R	R	S	S	R	I	R	R	R	S	R	R	I	R	S	S	R	R	I	S	R
CF09	CoS 767	R	R	S	S	R	R	R	R	R	I	R	R	I	R	S	R	R	R	S	S	R
CF11	CoJ 64	I	S	S	S	S	S	R	R	R	S	S	R	I	R	S	I	I	S	S	I	R
CF13	Co 0238	S	S	S	R	R	S	S	R	R	R	R	R	R	R	R	I	R	S	S	R	R
CF0238 (Afjalgarh)	Co 0238	S	I	S	R	R	S	S	R	R	R	R	R	R	R	R	R	R	S	S	R	R
CF0238 (Ajbapur	Co 0238	S	R	S	R	R	S	S	R	R	I	R	R	R	R	R	R	R	S	S	R	R
CF0238 (Faridpur)	Co 0238	S	S	S	R	I	S	S	R	R	I	R	R	R	R	R	R	R	S	S	I	R
CF0238 (Khumbi)	Co 0238	S	S	S	R	R	S	S	R	R	S	R	R	R	R	R	R	R	I	S	R	R
CF89003 (Karnal)	Co 89003	S	I	S	R	R	S	S	S	I	R	I	R	R	R	I	R	R	S	S	I	R
CF8436 (Karnal)	CoS 8436	R	I	R	R	R	S	R	R	I	S	S	R	R	S	S	I	R	I	S	S	R
Cf94184	CoLk 94184	I	R	R	I	R	S	I	R	R	I	I	R	R	R	R	R	R	R	I	I	R

R-Resistant; X- Intermediate; S- Susceptible

Table 29. Evaluation of zonal varieties for red rot and YLD resistance at SBI-RC, Karnal-2021

Entry	Red rot rating				YLD	*Other diseases
	CF08		CF13			
	Plug Method	CS Method	Plug Method	CS Method		
IVT (Early) - 8						
CoS 17232	MR	R	MR	R	R	
CoPb 18181	MR	R	MR	R	R	Smut
CoPb 18182	MR	R	MR	R	MR	wilt
CoLk 18201	MR	R	MR	R	R	
CoLk 18202	MR	R	MR	R	R	PB
CoPb 18211	MR	R	MS	R	S	
CoPb 18212	MS	R	S	S	R	
CoPant 18221	S	S	S	S	MS	PB
AVT (Plant II) - 6						
CoLk 14201						
Co 15025	R	R	MR	R	R	
Co 16029	R	R	MR	R	R	
CoLk 16201	MR	R	MR	R	R	wilt
CoLk 16202	MR	R	MR	R	MS	
CoPb 16181	MS	R	MS	R	R	
IVT (Mid-late) - 11						
Co 18021	MR	R	MR	R	R	
Co 18022	MR	R	MR	R	R	
CoLk 18203	MR	R	S	R	R	
CoLk 18204	MS	R	MS	R	R	PB
CoPb 18213	MR	R	MR	R	S	
CoPb 18214	MR	R	MR	R	R	PB
CoPant 18222	MR	R	S	R	R	
CoS 18231	MR	R	MR	R	MR	
CoS 18232	R	R	MR	R	MR	PB
CoS 18233	MR	R	MR	R	R	PB
CoS 18234	MR	R	MR	R	R	
AVT (Mid-late P I) - 9						
Co 17018	R	R	MR	R	MR	
CoLk 17204	MR	R	R	R	R	
CoPb 17215	MR	R	MR	R	R	wilt
CoS 17233	R	R	MR	R	R	
CoS 17234	MR	R	MR	R	MS	Smut
CoS 17235	MR	R	R	R	MR	
CoS 17236	MR	R	MR	R	MR	
CoH 17261	MS	R	MS	R	R	wilt
CoH 17262	MR	R	HS	S	MR	
AVT (Mid-late) P II - 5						
Co 16030	MR	R	MR	R	MR	PB

Entry	Red rot rating				YLD	*Other diseases
	CF08		CF13			
	Plug Method	CS Method	Plug Method	CS Method		
CoLk 16203	MR	R	MS	R	R	PB
CoLk 16204	R	R	R	R	R	PB
CoS 16232	MR	R	MS	R	R	
CoS 16233	MR	R	MR	R	R	
Standards						
CoJ 64	S	S	MR	R	MR	PB
Co 0238	MR	R	HS	S	MS	
Co 05009	MR	R	HS	S	R	
CoS 767	MR	R	MR	R	R	
CoPant 97222	MS	R	S	R	MR	PB
CoS 8436	MR	R	MR	R	R	
CoPant 84211	MS	R	S	R	R	
Co 05011	MR	R	MR	R	R	

**Trace incidence*

Assessment of elite ISH clones for resistance to red rot

Twenty ISH clones, three IGH clones, nine commercial hybrids and one waterlogging tolerant clone were evaluated for red rot resistance. with CF08 and CF13 pathotypes of red rot by plug method of inoculation. Among the ISH clones, three were R, seven MR, five MS, three S and two HS to CF08, while six clones were MR, seven MS, two S and five HS to CF13. Of the three IGH clones, IGH-829 exhibited susceptible reaction to both the isolates whereas, IGH 823 and IGH 833 were found to be MS with CF08 and susceptible to CF13 isolate. The waterlogging clone WL-10-85 expressed MR reaction to both the isolates. Further, all the nine commercial hybrid clones were rated R / MR to red rot with both the isolates.

(M.L. Chhabra)

Yellow Leaf Disease

Natural incidence of yellow leaf disease (YLD) was recorded based on the YLD severity scale (0-5) in 47 entries planted in the zonal varietal trial. Among the different IVT and AVT clones screened, 31 were apparently free from YLD symptoms and probably resistant to YLD. Ten clones were MR and four clones MS. Two clones *viz.*, CoPb 18211 and CoPb 18213 expressed severity scores >3 and showed susceptible reaction to YLD (Table 29).

(M.L. Chhabra)

Evaluation of zonal varieties for their reaction against major insect pests

AVT Ratoon: Ten genotypes along with two check varieties were evaluated against major insect pests *viz.*, black bug (BB), ESB, TB, root borer (RB) and stalk borer (SB). ESB and TB incidence ranged from 0.5 to 1.0 and 0.4 to 2.5% respectively. BB population varied from 0.5 to 1.0 bugs/leaf. All the 10 genotypes *viz.*, Co 15025, Co 16029, CoLk 16201, CoLk 16202, CoPb 16181, CoLk 16203, CoLk 16204, CoS 16232, CoS 16233 and Co16030 showed least susceptible (LS) reaction to BB (<25.0 individual/20 leaves), ESB (<15.0%) and top borer (<10.0%). Root borer incidence ranged from 14.1 to 30.%. CoS 16232 was least susceptible (<15%); Eight genotypes (Co 15025, Co 16029, CoLk 16201, CoLk 16202, CoPb 16181, CoLk 16203, CoLk 16204, Co 16030) were MS (15.1 to 30%) to RB. SB incidence ranged from 1.3-20.4% and infestation index varied from 0.1 to 2.5. Nine genotypeswere LS (infestation index < 2.0) and one genotype, CoLk 16204 was MS (infestation index > 2.1 to 5.0) to SB.

AVT Plant I: Nine genotypes along with one check variety were evaluated against ESB and

TB, incidence ranged from 0.7 to 3.0 and 0.4 to 3.4% respectively. All the genotypes (Co 17018, CoLk 17204, CoPb 17215, CoS 17233, CoS17234, CoS 17235, CoS 17236, CoH 17261 and CoH 17262) were LS to ESB and TB.

AVT Plant II: Ten genotypes along with two check varieties were evaluated for ESB and TB, incidence ranged from 1.1 to 5.2 and 0.4 to 1.7% respectively. All the genotypes (Co 15025, Co 16029, CoLk 16201, CoLk 16202, CoPb 16181, CoLk 16203, CoLk 16204, CoS 16232, CoS 16233 and Co 16030) were LS to ESB and TB.

(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 in the reserved areas of seven co-operative sugar mills of Haryana *viz.,* Shahabad, Karnal, Sonipat, Jind, Kaithal,Gohana, and Panipat, seven sugar mills of Uttar Pradesh *viz.,* Thanabhawan, shamli, khatauli, Chandanpur, Akbarpur, Sabitgarh and Ramkola, and one sugar mill, Milak Narayanpur area in Uttrakhand. ESB, TB, RB, SB, pyrilla, BB and termites were listed as key pests of sugarcane in Haryana. Gurdaspur borer, pink borer and blister mitewere identified as a minor pests of sugarcane in Haryana, Uttar Pradesh and Uttrakhand. Pyrilla, army worm, grass hopper, white fly, yellow mites, mealy bug and thrips were recorded as occasional pests in the zone. TB incidence was 0.0 to 60.0, 0.0 to 40.0 and 0.0 to 43.0% in Haryana, western Uttar Pradesh and Uttarakhand, respectively. RB incidence was 0.0 to 18.0, 0.0 to 20.0 and 0.0 to 25.0% in Haryana, western Uttar Pradesh and Uttarakhand, respectively. SB incidence was 0.0 to 17.0, 0.0 to 21.0 and 0.0 27.0% in Haryana, western Uttar Pradesh and Uttarakhand, respectively. Black bug incidence varied from traces to 9.0, 13.0 and 12.0, individuals/ tillers in Haryana, western Uttar Pradesh, and Uttrakhand. White grub incidence varied from traces to 2.0 grubs/ m^2 and traces to 2.0 grubs/m^2 mostly in sandy soils in western Uttar Pradesh and Uttarakhand. Blister mite varied from traces to 46.0, 53.0 and 50.0% in Haryana, western Uttar Pradesh and Uttarakhand, respectively.

(S.K. Pandey)

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

A non-replicated experiment with sugarcane variety Co 15023 was carried out and monitored the incidences of major insect pests and their bioagents at regular intervals. Incidence of ESB, pink borer and TB was 7.8, 11.0 and 2.3% respectively. RB and termite incidence was 21.2 and 2.3%, respectively. Mean population of black bug was 2.3/cane. *Isotima javensis and Stenobracon deesae* parasitized top borer larvae as 3.2 and 2.7 per cent, respectively. *Cotesia flavipes* a larval cum pre-pupal parasitoid of stalk borer parasitized 3.1% stalk borer larvae in November in the canes.

(S.K. Pandey)

Assessment of yield losses caused by borer pests of sugarcane under changing climate scenario

A new experiment with variety Co 15023 was planted in treated and untreated plots for the evaluation of yield losses caused by borer pests of sugarcane under changing climate scenario. ESB and TB incidence was 7.3 and 5.3% in treated plot and 8.5 and 9.6% in untreated plots, respectively.

(S.K. Pandey)

Unraveling the molecular mechanism of early maturing responsive genes in sugarcane through transcriptome analysis

Juice quality was evaluated at 10^{th} month. Co 15023 had higher sucrose content (20.58%) as compared to Co 0124 (19.10%). Biomass partitioning done at 120, 150 and 240 DAP showed significant difference between Co 15023 and Co 0124. Leaf and stem samples of 10^{th} and 12^{th} month crop of both the varieties were collected and sent for transcriptome and small RNA sequencing and another set of samples were stored at -80 ^{0}C deep freezer.

Sample purification and QC check was done using Agilent Bio-Analyzer and samples with RIN value more than seven were used for library preparation using Tru-seq RNA sample preparation kit and total transcriptome sequencing by using NovaSeq 6000 platform with 1x150bp paired end format. Raw transcriptome sequenc-

es were quality checked using the FastQC tool. Poor quality reads were removed using trimmomatic tools with a threshold Phred score of ≥ 30 (Q30) and a minimum length of ≥ 80 following the removal of the adapter sequences. After processing of raw reads, a total of 1495,270,560 clean reads and 2104161 contigs with the largest contigs having a length of 27320bp and N50 of 1145 bp were obtained from 12 samples of 8 months and which were used for further processing. At 10 months, 1226 372,037 clean reads and 2310251 contigs with N50 of 1003 bp and at 12 months, total of 1467 961, 463 clean reads and 1863548 contigs with N50 of 1364 bp were obtained. After removal of rRNA, the cleaned reads were assembled using the de novo assembler Trinity for both pooled and individual assembly for all the samples.

For *de-novo* assembly, high-quality, adapter-free Q30 reads of all three biological replicates were pooled together to generate clustered de novo assemblies for both early and midlate maturing samples of Co 15023 and Co 0124 by using Trinity assembler v2.11.0. PCA plots (Fig. 130) among the biological samples indicate that replicate of each stage of early and midlate maturing variety are clustered together, suggesting there was greater homogeneity among the replicates and similarly, MDS plot was constructed, the pattern of close proximity among the sets of samples group studied indicated that there was not batch effect error. Annotation and differential gene expression analysis is in progress. For small RNA sequencing, same 8th month and

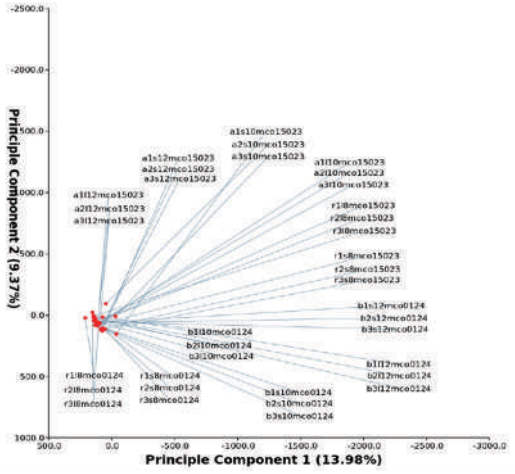


Fig. 130. PCA plot of the biological replicate of each stage clustered together

10th month samples were used for small RNA library preparation using Tru-seq small RNA library prep kit and the quality check was done using an Agilent bioanalyzer. Sample with RIN value more than six was sequenced by using Nova Seq 6000 platform with 1x50bp single end format. A total of 697,633,626 raw reads at 8th month and 902,981,888 raw reads at 10th month stage were generated, out of which 199,320,288 and 209,812,348 clean reads were obtained at 8th month and 10th month, respectively.

(M.R. Meena)

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

Maintenance of reference collection of sugarcane varieties: A total of 167 sub-tropical sugarcane reference varieties were field maintained under disease free conditions in two-row plots of 6m length x 0.9 m row to row spacing. Verification of DUS descriptors of reference varieties was taken as part of DUS characterization of the reference varieties. The following category DUS reference varieties being maintained at ICAR-SBIRC, Karnal are listed below:

BO series-17 varieties; CoP series-7; CoB series-1; CoBln series 8; CoH series 12; CoJ series 5; CoPb series 4; CoLk series 9; CoPant series 9; CoS series 50; CoSe series 14; CoPk 1; UP series 6 varieties, Co varieties 24.

Re-characterization of Reference Varieties: A total of 167 reference varieties maintained at ICAR-SBIRC, Karnal are further being verified and the database of all the verified DUS reference varieties will be submitted to the PPV&FR authority.

Cane yield and quality traits: At 120 DAP, general mean in the DUS reference trial for tiller population was 1.33 lakhs/ha and out of 167 entries, 94 reference entries had recorded numerically superior tiller population over mean tiller population. Top raking entries for higher tillers population were *viz.*, CoP 9103, CoPk 05191, CoS 797, CoS 95255, CoS 97269 and BO 147 with more than >2.0 lakhs tillers/ha. Mean NMC in the trial was 1.20 lakhs/ha and top raking entries with >1.40 lakhs/ha NMC were CoPant 84212, CoPk 05191, Co 12029, BO 153, BO 128, CoBln 9105, Co

0232, BO 120 and BO 136. Top ranking entries for sucrose content of juice at 10th month crop stage were Co 0118 (20.2%), Co 89003 (19.8%), CoLk 7201 (19.4%), CoJ 64 (19.4%), Co 0238 (19.2%), CoBln 9105 (19.15%) and Co 0237 (19%).

First Year DUS testing of candidate variety: First year DUS test results revealed that candidate variety, Co 12029 was distinct from other reference varieties (Co 05011 and CoS 97264) with respect to DUS descriptor traits and the population of Co 12029 was uniform.

Submission of application for registration: Application for registration of new sugarcane variety Co 13035 has been submitted to PPV&FR authority, New Delhi.

(M.R. Meena and Ravinder Kumar)

ICAR-Seed Project, Sugarcane

A total of 35836.97 quintals of quality breeder seed was produced and supplied (against the target of 2,500 quintals) to farmers and sugar mills of Haryana, Punjab, Uttar Pradesh, Uttarakhand and Bihar. Average yield of seed cane was 100.02 t/ha at on-farm and 108.04 t/ha at farmers' field under farmer participatory seed production programme (FPSP). The seed sale of the on-farm seed production was 3425.80 quintals whereas at FPSP farmer's field it was 32411.17 quintals. A total of 10157.79 quintals of seed was supplied in autumn season and 25679.18 quintals were supplied in spring season for planting. The net revenue generated from the sale of seed cane during 2020-21 was Rs 29,40,807 including on-farm seed sale, on-farm settling sale, on-farm SBS sale, institute's share from the FPSP seed sale (@ Rs 20 per quintal), institutes share from FPSP settling sale, and institutes share from FPSP SBS sale.

Variety-wise seed cane supply

Seed cane of the important released varieties of the Centre was supplied to the stakeholders (sugar mills/farmers) of six states *viz.*, Haryana, Punjab, Uttar Pradesh, Uttarakhand and Bihar. Among the states, the highest quantity of seed was supplied to Punjab (17949.86 quintals) followed by Uttar Pradesh (9033.03 quintals) and Uttarakhand (5484.57 quintals). The seed was also supplied to Bihar to test their suitability in respective zones (Table 30).

Settling production and sale: A total of 4,34,537 settlings were produced and sold worth Rs. 11,53,664.

Treated single bud production and sale: To promote settling transplanting technique, interested farmers were provided with fungicide and insecticide-treated single bud setts (7,67,953) using sett treatment device.

MoU signed with sugar mills: For rapid multiplication of healthy seed material using settling transplanting technology, MoUs were signed with M/s Avadh Sugar & Energy Ltd., Hargaon, UP and M/s Avadh Sugar & Energy Ltd., Seohara, UP.

Revenue Generated from MoU: Institute received Rs 2,50,000 from M/s Mawana Sugar Mill, Nangalmal Sugar Complex Nangamal, UP, from MoU, signed previous year for rapid production of healthy seed material.

Autumn season (2021)

Seed cane production and sale from FPSP farms: A total of 2574.4 quintals of breeder seed of varieties, Co 0118 (1558.1 quintals) and Co 0238 (1016.3 quintals) was produced and supplied to various sugar mills of the region.

Table 30. State-wise and variety-wise seed cane (quintals) supplied

State	Co 0118	Co 0238	Co 12029	Co 13035	Co 15023	Total
Haryana	642.60	249.30	30.80	21.50	454.31	1398.36
Punjab	274.00	16944.74		0.55	682.57	17949.86
Uttar Pradesh	2558.90	3248.39	449.95	5.81	2769.98	9033.03
Utrakhand	4874.12	607.95			2.50	5484.57
Bihar	1045.85	210.10			715.20	1971.75
Total	9394.97	21308.48	480.75	27.86	4624.56	35836.97

On-farm single bud setts sale: A total of 14,35,607 tissue culture single bud setts and 1,88,200 normal single bud setts of Co 15023 was supplied to various stakeholders.

FPSP single bud setts sale: A total of 1,12,400 tissue culture single bud setts and 3,43,560 normal single bud setts were produced and sold to various stakeholders from FPSP farmers' field.

Revenue generated: A total of Rs 24,38,697 was earned as revenue from on-farm (Rs. 23,41,613) and FPSP (Rs. 87,084) seed production activities.

(Ravinder Kumar)

Healthy seed production and mechanization of sugarcane agriculture - A farmer's participatory initiative

A total of 23,160 quintals of seed cane, nearly 7.0 lakhs settlings and 3.0 lakhs single bud setts were produced at seed entrepreneur's farm. Produced ready to transplant settlings within 7-8 days in plant growth chamber by standardizing the temperature and RH level (30 ^{0}C and 90% RH). Utilizing the facility, over 1.5 lakhs settlings were produced during peak winter (temperature at which sugarcane do not grow). To break the dormancy of aged buds, the practice of keeping them in jute sacks and covering with 2-3 inch cocopeat on the top at 30 ^{0}C temperature, 90% RH and 72 hrs darkness was found effective. For fast production of settlings during harsh climatic conditions, the facility of plant growth chamber was utilized, the temperature, relative humidity and photoperiod were standardized. Generally, during winter sugarcane does not grow; during favorable temperatures also it takes 15-20 days for germination. But at 30 ^{0}C temperature, 90% RH and 24 hrs artificial light (in tissue culture racks), uniform germination occurred within 72 hrs and settlings attained ready to transplant stage within 8-10 days. Nearly 1.5 lakhs settlings were produced during December-January by this practice. Designed racks for keeping seedling trays/portrays in a multilayer (seven) for efficient utilization of space in plant growth chamber and in open area.

(Ravinder Kumar, M.R. Meena, M.L. Chhabra, S.K. Pandey and Pooja)

Sugarcane breeder seed production and demonstration of intercropping

Breeder seed of varieties *viz.*, Co 0238, Co 0118 and Co 05011 was planted at farmer's field in Haryana and Uttar Pradesh in 10 ha. A total of 12,000 quintals of breeder seed was produced and the farmers were referred to the NFSM (CC) seed farms for purchasing healthy seed. The seed crop was monitored at regular intervals and farmers were advised to take various intercrops *viz.*, chickpea, carrot, garlic, radish, wheat, mustard, cabbage, potato, onion etc. in autumn planted seed crop.

(Ravinder Kumar and M.R. Meena)

5.7 ICAR-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 of 15 test clones was conducted along with three check varieties under waterlogged conditions in randomized block design with three replications. Analysis of variance showed that significant difference existed among the clones for all the traits except for juice extraction percent. NMC ranged from 38 to 78. Three clones WL 17-2022, WL 17-785 and WL 17-1434 had the highest number of canes. Cane thickness ranged from 2.1 to 2.9 cm and the clone WL 17-853 had the thickest cane. Cane length of the clones varied from 210 to 299 cm and single cane weight from 0.7 to 1.7 kg. HR brix at 8th month ranged from 19.3 to 24.7%. All the test clones recorded above 20% HR brix at 7th month and the highest was in WL 17-785. Brix at 10th month ranged from 16 to 22.8%. The lowest recorded brix was for Co 62175 and the highest for WL 17-1373. Sucrose content of the clones varied from 15.2 to 21.5%. Clones WL 17-1344, WL 17-760, WL 17-1373,WL 17-785 and WL 17-1804 had high sucrose content and are potential genetic stocks for sucrose. Co 62175, WL 17-1344 and Co 86032 were the highest yielders. CCS yield per plot ranged from 6.1 to 12.3.WL 17-

1804 and WL 17-1344 along with Co 86032 are top performing clones for CCS yield per plot. Of the clones tested, eight were MR, five MS and two susceptible to red rot. Based on CCS yield, WL 17-1804 and WL 17-1344 were advanced to PZVT trial. From the pre-zonal varietal trial 2020-21 at Coimbatore, a waterlogging resistant clone WL 13-711 (Co 99006 X WL 10-20) was selected as Co 21010.

In the second clonal trial, 35 clones were evaluated for yield and quality traits along with three check varieties in three replications. Reaction of test clones to red rot pathogen through artificial inoculation revealed that 19 clones were MR, 12 MS and two S. Analysis of variance showed that significant variation existed among the clones for traits like HR Brix at 8th month, SCW, extraction percent, cane length , Brix at 10th month , sucrose % and CCS%. Traits like cane thickness, yield and CCS yield per plot showed significant variation at 5% level of significance. There was no variation for NMC. Single cane weight ranged from 0.8 to 1.6 kg, WL 18-586 and Co 62175 recorded the highest SCW. HR brix at 8th month ranged from 17.7 to 23.8% (WL 18-720). Most of the clones (68%) had HR brix above 20%. Extraction percent of the clones ranged from 18 to 51%. Wide variation exists among the clones for cane length from 187 to 306 cm. Variation among the clones was comparatively less for cane thickness which ranged from 2.2 to 2.8 cm. Brix at 10th month ranged from 17 to 22 %. The highest brix was for Co 99006. Sucrose content at 10th month ranged from 14 to 21% (Co 99006 and WL 18-720). Yield per plot of the clone ranged from 13 to 51 kg. CCS yield per plot ranged from 1.8 to 7.4 kg. Three check varieties along with 30 test clones didn't have any significant difference among them.

In the first clonal trial, 116 clones were evaluated for yield and quality traits. Germination count ranged from three to 42 with an average of 22 and tiller number ranged from 2 to 79 with an average of 41. NMC ranged from 1 to 46 shoots with an average of 26. WL 19-500, a progeny of WL15-1179 x WL 13-456 had the highest NMC. Average cane thickness was 2 cm and it varied from 1.5-3 cm. Around 38 % of the clones had thickness above 2.5 cm. Average HR brix at 8th month was 22% and it varied from 18-25% for both top and middle portion of the cane whereas it was 18-24% for bottom of the cane. Most of the clones (98%) had HR brix 20% and above. Selected clonal were advanced to the second clonal trial.

Seedlings (912 nos) from 12 crosses were evaluated for NMC, cane thickness and HR Brix at 8th month. NMC ranged from 1-12 with an average of 2.3. Cane thickness ranged from 0.8-3.2 cm with an average of 1.8 cm. Average HR brix at 8th month was 20.5% and it ranged from 10 to 25.8%. The highest HR brix % was for the clone WL20-736 a progeny from the cross WL 15-1179 x WL 10-118. Based on the performance, 71 were advanced to first clonal trial.

Seventeen crosses were made for developing waterlogging resistant clones and the fluff obtained were sown in trays for germination to transplant in the field.

Potential clones of waterlogging resistance (29 clones) that are maintained over the years were evaluated for yield and quality traits for registering as genetic stocks. Yield and quality traits were compared with the standard check varieties Co 86032, Co 62175 and Co 99006. All the evaluated clones were either R or MR to red rot pathogen. NMC ranged from 13 to 42 with an average of 26. Clone WL11-2534 had the highest NMC. WL 08-259 and WL 05-726 also had tiller count above 40. Average cane thickness was 2.4 and 11 clones (WL06-85, WL 06-182, WL07-653, WL09-785, WL 10-24, WL 10-102, WL 10-105, WL 13-318, WL 13-711, WL 16-457 and WL 16-498) had thickness above 2.5 cm. SCW of the clones ranged from 0.8- 1.5 cm and the clone WL 16-457 had the highest SCW. Brix% at 11th month ranged from 16.4 (WL 08-270) to 22.7(WL 10-24) and 15 clones had Brix% over and above the average value of 19.9. Sucrose content at 11th month ranged from 13.6 (WL 08-270) to 21.5% (WL 05-499). WL 16-498, WL 13-711, WL 12-749, WL 11-2230, WL 10-102, WL 10-24 and WL 05-499 recorded sucrose content above 20%. CCS yield in kg per plot ranged from 1.6 to 6.4. Clones WL 05-726, WL 10-85 and WL 10-102 recorded CCS yield in kg per plot on par with check variety Co 99006.

(M. Nisha K. Chandran and V. Krishnapriya)

Enhancement of sugarcane germplasm and development of pre-breeding material

Utilisation of germplasm resources for developing new genetic stocks

A final clonal trial was conducted with 13 clones of different back cross progenies of inter-specific crosses. GUK 17-409,17-301 and 17-374 was shown high brix >21% brix at 7th month and MR to red rot. One clone GUK 17-301 was found significantly superior for CCS yield over check varieties and was MR to red rot and identified for PZVT. GUK 17-302 was on par with the check varieties for CCS yield and were MR to red rot. Of the five clones evaluated with the background of red fleshed *S. robustum,* GUK 17-195 showed brix above 20% at harvest with sucrose 18.5%. In the second clonal trial, 25 clones were evaluated with two checks. Four clones were found promising for CCS yield on par with the standards out of which GUK 18-413, GUK 18-452 and GUK 14-454 were with red-fleshed *S. robustum* and five clones had more than 20% brix an 19% sucrose at harvest. Sixteen clones were advanced to final clonal trial.

Seventy-two clones of various interspecific crosses were evaluated in first clonal trial along with two check varieties for cane thickness, brix at bottom, middle and top, NMC and tillering. About 40% of the clones had HR Brix above 20% and 25 clones were selected for further evaluation. Twenty-eight crosses were attempted and fluff is sown for germination.

A total of 257 inter/ intraspecific derivatives developed over the years were evaluated under waterlogged conditions for yield and quality traits in an un-replicated trial. The promising clones for CCS yield and cane yield were selected for evaluation under replicated trial. Thirty-three clones were found promising for CCS yield and 21 clones for cane yield.

In the trial to identify new sources of resistance to internode borer, red-fleshed *S. robustum* accessions *viz.,* 28 NG 219, NG 77- 132 were found to be free from INB incidence consequently for two years at field level.

(K. Chandran, M. Nisha and B. Mahendran)

Maintenance of world collection of sugarcane germplasm

Maintenance and evaluation of germplasm

Maintenance: The world collection of sugarcane germplasm, with 3375 clones are maintained in field gene bank by annual re-planting. Two *S. robustum* clones (NG 77-215 and IJ 76-336) with very poor growth in field conditions were lost because of germination failure. These clones were not even amenable to in vitro culture methods. Flowering of the germplasm clones was monitored. Striped canes 28 NG 210, 28 NG 220, 57 NG 77 and IJ 76 58 and one clone with purple coloured leaves flowered and was utilized for crossing. Flowering ranged from 10.2% *(S. officinarum)* to 96.2% (IA clones). Flowering percentage of other sets of clones were *S. spontaneum* (Exotic collection) 89.9%, Allied genera (IND) 71.6%, exotic hybrids 58.8%, allied genera (exotic collection) 29.6%. *S. robustum* 31.7%, Indian hybrids 40.7%, *S. barberi* 14.3%, *S. sinense* 20% and *S. spontaneum* (IND) 20.7%.

Evaluation: Forty-two clones of *S. barberi* and 30 clones of *S. sinense* were evaluated for yield and quality traits. In *S .barberi* collection only 12 clones showed brix above 15%. Brix ranged from 8-17.4% and sucrose 3 to 14.5%. Similarly, in *S. sinense* 13 clones showed brix above 15% and the range for brix was from 11.01 to 17.34% and 3.64 to 13.99% for sucrose.

A trial was conducted to understand the yield potential of soft rind *S. officinarum* clones to identify promising clones for chewing/ornamental purposes. None of the *S. officinarum* clones out yielded the check variety for any of the yield and quality traits. However, for cane yield, Kaludai Boothan and 57 NG 257 falls in the same homogeneous subset with the check variety Co 86032 for cane yield and Chittan and Creola ryada were in the immediate below subset. For CCS yield, Kaludai boothan was promising followed by Malabar, 57 NG 257, Chittan and Poona.

A total of 46 germplasm clones comprising *S. officinarum, S. barberi, S. robustum* clones that are identified as promising under natural flood condition in the previous year were evaluated for yield and quality under waterlogged conditions in two replications along with two standard va-

rieties Co 62175 and Co 99006. Average performance of the clones for cane thickness, Brix% at 10th month, Pol% at 10th month, CCS% and CCS yield per plot was better in the waterlogged condition compared to the control without waterlogging. Under waterlogging condition, average cane thickness was 1.9 cm and 21 clones recorded thickness above 2.0 cm. Average brix under waterlogging was 13.9% whereas, it was 13.3% under normal conditions. Similarly, pol% was 10.6% under waterlogging and 9.0% under normal conditions. *S. officinarumclones* 28 NG 54, Aboe amboina, Awela 68, Badila, Caira, IJ 76-315 and *S. barberi* clone White Pindaria were not affected for NMC under waterlogging. All clones showed a reduction in internode length and leaf width under waterlogging conditions. *S. robustum* clones NG 77-132 and NG 77-73 and the check variety Co 99006 showed no reduction in leaf length under waterlogging. Cane length of the clones considerably reduced under waterlogged except 28 NG 219 and NG 77 78 *(S. robustum)*. Extraction %, cane yield and SCW was showing a reduced trend under waterlogging in majority of the clones. However, sucrose content was higher under waterlogged conditions and CCS yield was not severely affected due to waterlogging in many of the *S. officnarum* clones. CCS yield of *S. robustum* clones could not be carried out as the extraction percentage was very low in the clones under waterlogged condition.

(K. Chandran and M. Nisha)

Monitoring of diseases and quarantine

Ring spot, brown spot, wilt, stalk rot, smut, freckle and YLD were observed in germplasm clones. Ring spot was found maximum with 4-5 disease scale in Awela Green Sport, Azul de Caza, Saipan D, Sarawak unknown of *S. officinarum,* 57 NG 28, IJ 76-449 *S. robustum* and Co 1026 and Q42, H 48, F 46-240, POJ 2946, LF 65-3705 of Foreign hybrids. 21 NG 54, 57 NG 156, 57 NG 159 STR, IJ 76-522, IJ 76-556, NG 77-117 of S. officinarum and Co 252, Co 303, Co 308. Co 309, Co 312, Co 863, Co 864, Co 873, Co 878, Co 993, found free from ring spot. Many clones of *S. barberi,* and *S. robustum* were found either free or very low incidence of ring spot.

Rust appeared first in July. IND 81-74, IND 81-80, IND 81-82, and IND 81-83, IND 81-99, IND 81-100 clones of *S. spontaneum,* IJ 76 501 of S. officinarum, Co 205, Co 213, Co 214, Co 229, Co 237, Co 361, Co 388, Co 371, Co 372, Co 373, Co 376, Co 377, Co 462, Co 483, Co 508, Co 518, Co 519, Co 527, Co 529, Co 659, Co 686, Co 697, Co 749, Co 850, Co 1092, Co 1126, Co 1107, Co 1108, Co 1109, Co 1110, Co 1113, Co 7703, Co 62160, Co 62161, Co 62218 of Indian hybrids, CP 44-155, CP63-307, CP63-313, CP84-1198, PR 1053, 1085, POJ 279, ORB 6 foreign hybrids were affected. Disease incidence was less in many clones and among the clones, disease rating scale was high in IJ 76-501(7), IND 81-74(9), IND 81-82(9) IND 81-83(9), IND 81-99(7), Co 519(7), 749(7), 1092(7), 376(7), CP 84-1198(7), CP 63-313(7), PR 1083(7).

Brown spot was observed in 51 NG-143 and 57 NG-248 Tolo Fau Lau 1, Tombiapa, Warni Bola, NC 33, NC 90, 96 NG 14A, 28 NG 15, 28 NG 62, 28 NG 224, 57 NG 188, 57 NG 203, Penang, 21 NG 5, of *S. officinarum* and Co 213, Co 244, Co 248, Co 293, Co 295, Co 302, Co 308, Co 319, Co 322, Co 325, Co 333, Co 334, Co 335, Co 336, Co 337, Co 341, Co 348, Co 349, Co 375, Co 376, Co 377, Co 378, Co 385, Co 387, Co 62057, Co 62023, Co 6509, Co 7702, CoK 30, CoK 32, CoK 36, CoS 221, CoS 443, CoS 574, Co 7709, Co 7804, Co 8232, Co 5568, IC 232, 227, SEL 76159, Co 0238. Brown spot incidence was maximum at the end of cropping season.

Smut was observed in Putlee Khajee, NG 77-76, 57 NG 231, IJ 76 268, IJ 76-489, 51 NG 27 of *S. robustum,* H 15-723, H 15-7000 of foreign hybrids, Co 62175 and Co 06030.

False smut was recorded in hybrid clones only (Fig. 131). The affected clones were Co 292, Co 293, Co 318, Co 337, Co 648, Co 641, Co 639, Co 628, Co 625, Co 621, Co 805, Co 804, Co 822, Co 857, Co 1000, Co 1177, Co 6201, Co 62073 of Indian hybrids, POJ 2802, POJ 2805 of foreign hybrids.

Stalk rot was found in Big Tanna St Felix, Korpi, Kaludai Boodhan, Mauritius 131, NC 53, 57 NG 149 N. S, NG 77-11, NG 77-28. 57 NG 140 and 28 NG 10 of *S. officinarum* were affected by wilt. Freckle and chlorosis due to SCBV was found in Listada, Castilla, China, Guam A, 28 NG 36, Stripped Tanna, Irang Malang, Hawai Original 36, Hawai Original 38 and 28 NG-264 of S. officinarum. YLD was recorded in *S. robustum* clones

Fig. 131. False floral smut caused by **Claviceps purpurea**

such as IJ 76-435, IJ 76-494, IJ 76-496, NG 77-176, NG 77-214, IJ 76-427, IJ 76-459 and IJ 76-494 and also EPC 33-332 of foreign hybrids. Disease affected plants were treated with fungicides and smut affected plants were uprooted and burned.

(R. Gopi)

Monitoring for pest incidence, biological control of the pests

Sugarcane germplasm maintained at ICAR-SBIRC, Kannur was monitored for occurrence of insects and their natural enemies. Insect pests *viz.,* INB, pink borer, *Pyrilla* and leaf mites were found to be occurring at various ranges. In addition to that, sporadic infestation of mealy bugs, scale insects, and sugarcane aphid, *Melanaphis sacchari* were noticed. Sugarcane leaf web mite infesting germplasm accessions of *S. spontaneum,* morphologically identified as *Schizotetranychus krungthepensis* Naing & Auger (Acarina: Tetranychidae) and biological control option using predatory mite *Typhlodromus (Anthoseius)* transvaalensis (Nesbitt) (Acari: Phytoseiidae), which is available with ICAR–NBAIR is being explored.

During September-October, sugarcane woolly aphid: *Ceratovacuna lanigera* colonies was noticed in Indian hybrid accessions *viz.,* SEL 76/59, Co 201, Co 204, Co 213, Co 214, Co 229, Co 353, Co 355 Co 392, Co 393, Co 395, Co 512, Co 785, Co 786, Co 787, Co 62037, Co 96011, Co 96017, Co 96018, Co 98007, Co 99006, CoS 574 and IC 218. The activity of parasitoid, *Encarsia flavoscutellum* adults was noticed on aphid colonized leaves and the same have emerged from aphids in captivity. Moreover, the processed aphids showed up to 24.0% parasitism from *E. flavoscutellum* during September-October and syrphid predators such as *Dideopsis aegrota* larvae were very active during the period. Soap solution was used in border rows to prevent spread of aphid and small patches of infestation being monitored and maintained as refugee crop in order to encourage and sustain the natural enemies. Parasitoid *E. flavoscutellum* and syrphid predators have successfully wiped out the aphid population by November first week and no new infestation was noticed after that.

INB incidence was noticed less than 6% of the accessions across all crop assemblages with mean percent infestation of 9.1% on cane basis. Soil based application of insecticide Fipronil 0.3% GR was undertaken at the time of sett planting for the management of pink borer. Pyrilla population was effectively suppressed by natural pathogenicity of entomopathogenic fungi, *Hirsutella sp.* along with other natural enemies *viz.,* egg parasitoid, *Parachrysocharis javensis* and nymphal parasitoid, *Dryinuspyrillae.*

Diversity and abundance of above-ground arthropods in different sugarcane germplasm crop assemblages were studied. A total of 523 inver-

tebrates belonging to 10 taxonomic orders *viz.*, Orthoptera, Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Odonata, Blattodea, Mantodea and Araneae were recorded. In terms of abundance, Hymenoptera recorded the highest abundance constituting 21.41% of all individual morpho-species recorded, followed by the Coleoptera with 20.84% and Hemiptera with 19.50%.

(B. Mahendran)

In vitro conservation of germplasm

Around 100 *S. officinarum* clones were *in vitro* cultured using shoot tip and are maintained through sub culturing. Indirect regeneration through callus was attempted in six clones of *S. officinarum* (51 NG 131, IJ 76-314, IJ 76-559, NG 77-92, NG 77-63, NG 77-67, NG 77-18) with ornamental value for inducing further variation and selection. 51 NG 131 and NG 77-92 were regenerated through callus culture (Fig. 132).

Fig. 132. Indirect regeneration from explant of 51 NG 131

Molecular characterization of *S. officinarum* clones

DNA fingerprinting of 50 *S. officinarum* clones were done using SSR markers *viz.*, MSSCIR 68, MSSCIR 1, MSSCIR 9, SMC 278 CS, SMC 1572 CL, SMC 336BS, NKS 27, NKS 23, SCC 01 and SCB 10. The primers produced a total of 73 amplified fragments. The number of fragments amplified by the primers ranged from 4 to 7. Polymorphism information content of the primers varied from 27 to 60%. Primer NKS 27 had the least PIC value and primer SMC 1572 CL had the highest PIC value. Similarity coefficient among the clones ranged from 65 to 100%. IJ 76-314 and IJ 76-474 had similar patterns with these primers and could not be differentiated. Similar was the case with the following pairs Fiji 15 and Fiji 20; Tamarin reunion and Tanna.

(K. Chandran and M. Nisha)

Harnessing antagonistic microbes for the management of wilt and rot diseases in sugarcane

Mass multiplication of best performing *Trichoderma* isolates for wilt, stalk rot and sett rot was done using liquid jaggery-yeast medium and Potato dextrose broth (PDB). The number of spores were counted 10 days after inoculation and it was found that liquid jaggery yeast medium recorded maximum spores (more than 10^6) than PDB(10^5). Talc based formulation was made and is stored for further analysis, field and pot study. Rhizosphere bacteria (BC 20 (2.5 & 5%), BC 23 (2.5 & 5%), PF 4 (2.5 & 5%), PF 60 (2.5 & 5%), BC 36 (2.5 & 5%), consortia along with Bavistin 0.1% and control) were tested in field for its efficacy for growth promotion. The treated plots also were monitored for the occurrence of diseases. BC 36, PF 4 and PF 60 @ 2.5% recorded maximum germination of 61.66%, 58.88% respectively whereas control recorded only 30.66%; all the isolates recorded maximum tiller count @ 2.5% than @ 5%. NMC was maximum for PF 60(41.33) and hot water followed by BC 36 @2.5% (41) than control (38). Number of leaves, leaf length, width, cane length, cane weight, cane thickness, juice weight, Brix and sucrose were studied for all the treatments and all the parameters were found non-significant except cane weight. Three cane weight was maximum for PF 4 @ 2.5%(3.90 kg) followed by BC 36@ 2.5% (3.83 kg) and 5%(3.77 kg) and control recorded 3.65 kg.

(R. Gopi and K. Nithya)

Studies on sugarcane pests and their management

Evaluation of seasonal dynamics and biological control of sugarcane pyrilla, Pyrilla perpusilla, in crop island scenario

Seasonal dynamics of P. perpusilla *and its natural enemies:* Observations were recorded on population dynamics of *Pyrilla* and its natural enemies on sugarcane germplasm across different crop assemblages from June to December 2021. Over-

all seasonal activity of pyrilla was less compared to the previous three years. The peak *Pyrilla* population comprising nymphs and adults were recorded during October-November (4.18-6.17pyrilla/leaf), with most abundant on *S. officinarum* and hybrids of Indian and foreign origin that are in high density crop patches in the ecosystem. The activity of egg parasitoid, *Parachrysocharis javensis* was noticed throughout the cropping season with a mean parasitizaton of 71.38%. Parasitization by *Dryinus pyrillae* on nymphs of *P. perpusilla* was noticed during June to October with peak level of activity (11.06% mean parasitization) in August. Natural pathogenicity of *Hirsutella* sp. was also noticed on nymphs and adults with highest number of mycosed dead cadavers (0.18 cadavers/leaf) recorded in October.

Introduction and colonization of the ecto-parasitoid, Epiricania melanoleuca: The egg masses and pupae of *E. melanoleuca* collected from fields of Karnal Centre were brought to Kannur for introduction and colonization. During 1st week of September, inoculative release of more than 75 pupae and egg masses was done at field level in *S. officinarum* crop assemblage by tagging to selected accessions. Consequently, as the first sign of establishment, numerous pupae of *E. melanoleuca* were noticed on various accessions *viz., Aboe Amboina, Koelz 11132, Raratonga 2, Fiji 31, Hina Hina 18, Badila Fiji, Awela 68, Bandjer Masim Hitam, Local Red, NC 18, Big Tanna St. Aubin, Big Tanna Mon Desert, Pompex Rat Gros Ventre and Vae Vae Ula* in the field during post release period of October-December. Since first inoculative release was found to be successful, it is expected that *E. melanoleuca* fully establishes and exert control over *Pyrilla* populations in coming seasons.

Augmentative use of entomopathogenic fungi for pyrilla control: Natural pathogenicity of entomopathogenic fungi (EPF) on *Pyrilla* were found to occur at Kannur and during favourable conditions it caused epizootics that led to complete suppression of the *Pyrilla* populations at the field level. Attempt has been made to isolate and laboratory culturing of EPF associated with *Pyrilla* cadavers. Field occurrence of EPF, *Metarhizium sp.* was recorded during 2018-20 and subsequent isolation, pure culturing (Fig. 133) and

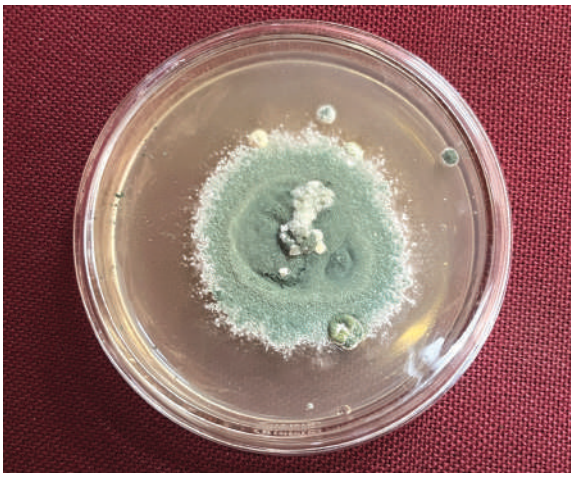


Fig. 133.* Metarhizium flavoviride *culture on PDA

molecular identification (GenBank accession: OK175688) confirmed the occurrence of *Metarhizium flavoviride* Gams & Rozsypal at field level causing pathogenicity on *Pyrilla* populations for the first time in India. The highly fastidious entomopathogenic fungus, *Hirsutella sp.* also isolated from adult cadavers and found to be producing mucilaginous colonieson SDAY with numerous synnemata and blastospores. For the augmentative use of EPF, three-pronged strategy *viz.,* spray of spore suspension on leaf surfaces, distribution of mycosed adult cadavers and release of spore-laden/contaminated adults was devised. Mass culturing of *M. flavoviride* inpotato dextrose broth (PDB) under laboratory conditions was successfully done and talc based formulation has also been made (Fig. 134) for easy

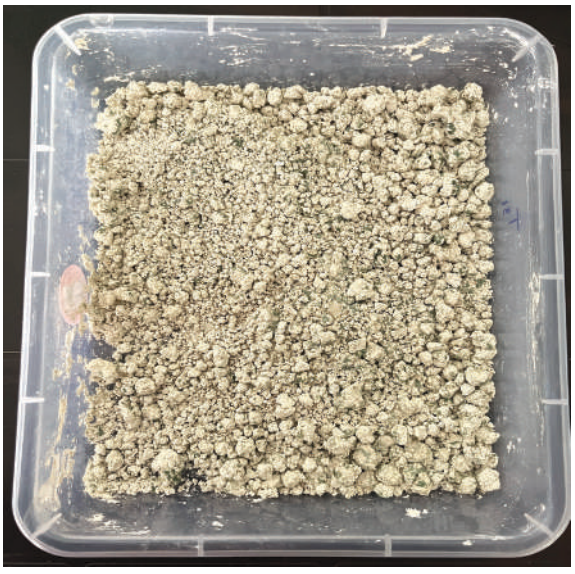


***Fig 134. Talc based formulation of* Metarhizium flavoviride**

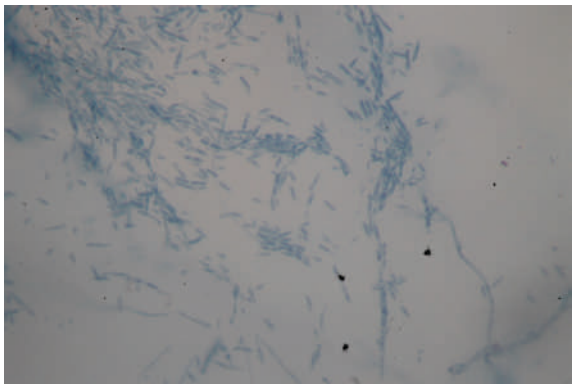


Fig. 135. Blastospores of **Hirsutella** *sp.*

handling, storage and field level augmentation. High concentration of blastospores of *Hirsutella* sp. (Fig. 135) has been obtained in liquid cultures and its infectivity efficiency is being studied on *Pyrilla* nymphs and adults.

(B. Mahendran, R. Gopi and P. Mahesh)

Value addition and product diversification in sugarcane

Development of technologies for value-added products from sugarcane

Powder jaggery production process with organic clarificant was standardized and licensed as technology for commercialization.

A total of 1036 Indian hybrids were characterized for flesh colour in a view of freeze preservation of sugarcane juice. Flesh colour was found to influence juice colour. Majority of the clones had yellowish green (62%) coloured flesh followed by light green 20.8%. The other shades creamy yellow in 6.1%, greenish white 4.7%, off white 3.8% and yellowish brown 2.5% were also observed. Light green flesh colour yielded more attractive colour to the fresh juice.

Freeze preservation method of fresh juice was standardized in the form of sip-up packing (Fig. 136a) and blocks of 500ml/ 1L (Fig. 136b) without losing the colour, freshness and quality.

Fig 136a. Sip-up

Fig. 136b. Juice blocks

5.8 ICAR-SUGARCANE BREEDING INSTIUTE RESEARCH CENTRE, AGALI

Germplasm maintenance, hybridization and off-season nursery

Germplasm maintenance

A total of 1390 germplasm including 'Co' canes, 'Co' allied clones, exotic clones, inter-specific and inter-generic hybrids, core collection of *S. officinarum,* species clones of *S. barberi, S. sinense, S. robustum, Erianthus* spp., *Sclerostachya* and *Narenga* are clonally maintained in the field.

Flowering in 2021: Out of 1390 germplasm accessions, 907 accessions flowered and the intensity of flowering was 65.25%, which is nearly 20% higher than the previous year (46.01%). The increased flowering intensity was noticed in commercial canes, and in species clones of *S. officinarum.* Among the 230 *S. officinarum* clones maintained at National Distant Hybridization Facility (NDHF), Agali, 76 clones flowered in 2021, which is 5% higher than the previous record (28.30%). However, flowering intensity with respect to other species clones such as *S. barberi, S. sinense* and *S. robustum* was negligible. Three clones of *S. robustum,* eight clones in *S. sinense* and three clones in *S. barberi* flowered. Intensity of flowering in 'Co' canes (81.90%) and Co-allied clones (83.92%) were nearly 30% high-

er than 2020 (59.50%). The flowering intensity recorded in *E. arundinaceus*, other *Erianthus* sp. and allied genera was not significant as compared to the previous year. Anthesis (opening of spikelets) began from 30 August 2021 and lasted up to 30 November 2021. The *S. officinarum* clones *viz.*, 57 NG 174, Monget gayam, Naz, Otaheite, LF 89-2064, Suphan-50, Sugar doctor, White transparent, were the early flowerers (flowered in last week of August 2021).

Hybridization: A total of 220 crosses were made in 2021. Due to Covid-19 restrictions, breeders from eight AICRP(S) centers (Cuddalore, Karnal, Kapurthala, Lucknow, Padegeon, Powarkheda, Sankeshwar and Shahjahanpur) only utilized the NDHF. Five each distant/wide crosses, were made for Pune and Perumalapalle Centres as per their request and choice of parents.

Ground nursery: A total of 28 clones having >24% brix at 300 days were selected from the 564 BC3 progenies, derived crosses involving cold tolerant *S. spontaneum* (SES 114) as one of the parent, in ground nursery.

(V. Sreenivasa and A. Annadurai)

DUS testing of sugarcane

Maintenance of Reference varieties: A total of 233 reference varieties (RV) of tropical sugarcane were maintained in field through clonal propagation at Agali Centre (Kerala) of ICAR-SBI. Recorded DUS data of newly added 45 RV.

DUS testing: DUS test for three new sugarcane varieties (NV) namely, Co 09004, Co 11015 and Co 10026 were undertaken at Agali Centre during 2021-22 season. For the conduct of first year DUS test for the NV, Co 11015 and Co 10026 settlings of these varieties along with its closely resembling RV (Co 85002, Co 85019 for Co 11015 and CoN 95132, Co 7508 for Co 10026) and Zonal standards (Co 86032, CoC 671) were raised in polybags during January 2021 and were transplanted in the main field on 10 March 2021. For the conduct of second year DUS test for the NV Co 09004, setts of this variety and its closely resembling RV (CoV 89101, CoN 95132, Co 7717) and zonal standards (Co 86032 and CoC 671) were transplanted in field on 10th March 2021. In both the trials, the plot size for each variety was 4 x 6 m x 0.9 m, and 10 settlings per row was maintained. Each variety was planted in two replications. Recording of DUS data from NV and RV were completed in both the trials. Preliminary results indicated that the NV Co 09004, Co 11015 and Co 10026 were distinct from the closely resembling RV.

Multiplication of seed cane of candidate varieties: Received seed canes of two new cane varieties namely, CoA 14321, CoA 14323 and one extant variety, CoM 0265 for DUS test. Setts of these varieties were planted and multiplied to take up DUS trial.

(V. Sreenivasa and R. Karuppaiyan)

6. EDUCATION AND TRAINING

6.1 EDUCATION – M.Sc. /Ph.D. program

- Mrs. K. Devi (Guide: Dr. A. Selvi) was awarded Ph.D. degree by Bharathiar University w.e.f. 7.04.2021 for the thesis entitled 'Gene profiling in sugarcane genotypes for drought response and rehydration'.
- Ms. S. Kohila (Guide: Dr. R. Gomathi) was awarded Ph.D. degree by Bharathiar University w.e.f. 16.04.2021 for the thesis entitled 'Characterisation of heat shock proteins and transcript expression profiling of sugarcane in response to high temperature stress'.
- Mr. V.M. Manoj (Guide: Dr. C. Appunu) was awarded Ph.D. degree by Bharathidasan University w.e.f. 07.05.2021 for the thesis entitled 'Overexpression of Glyoxalase III in sugarcane for enhanced salinity and drought stress tolerance'.
- Mrs. C. Brindha (Guide: Dr. S. Vasantha) was awarded Ph.D. degree by Bharathiar University w.e.f 07.09.2021 for the thesis entitled 'Physiological, biochemical and molecular response of sugarcane genotypes to salinity'.
- Mr. Ashwin Narayan (Guide: Dr. M.N. Premachandran) was awarded Ph.D. degree by Bharathiar University of w.e.f. 29.10.2021 for the thesis entitled 'Isolation and functional characterization of Expansin and BRICK genes from wild relatives of sugarcane'.
- Mrs. S. Dharshini (Dr. C. Appunu) was awarded Ph.D. degree by Bharathiar University w.e.f. 28.10.2021 for the thesis entitled 'De novo transcriptome analysis of cold tolerant *S. spontaneum* under low temperature stress and functional validation of selected cold responsive genes in commercial sugarcane'.

Trainings organized

At Coimbatore

- UG/PG Project work: Fifty post graduate students from various colleges/ Universities of Tamil Nadu, Kerala and Rajasthan were allotted to scientists for three/six months and completed their project work earning a revenue of Rs. 10,20,000.
- An exposure training under the SERB project (Project file No: EEQ_2019_000225) was given by Dr. K. Lakshmi, Senior Scientist to Smt. R. Mahalakshmi during 08 November 2021 to 08 December 2021.
- Organized a training program for sugarcane seed farmers on 18 December 2021 at Chengapalli village in collaboration with The Salem Co-operative Sugar Mills, Mohanur. More than 50 sugarcane farmers and all the cane development staff of the sugar mill attended the meeting. Dr. S. Karthigeyan, P.S. (GPB) & Nodal Officer, AICRP on Seed (Crops) – Sugarcane participated.
- Dr. V.P. Sobhakumari organized an awareness program on 'Advanced cytogenetics techniques' to 30 postgraduate students and faculty of Department of Biotechnology, Nehru Arts and Science College, Coimbatore, on 23 December 2021 under 'Scientific Social Responsibility' program of DST-SERB project 'Potential application of Genomic in situ hybridization (GISH) to understand genomic constitution of Saccharum hybrids' (Project No. EEQ/2019/000124).
- Dr. M.R. Meena organized a student exposure visit under DST-SERB project to inculcate scientific culture among the students at ICAR-SBIRC, Karnal on 24 December 2021 for 25 students along with teachers.
- Dr. S.K. Pandey and Dr. M.L. Chhabra visited Triveni Eng. & Ind. Ltd., Sugar Unit-Chandanpur, (UP) and inspected insect pest and disease incidence in the crop. Training was also imparted to cane development officials on 30 December 2021.

At Karnal

Organized three days Orientation Program for cane development officials of Guru Nanak Deo Sugarcane Research & Development Institute, Gurdaspur, Punjab during 23-25 August 2021 (Fig. 137).

Fig. 137. Orientation program (23-25 August 2021)

Organized a training program to cane development staff of Triveni Eng. & Ind. Ltd. Sugar Unit –Sabitgarh, Uttar Pradesh on the management of insect pests and diseases on 16 September 2021 (Fig. 138).

Fig. 138. Training program in Sabitgarh (16 September 2021)

Organized a staff training in 'Ganna Gosth' at Triveni Eng. & Ind. Ltd. Sugar Unit – Raninangal, Uttar Pradesh on 25 September 2021 (Fig. 139).

Fig. 139. Training program in Raninangal, Uttar Pradesh (16 September 2021)

Organized a staff training during 'Ganna Vichar Gosth' at Triveni Eng. & Ind. Ltd. Sugar Unit – Milak Narayanpur, Uttar Pradesh on 26 September 2021.

Organized a training program for staff of Triveni Eng. & Ind. Ltd. Sugar Unit – Chandanpur, Uttar Pradesh during 'Ganna Krishak Gosth' on 27 September 2021.

Fig. 140. Training program in Milak Narayanpur, Uttar Pradesh (26 September 2021)

Organized webinar on 'Successful Sugarcane Entrepreneurship Model' (online) for farmers and sugar mill officials on 08 November 2021.

Under Inter-state program, imparted training on sugarcane cultivation to 50 farmers of Haridwar, Uttrakhand on 08 December 2021 (Fig. 141).

Fig. 141. Training program for farmers (08 December 2021)

6.2 TRAINING AND CAPACITY BUILDING

Participation in training program by officials

- Smt. D. Subhadra: Generic online Training in Cyber security for central government ministries / departments' organized by Ministry of Electronics and Information Technology, New Delhi on 05 January 2021.

- Smt. M. Jainub: Workshop (online) on 'Reservation in services for SC/ST/OBC/EWS' organized by ISTM, New Delhi during 11-14 January 2021.
- Smt. D. Subhadra: 'ICAR-HRM Virtual training program on Health and mental well-being of ICAR staff for enhancing proficiency' organized by ICAR-Indian Institute of Wheat and Barley Research during 25-27 February 2021.
- Smt. V. Ashakumari: Workshop (online) on 'E-office' organized by ISTM, New Delhi during 25-26 February 2021.
- Dr. Krishnapriya Vengavasi: Online training program on Certified professional in carbon foot print organized by Confederation of Indian Industries, New Delhi during 1-5 March 2021.
- Shri.V. Sadhasivam: Workshop on 'Generic online training course in cyber security' organized by Ministry of Electronics and Information Technology, New Delhi on 17 March 2021.
- Smt. M. Jainub: Online workshop on Noting and Drafting organized by ISTM, New Delhi during 22-24 April 2021.
- Dr. V. Jayakumar: Training program for Vigilance Officers of ICAR institutes' organized by NAARM, Hyderabad during16-18, August 2021.
- Dr. A Ramesh Sundar: Training program on 'Biosecurity and biosafety: Diagnostics, phytosanitary treatments and issues' organized by ICAR-NBPGR, New Delhi during 15-24 September 2021.
- Shri. V. Vasudev Galagali: 'Generic online training of Government personnel of central govt. ministries / depts. in cyber security' organized by CDAC, Hyderabad on 16 September 2021.
- Smt. J Emily Florence Daisy Rani: Online training on 'Accrual accounting' organized by ICAR-National Rice Research Institute during 20-24 September 2021.
- Smt. G. Aswathy: 'Competence enhancement program on soft skills and personality development for T1-T4 staff of ICAR' organized by ICAR – NAARM, Hyderabad during 20-25 September 2021.
- Dr. R. Manimekalai, Dr. M. Nisha, Dr. K. Kaverinathan, Dr. N.M.R. Ashwin: Online training programme on Analysis of multi-location experiments organized by NAARM, Hyderabad during 28-30 October 2021.
- Smt. R. Mahalakshmi: Online training on 'Accrual Accounting' organized by ICAR-National Rice Research Institute during 22-26 November 2021.
- Dr. M. Nisha: Online national training programme on 'Conservation, management and utilization of horticulture genetic resources for livelihood and national security' conducted by Indian Institute of Horticulture Research during 22-26 November 2021.
- Dr. K. Lakshmi: Online training program on 'Proteomics data analysis' organized by Centre for Agricultural Bioinformatics, ICAR, New Delhi during 24-26 November 2021.
- Dr. R. Selvakumar: Online training programme on 'Advances in web and mobile application development' organized by ICAR-NAARM, Hyderabad during 6-10 December 2021.
- Dr. A. Vennila: Training on 'Modeling soil physical processes for improving resource use efficiency in agriculture' organized by the Indian Society of Agro Physics, Indian Society of Agro physics and Division of Agricultural Physics ICAR-IARI, New Delhi on 8 December 2021.
- Dr. V. Vinu: Online training programme on 'Statistical designs and analytical methods for multifactor experiments' organized by ICAR-CMFRI, Cochin during 8-17 December 2021.
- Shri. T. Lakshmipathy, Smt.V.P. Rabisha: Online training programme on 'SNP mining, GWAS and genomic selection' organized by Centre for Agricultural Bioinformatics (CABin), ICAR , New Delhi during 16-21 December 2021.
- Dr. S. Anusha: Online national training program on 'Advances in weed management for sustainable agriculture' organized by Indian Society of Weed Science, Directorate of Weed Research, Jabalpur during 13-18 December 2021.

7. AWARDS AND RECOGNITIONS

- Dr. R. Viswanathan, Principal Scientist and Acting Head, Division of Crop Protection, received Sir Syed Ahmed Khan memorial award (Above 45 years) from Aligarh Muslim University (AMU), Aligarh, the AMU Centenary Award for the outstanding research work done in the field of Plant Pathology in the country.
- Dr. R. Viswanathan, Principal Scientist and Acting Head, Division of Crop Protection, received Outstanding Agriculture Scientist Awards – 2020 for the commendable contribution to Plant Pathology and Higher Education by Dr. B. Vasantharaj David Foundation, Chennai.
- Dr. J. Srikanth, Principal Scientist, has been elected as a Fellow (2021) of The Academy of Sciences, Chennai.
- Dr. J. Srikanth, Principal Scientist, has been conferred with Life Time Achievement Award 2020 in Agricultural Entomology by Agricultural and 1-4, Environmental Technology Development Society, Uttarakhand, India
- Dr. J. Srikanth, Principal Scientist, has been conferred with Life Time Achievement Award 2020 in Agricultural Entomology by Dr. B. Vasantharaj David Foundation. Chennai, Tamil Nadu State, India
- Dr. J. Srikanth, Principal Scientist, has been conferred with Paramount Achievement Award 2020 (with cash incentive) by Society for Advancement of Human and Nature, Solan), Himachal Pradesh State., India
- Dr. J. Srikanth, Principal Scientist, has been conferred with Life Time Achievement Award 2020 in Agricultural Entomology by Agro Environmental Development Society, Rampur, Uttar Pradesh State, India
- Dr. J. Srikanth, Principal Scientisi, has been conferred with Life Time Achievements National Award 2021 in the field of Research and Publications by Innovative Research Developers and Publishers., Chennai, India
- Dr P. Malathi, Principal Scientist (Plant Pathology) was awarded 'Sharda Lele Memorial Award (2021)' by Indian Phytopathological Society, New Delhi.
- Dr. P. Mahesh has been conferred 'Scientist Award 2020' in Agricultural Entomology by the Dr. B. Vasantharaj David Foundation, Chennai India
- Dr P. Malathi, Principal Scientist (Plant Pathology) received 'Best Oral Presentation award for Scientists' for the oral paper on 'Vacuum based treatment– An innovative technology of treating planting materials with various agro-inputs for enhanced crop protection' presented during Golden Jubilee International Conference on 'Global perspectives in crop protection for food security' conducted during 8-10 December by CPPS at TNAU, Coimbatore.
- Drs. A.S. Tayade, P. Geetha and S. Anusha: Best paper award for the paper on 'Climate smart weed management practices to mitigate the abiotic stresses in sugarcane' in the International Plant Physiology Virtual Symposium IPPVS 2021 on 'Physiological Interventions for climate smart agriculture' organized by ICAR-SBI, Coimbatore in collaboration with Indian Society of Plant Physiology, New Delhi, Society for Sugarcane Research and Development, Coimbatore, NAAS Chapter of Coimbatore and Indian Society of Plant Physiology, New Delhi held during 11-12 March 2021.
- Dr. A.S. Tayade: 'ECO-Agri Award 2021' in the category of Best Extension Service for waste management. Agriculture Today Group, New Delhi.
- Rajarshi Tandon Award 2021 for ICAR-SBI, Coimbatore for outstanding works in implementation of official language. ICAR, New Delhi.
- Dr. T. Arumuganathan: Best Poster Award for the paper 'Modelling oxygen diffusion during storage of fresh button mushroom

under modified atmosphere storage system'. International Plant Physiology Virtual Symposium IPPVS 2021 on Physiological Interventions for Climate Smart Agriculture' organized by ICAR-SBI, Coimbatore in collaboration with Indian Society of Plant Physiology (ISPP), New Delhi, Society for Sugarcane Research and Development (SSRD), Coimbatore and NAAS Chapter, Coimbatore Indian Society of Plant Physiology (ISPP), New Delhi during 11-12 March 2021.

- Drs. Mahesh, P., Srikanth, j., K.P. Salin, B. Singaravelu, Chandran, K., Mahendran, B. 2019. Kanwar Virender Singh Memorial All India Best Publication Award 2020 for the paper Phenology of sugarcane leaf hopper *Pyrilla perpusilla* (Walker) (Homoptera: Lophopidae) and its natural enemies in a crop island scenario. Crop Protection (2019)170:151-162, by Society for Advancement of Human and Nature, Bolan, HP. India
- Drs. 'Mahesh, P., Srikanth, J., Singaravelu, B. and Salin, K.P. : Best poster presentation award for the research paper "Dynamics of sugarcane leaf hopper and its biotic agents: impact of short-term climatic changes" at the International Plant Physiology Virtual Symposium 2021 (WM-2021) on Physiological Inlerveniion for Climate Smart Agriculture, 11-12th March, 2021, 1CAR-Sugarcane Breeding institute Coimbatore. India
- Drs. Mahesh, P., Srikanth, J., Singaravelu. B., K.P., Mahendran, B. and Chandran, K: Best short oral presentation for the research paper 'Screening of sugarcane germplasm against scale insect *Melanaspis glomerata*' at the International Conference on Sugarcane Research: Sugarcane for Sugar and Beyond (CaneCon2021), June 19-22, 2021. ICAR-Sugarcane Breeding Institute, Coimbatore, India
- Drs. S. Anusha, P. Geetha and A. S. Tayade: Best Short Oral Presentation for the paper 'Evaluation of new generation herbicides against weeds in sugarcane under wide row planting' in the CaneCon 2021 held during 19-22 June 2021 at ICAR-SBI, Coimbatore.
- Drs. R. Arun Kumar, P. Geetha. A.S. Tayade, S. Anusha and V. Krishnapriya: Best Oral Paper for the paper 'Radiation use efficiency of sugarcane genotypes as influenced by crop geometry' in the International Plant Physiology Virtual Symposium IPPVS 2021 "Physiological Interventions for Climate Smart Agriculture" organized by ICAR–SBI, Coimbatore in collaboration with Indian Society of Plant Physiology (ISPP), New Delhi, Society for Sugarcane Research and Development (SSRD), Coimbatore and NAAS Chapter, Coimbatore Indian Society of Plant Physiology (ISPP), New Delhi during 11-12 March 2021.
- Drs. P. Geetha, K. Hari, P. Malathi, and N. Rajendra Prasad. 2021: Best poster award for the paper titled enhancing the growth and vigor of sugarcane settlings through Plant Growth Promoting Rhizobacteria (PGPR): A strategy to augment cane growth under changing climatic scenario'. International Plant Physiology Virtual Symposium IPPVS 2021 on Physiological Interventions for Climate Smart Agriculture' organized by ICAR-SBI, Coimbatore in collaboration with Indian Society of Plant Physiology (ISPP), New Delhi, Society for Sugarcane Research and Development (SSRD), Coimbatore and NAAS Chapter, Coimbatore Indian Society of Plant Physiology (ISPP), New Delhi during 11-12 March 2021.
- Swathi, S, Suresha G S, Darshini S, Ashwin N, Mahadevaiah, C, Appunu, C and Hari, K. 2021. Best poster award for the paper on Sub-cellular targeting of invertase inhibitor proteins: A novel approach to increase sucrose yield and to test physiological threshold of sucrose accumulation in sugarcane. International Plant Physiology Virtual Symposium IPPVS 2021 on Physiological Interventions for Climate Smart Agriculture' organized by ICAR-SBI, Coimbatore in collaboration with Indian Society of Plant Physiology (ISPP), New Delhi, Society for Sugarcane Research and Development (SSRD), Coimbatore and NAAS Chapter, Coimbatore Indian Society of Plant Physiology (ISPP), New Delhi during 11-12 March 2021.
- Drs. B. Parameswari, K. Nithya, Subham Kumar, A. Annadurai, M.L. Chhabra, Praveen Kumar, R. Viswanathan: Best oral presentation award for the research paper entitled 'Real time PCR based screening for identifi-

cation of resistance against sugarcane yellow leaf virus in Indian sugarcane germplasm' during IPS (Central Zone) National symposium (virtual) on Advances in Phytopathology during 6-7 January 2021.

- Drs. Krishnapriya, E. Karpagam, R, Arun Kumar and R. Gomathi: 'Best Poster Award' for the paper 'Root anatomical phenes in response to abiotic stress in sugarcane germplasm clones' in organized by ICAR-SBI, Coimbatore in collaboration with Indian Society of Plant Physiology (ISPP), New Delhi, Society for Sugarcane Research and Development (SSRD), Coimbatore and NAAS Chapter, Coimbatore Indian Society of Plant Physiology (ISPP), New Delhi during 11-12 March 2021.
- Drs R. Gomathi, A. Rajakumari, V. Krishna priya, R. Arunkumar and K. Elayaraja: "Best Oral Paper Award" on Comparative physiological and metabolic analysis of tropical and subtropical sugarcane varieties under tropical condition. In First NABS-International Conference on "Life Sciences: Contemporary approaches in Biological Sciences for Food, Health, Nutrition Security and Conservation of Biodiversity" held during August 26th to 28th ,2021 at Annamalai University, Chidambaram, Tamil Nadu, India.
- Dr. R. Gomathi received Fellow of National Academy of Biological Sciences (NABS), Chennai for election year 2020.
- Drs. K. Nithya, B. Parameswari, M.L. Chhabra, R. Viswanathan: Best oral paper award for the research paper on 'Grassy shoot disease caused by Ca. Phytoplasma sacchari, a major biotic stress and physiological intervene in sugarcane cultivation' in the International Plant Physiology Virtual Symposium on 'Physiological interventions for climate smart agriculture (IPPVS 2021)' held at ICAR-SBI, Coimbatore during 11-12 March 2021.
- Dr. M.L. Chhabra: Received Reviewer Excellence Award of Legume Research on 24 April 2021.
- Dr. S.K. Pandey: Nominated as member of Board of Directors of Sugarfed, Punjab and attended meetings regarding cane seed development program in Punjab state with Hon'ble Cooperation and Jail Minister, Punjab at Mohali on 17 and 21 June 2021.
- Drs. Pooja, Ravinder Kumar, Neeraj Kulshreshtha, M.R. Meena, S.K. Pandey: Best short oral paper on 'Effect of different saline water irrigation on performance of sugarcane clones' in International Conference on Sugarcane Research: Sugarcane for Sugar and Beyond, held during 19-22 June 2021.
- Dr. M.L Chabbra: Reviewer Excellence Award of India Journal of Agricultural Research on 4 June 2021.
- Dr. Ravinder Kumar: Co-convener in the session 'Sugarcane improvement- Plant Breeding and Genomics- oral'' in the International Conference on Sugarcane Research: Sugarcane for sugar and Beyond (CaneCon2021) during 19-22 June 2021.
- Dr. S.K. Pandey: Chairman of the Assessment Committee of Technical at ICAR-IIWBR, Karnal on 29 November 2021.
- Drs. M.R. Meena and Pooja: Acted as Judges during *Hindi Kavita Paath Pratiyogita* at ICAR-IARI, Regional Station, Karnal on 28 September 2021.
- Dr. M.R. Meena: Acted as judge cum chief guest during *'Hindi Pakhawara'* program at ICAR-IARI, Regional Station, Karnal on 28 September 2021.
- Dr. M.R. Meena: Selected as Executive Councilor member of Society for sugarcane research and development (SSRD) for the period 2021-2023.
- Dr. Pooja: As member selection committee for the interviews of young professionals at ICAR-IIWBR, Karnal on 15 December 2021.
- Drs. M.L. Chhabra, B. Parameswari and S.K. Pandey: 'Uttar Bharat Me Ganne Ka Kandwa Rog Ke Prabandhan ki Vartman Isthiti *(Hindi)'*, Bhariya Krishi Anusandhan Patrika: 35(3), 159-164, awarded the second prize by Town official Implementation Committee, (TOLIC) Karnal on 31 December 2021.
- Drs. S.K. Pandey, M.L. Chhabra, Pooja, Bakshi Ram: *'Ganna Fasal Suraksha* (Sugarcane

Advisory Hindi)' published in Ganna Parkash (2021), 5: pp 7 awarded the first prize by Town official Implementation Committee, (TOLIC) Karnal on 31 December 2021.

- Dr. A. Ramesh Sundar: SIR T.S. Venkatraman award for Outstanding research in Sugarcane agriculture for the Biennium 2018-19 on sharing basis with Dr. Sangeeta Srivastava, Principal Scientist and Head, Crop Improvement, ICAR-IISR, Lucknow.
- Dr. N.M.R. Ashwin: SIR T.S. Venkatraman award for Best Ph.D. thesis in sugarcane agriculture for the Biennium 2018-19.
- Drs. S. Alarmelu, P. Govindaraj and A. Ramesh Sundar: Foundation Day Award -2021 under Principal Scientist category.
- Drs. K. Mohanraj and C. Appunu: Foundation Day Award -2021 under Senior Scientist category.
- Smt. R. Nirmala: Foundation Day Award -2021 under Technical category.
- Shri. Vasudev. V. Galagali and Smt. Jainub: Foundation Day Award-2021 under Administrative category.
- Shri. R. Sekar and Shri. M. Manickam: Foundation Day Award -2021 under Skilled Support Staff category.
- Agricultural Knowledge Management Unit (AKMU) and Audit & Accounts Section: Foundation Day Award -2021 under Administrative Sections category.
- Dr M. Scindiya (Guide: Dr. P. Malathi) was awarded 'Prof. M.J. Narashiman Academic Merit Award 2020' for her research work on 'Molecular characterization and functional analysis of pathogenicity related genes in *Colletotrichum falcatum* causing red rot in sugarcane' by Indian Phytopathological Society, New Delhi during the 73rd Annual Meeting of the Society and National Symposium (Virtual) held during 25-27 March 2021.

8. LINKAGES AND COLLABORATION IN INDIA INCLUDING EXTERNALLY FUNDED PROJECTS

The Institute has established linkages with ICAR Institutes like IARI, NBPGR, NRCPB, NBAIR, IISR, Sugarcane Research Centres 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 Scientists involved	Source of funding	Total outlay (Rs in Lakhs)
Identification, characterization and verification of new sugarcane varieties for DUS testing at Coimbatore - R. Karuppaiyan, S. Alarmelu and C. Jayabose	PPV&FRA	9.50
ICAR Seed Project: Seed production in agricultural crops and fisheries – sugarcane (Coimbatore) - A.J. Prabakaran	ICAR	11.00
Enhancing sugar productivity in Tamil Nadu through Institute-Industry Participatory Approach - Bakshi Ram and C. Appunu	SISMA	46.20
Identification of location specific sugarcane varieties suitable for different agro – climatic zones of Tamil Nadu - BakshiRam and G. Hemaprabha	Dept. of Sugar, Govt. of TN	7.00

Project Title and Scientists involved	Source of funding	Total outlay (Rs in Lakhs)
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	175.00
Sub-cellular targeting of invertase inhibitory proteins: a novel approach to enhance sucrose yield in sugarcane- G.S. Suresha	DST-SERB	30.48
Identification of salt responsive genes and micro RNA targets from salt tolerant *Erianthus arundinaceus* through transcriptome analysis –C. Mahadevaiah	DST-SERB	12.99
Isolation, functional characterization and evaluation of water deficit stress tolerance responsive genes from high drought tolerant *Erianthu sarundinaceus* by comparative drought transcriptome analysis- C. Appunu, G. Hemaprabha and G.S. Suresha	DBT	53.91
Network project of transgenics in crops - transgenic development in sugarcane - C. Appunu and R. Valarmathi	ICAR-NPTC	30.00
Unraveling the molecular mechanism of early maturing responsive genes in sugarcane through transcriptome analysis-M.R. Meena	DST-SERB	31.25
Novel application of sugarcane vacuolar targeting technology for recombinant protein - C. Appunu and G.S. Suresha	TRANAL-AB	22.8
A proteomic approach for identification and characterization of new ligninolytic enzymes for improved sugarcane bagasse delignification - K. Lakshmi	DST-SERB	42.85
Development of white grub *(Holotrichia serrata)* resistance in sugarcane and groundnut by deploying novel Cry toxin holotype genes - C. Appunu, B. Singaravelu, K. Hari and G.S. Suresha	NASF	78.23
Potential application of genomic in situ hybridization (GISH) to understand the genomic constitution of *Saccharum* hybrids - V.P. Sobhakumari	DST-SERB	50.25
Doubling income of small farms through sugarcane based farming system - P. Geetha, T. RajulaShanthy, C. Palaniswami, A.S. Tayade	NADP/ RKVY	67.00
NFSM demonstration of pulses intercropping with sugarcane - A.S. Tayade, P. Geetha, S. Anusha and D. Puthira Prathap	NFSM	3.50
Characterisation of root system traits in sugarcane germplasm -V. Krishnapriya	DST-SERB	36.37
A whole genome based reduced representation approach for identification of resistance against sugarcane yellow leaf virus in Indian sugarcane- B. Parameswari	DST-SERB	45.24
ICAR-CRP on Development and application of diagnostics to viruses and phytoplasmas infecting sugarcane - R. Viswanathan, B. Parameswari, D. Neelamathi and K. Nithya	ICAR	75.82
Dissecting the molecular interface between the biotrophic pathogen *Sporisorium scitamineum* and its host sugarcane-A. Ramesh Sundar, R. Viswanathan, P. Malathi and P.T. Prathima	DBT	48.9
Deciphering in plantasecretome of *Sporisorium scitamineum* x sugarcane interaction - A. Ramesh Sundar, R. Viswanathan and G. S. Suresha	DST-SERB	24.55

Project Title and Scientists involved	Source of funding	Total outlay (Rs in Lakhs)
Deciphering interacting partners of PAMPs/ Effectors of *Colletotrichum falcatum* that trigger innate immunity in sugarcane - A. Ramesh Sundar, R. Viswanathan, P. Malathi, C. Appunu and Rajeev Sukumaran, NIIST, Trivandrum	DBT	75.03
Development of sugarcane bacilliform virus (SCBV) based VIGS vector for functional genomics in sugarcane - R. Viswanathan, B. Parameswari, C. Appunu and K. Nithya	DST-SERB	40.73
Biogenesis of nanomaterials from effective *Trichoderma spp.* for the management of red rot disease in sugarcane - P. Malathi and V. Bhuvaneshwari (KASC, BU, CBE)	DST-SERB-TARE	18.30
Development of recombinase polymerase amplification combined lateral flow dipstick kits for rapid detection of major viruses infecting sugarcane - B. Parameswari	DST	18.00
Establishment of native entomo-pathogenic nematodes as potential bio-pesticide to tackle the exotic invasive pest fall armyworm menace - C. Sankaranarayanan, N. Seenivasan (TNAU, CBE) and B. Singaravelu	DST-SERB-TARE	18.30
Sugarcane based Agri-Business Incubator (ABI) (National Agricultural Innovation Fund Scheme (NAIF) - Component II, IP & TM, ICAR) - P. Murali, V. Venkatasubramanian, K. Hari, A.J. Prabakaran, G.S. Suresha, D. Puthira Prathap and Bakshi Ram	NAIF	89.5
Intellectual Property Management and Technology Transfer/ Commercialization – Institute Technology Management Unit (ITMU) (National Agricultural Innovation Fund Scheme (NAIF) - Component I, IP & TM, ICAR) - K. Hari, K. Rathnavel (CICR RS, Coimbatore), G. Hemaprabha, J. Srikanth, A. Ramesh Sundar, P. Murali and Bakshi Ram	NAIF	6.20
Implemented developmental programs in selected tribal vilalges – Phase I - T. Rajula Shanthy, C. Jayabose, C. Sankaranarayanan and R. Arunkumar	Ministry of Tribal Affairs	0.00
Implementation of developmental programs in selected tribal villages - Phase II- D. Puthira Prathap, K. Mohanraj, P. Geetha, V. Sreenivasa	Ministry of Tribal Affairs	50.00
Identification, characterization and verification of new sugarcane varieties for DUS testing - M.R. Meena, Ravinder Kumar	MoA/GoI	7.00
ICAR Seed project – Seed production in agricultural crops and fisheries – sugarcane (RFS, Karnal) –Ravinder Kumar	PPV&FRA	11.00
Healthy seed production and mechanization of sugarcane agriculture - A farmers participatory initiative (RKVY Haryana) – Ravinder Kumar, M.R.Meena, M.L. Chhabra, S.K. Pandey, B. Parameswari and Pooja	RKVY	87.32
Sugarcane Breeder Seed production and demonstration of intercropping – Ravinder Kumar and M.R. Meena	NFSM	8.50
DUS testing of sugarcane (Agali) - R. Karuppaiyan and V. Sreenivasa	PPV&FRA	9.50

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 programs. The following are the research areas under this project:

- Fluff supply to various sugarcane research institutes / centres.
- Evaluation of elite sugarcane genotypes under different sugarcane growing regions and acting as the coordinating unit for the identification of 'Co' and other Co- regional selections.
- To gather information on general and specific combining ability of biparental crosses / parents.
- Collaboration for development of national varieties.
- Collaborative research on Agronomy, Soil science, Plant Physiology, Entomology and Plant Pathology.

Dr. Bakshi Ram, Director was the Principal Investigator of Crop Improvement till 30.6.2021, Dr. G. Hemaprabha from 01.07.2021 and Dr. R. Viswanathan, Head I/c, Division of Crop Protection is the Principal Investigator of Plant Pathology.

10. PUBLICATIONS

Research papers

1. Agisha, V.N., N.M.R. Ashwin, R.T. Vinodhini, K. Nalayeni, A. Ramesh Sundar, P. Malathi and R. Viswanathan. 2021. Protoplast-mediated transformation in *Sporisorium scitamineum* facilitates visualization of in planta developmental stages in sugarcane. *Molecular Biology Reports* 48:7921–7932 https://doi.org/10.1007/s11033-021-06823-x
2. Alarmelu, S., A. Anna Durai, H. K. Mahadeva Swamy, G. Hemaprabha, and S. P. Adhini. 2021. Genetic diversity of parental clones used in breeding programs of sugarcane. *Electronic Journal of Plant Breeding* 2(2): 529-539.
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5. Anuratha, A., M. Ramasubramanian, G. Selvarani, D. P. Prathap and M. Senthil Kumar. 2021. Determinants of Gender Responsive Spending in Rural Families in Tamil Nadu. International Journal of Arts, Science and Humanities, 8(4), 129-138
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11. RESEARCH PROJECTS

1. Breeding superior sugarcane varieties of different maturity with improved cane yield, quality and resistance to biotic and abiotic stresses
2. Enhancement of sugarcane germplasm and development of pre-breeding material
3. Sugarcane genomics and molecular markers
4. Gene discovery and genetic transformation in sugarcane
5. Development of cropping systems and improved agronomic practices to enhance sugarcane productivity
6. Enhancing physiological efficiency of sugarcane
7. Natural resource management for enhancing productivity and sustainable sugarcane production
8. Host resistance, interactomics, pathogen variability, diagnosis and disease management in sugarcane.
9. Studies on sugarcane pest and their management
10. Basic and applied studies of sugarcane phytonematodes and entomopathogenic nematodes
11. Economic and statistical studies in sugarcane and sugar production system
12. Transfer of sugarcane technologies
13. Standardization of true seed production technique through developing homozygous parental lines and apomixes
14. All India Coordinated Research Project (Sugarcane)

12. CONSULTANCY, PATENTS, COMMERCIALIZATION OF TECHNOLOGIES

- Submitted new sugarcane variety Co 13035 (Karan-14) for registration with PPV&FRA on 24.09.2021. Nine ICAR-SBI varieties registered with PPV&FRA *viz.,* Co 94012, Co 99004, Co 0118, Co 05011, Co 0403, Co 0237, Co 0238, Co 06027 and Co 06030 were renewed.
- Status reports for National Biodiversity Authority (NBA) by ICAR-SBI for the technologies/patents *viz.,* (a) Patent application No. 1309/CHE/2011, Process for preparation of sugarcane juice powder, (b) Patent application No. 1829/CHE/2006 Method for preparing spray dried sugarcane juice, (c) Patent application No. 3421/CHE/2010, Porteresia ubiquitin derived promoter system and uses thereof and (d) Patent application No. 5384/CHE/2013 Vacuolar targeting determinants for plants and uses thereof was submitted on 04.09.2021.
- Signed two MoUs for Clean healthy seed production with M/s Avadh Sugar & Energy Limited, Unit Seohara, Bijnor, Uttar Pradesh on 15.01.2021 and M/s Avadh Sugar & Energy Limited, Unit Hargaon, Uttar Pradesh on 12.01.2021. ICAR-SBI and Kumaraguru College of Technology (KCT), Coimbatore has signed an agreement for evaluating the suitability of energy cane bagasse for the production of textiles fibre. An MoU was signed between ICAR-SBI and M/s T. Stanes Co., Coimbatore for up scaling and efficacy testing of Bt62 for white grub control. As per the MoU the committed activities were completed and the reports from respective parties exchanged, hence this MoU is closed.

- Received eight technology disclosures viz., (1) SBIEC 14006 – An energycane with high biomass production, (2) Sugarcane variety Co 91010 (Dhanush), (3) Sugarcane variety Co 11015 (Atulya), (4) Sugarcane True Seed (Fluff/Fuzz), (5) Updated technology of Spray dried sugarcane juice (6) System and method for powder jaggery processing from sugarcane juice with organic clarificant, (7) Novel lepidopteran active toxin gene(s) from Indigenous *Bacillus thuringiensis* and its use thereof and (8) A process for producing *Bacillus thuringiensis* Biopesticide formulation for management of white grub *Holotrichia serrata.*
- Two techno commercial meetings of Agrinnovate were held on 11.06.2021 and 30.11.2021. The formalities for global license terms were finalized for the following ICAR-SBI technologies *viz.,* (i) Sugarcane Variety Co 11015 – Atulya, (ii) Sugarcane variety Co 91010 – Dhanush, (iii) SBIEC 14006 Energycane, (iv) Sugarcane True seed (Fluff/Fuzz), (v) Soil Moisture Indicator and (vi) Cane Jam. The formalities license terms for Indian territory were finalized for (1) Production of spray dried sugarcane juice, (2) Cane jam production from sugarcane juice (3) Production of cane dietary fibre food products and (4) System and method for powder jaggery processing from sugarcane juice with organic clarificants.
- Some of the novel genes *viz.,* (1) Cry1D family, (2) Cry2Af and (3) Vip3Bb, disclosed in the technology titled 'Novel lepidopteran active toxin gene(s) from indigenous *Bacillus thuringiensis* and its use thereof' were licensed to M/s Rasi Seeds (P) Ltd, Attur, Salem, Tamil Nadu. This technology has realised a revenue of Rs.10,00,000/-. ITMC has approved a partnership collaborative project between ICAR-SBI and M/s Rasi Seeds (P) Ltd for up scaling the technology to develop transgenics toxic against pink boll worm, this project is partly funded (Rs. 18,05,000/-) by the firm. IP arising out of this project will be shared between ICAR-SBI and Rasi Seeds (P) Ltd after mutual negotiations. In this regard, a MoU has been signed between ICAR-SBI and Rasi Seeds (P) Ltd on 08-12-2021.
- ITMC has approved a partnership collaborative project between ICAR-SBI and M/s SKR Agrotech, Nagpur (ICAR-SBI licensee for SMI) and a MoU was signed on 25.11.2021. The project will be on calibrating and validating the digital soil moisture sensor, which is an improved version of the SMI. This project is partly funded (Rs. 3,33,522 /-) by the firm. IP arising out of this project will be shared between ICAR-SBI and M/s SKR Agrotech, Nagpur after mutual negotiations.
- Soil Moisture indicator technology was licensed to five firms viz., (i) M/s Ranaji Biotech, Kanpur, UP on 30.05.2021, (ii) M/s Celebrating farmers edge international Pvt. Ltd (CFEI), Nashik, MS on 29.06.2021, (iii) M/s Varsha Agrotech, Bijapur, KA on 28.06.2021, (iv) M/s Microplex India, Wardha, MS on 29.06.2021 and (v) M/s Next Gen Agro Tech, Chhindwara, MP on 29.06.2021. This technology has earned a revenue of Rs. 2,50,000 by licensing and about Rs. 1765,398/- (Rs. 69,028 + 16,46,370+ 50000) for the financial year 2020-21 as royalty.
- EPN biopesticide formulation was licensed to three firms *viz.,* (i) M/s SKR Agrotech, Wardha, Maharashtra on 12.01.2021, (ii) Biovygan, Tirunelveli, TN on 02.08.2021 and M/s Linga Chemicals, Madurai (24-09-2021). This technology has earned a revenue of Rs. 6,00,000 through licensing.
- Cane Jam technology has been licensed to two firms, *viz.,* M/s Celebrating farmers edge international Pvt. Ltd, Nasik, MS on 29.06.2021 and M/s Du Sucre Products, Cuddalore on 16-08-2021. This technology has earned revenue of Rs. 1,50,000/- through licensing.
- Technology for liquid Jaggery production was licensed to six firms viz., (i) M/s Pon-

adhini Agro Products, Erode, Tamil Nadu on 22.01.2021, (ii) M/s OSS Sugarcane factory, Erode, TN on 16.04.2021 (iii) Celebrating farmers edge international Pvt. Ltd, Nasik, MS on 29.06.2021. (iv) M/s Du Sucre Products, Cuddalore (16.08.2021), (v) ATMA Malaprabha Kabbu Belegarara Sangha, Kadabi Shivapur-591129, Karnataka (29.11.2021) and (vi) Sri Vishnu Food Products, Erode, Tamil Nadu (16-12-2021). This technology has earned revenue of Rs. 60,000 through licensing.

- Technologies *viz.,* (i) Quatro Sugarcane Single Bud Cutter Machine to M/s Bhoosarthi, Dwarka, New Delhi on 11.02.2021, (ii) Sugarcane De-trashing tool, (iii) Sugarcane dietary Fibre food Products on 29.06.2021 (iv) ICAR-CIAE-SBI Sett treatment Device to M/s Amit Agro Associates, Rampur, UP on 17.06.2021, (v) ICAR-CIAE-SBI sugarcane rind removing equipment to M/s Celebrating farmers edge international Pvt. Ltd, Nasik, MS on 29.06.2021, (iii) ICAR-CIAE-SBI Motorised double headed sugarcane single bud cutting machine to M/s Balaji Industry Coimbatore, Tamil Nadu on 29.06.2021 and (iv) ICAR-IISR-SBI Deep Furrow Sugarcane Cutter Planter licensed to M/s Pishon Technologies, Coimbatore (08-09-2021). These technologies have realized revenue of Rs. 2,20,000.
- ICAR-SBI has signed MoU with SKR Agrotech, Wardhato work together for project on 'Calibration and validation of digital soil moisture sensor advanced in comparison with gravimetric method of soil moisture estimation' on 25-11-2021.

ICAR-SBI has realised Rs. 20,60,000 by licensing and Rs. 17,65,398 by royalty with overall revenue of Rs. 38,25,398 by the commercialization of ICAR-SBI technologies.

ICAR-SBI and KCT, Coimbatore signed aggrement for evaluating energycane bagasse for textiles fibre

ICAR-SBI has signed a colloborative project with SKR Agrotech Wardha for evaluation of Digital Soil Moisture Sensor device 25-11-2021

Licenced cane dietary fibre food products to Celebrating Farmers Edge International Pvt Ltd Nashik Maharastra

Licenced cane jam production technology to Celebrating Farmers Edge International Pvt Ltd Nashik Maharastra

Licenced EPN formulation for white grub control to Bio Vigyan Agritech Pvt. Ltd, Tirunelveli, Tamil Nadu

Licenced EPN formulation for white grub control to SKR Agrotech, Wardha, Maharashtra on 12-01-2021

Licenced Liquid Jaggery and Cane Jam technology to Du Sucre Products, Cuddalore on 16.08.2021

Licenced liquid jaggery technology to Celebrating Farmers Edge International Pvt Ltd Nashik Maharastra

Licenced liquid jaggery technology to Sri Vishnu Food Products, Vellode, Erode on 16-12-2021

Licenced soil moisture indicator technology to Celebrating Farmers Edge International Pvt. Ltd. Nashik Maharastra

Licenced sugarcane detrashing tool to Celebrating Farmers Edge International Pvt. Ltd. Nashik Maharastra

Licenced sugarcane rind removing equipment to Celebrating Farmers Edge International Pvt. Ltd. Nashik Maharastra

Licensed DEEP FURROW SUGARCANE CUTTER PLANTER to PISHON Technologies, Coimbatore on 04-10-2021

Licensed Liquid jaggery production technology to OSS Sugarcane Factory, Arachalur Erode TN on 16-04-2021

Licensed Liquid jaggery production technology to PonAdhini Agro Products Sivagiri 22-01-2021

Licensed Liquid jaggery production to ATMA Malaprabha Kabbu Belegarara Sangha, Kadabi Shivapur, Karnataka 30-11-2021

RASI Seeds Private Ltd., Attur, Salem signed MoU for a collobotative project for Bt genes on 08-12-2021

Fig. 142. Licensing Sugarcane Technologies

13. MEETINGS AND WORKSHOPS ORGANIZED BY THE INSTITUTE

Republic Day celebration

Republic Day was celebrated at the Institute on 26 January 2021. Dr. Bakshi Ram, Director, ICAR-SBI hoisted the national flag and addressed the staff of the Institute (Fig. 143).

Fig. 143. Dr. Bakshi Ram, Director, ICAR-SBI addressing the staff

Field Day

A field day was organized at a seed village (Pasur) near Coimbatore on 4 February 2021 to interact between the scientists and seed farmers on various aspects of a successful quality seed production in sugarcane.

International Womens' Day

International Womens' Day was celebrated on 8 March 2021 Padmashri. R. Rangammal, 106 years old woman organic farmer and Dr. Rajini graced the occasion as Chief Guests (Fig. 144).

Fig. 144. Padmashri R. Rangammal being felicitated by Director, ICAR-SBI

International Plant Physiology Virtual Symposium 2021

International Plant Physiology Virtual Symposium 2021 (IPPVS -2021) on "Physiological Interventions for Climate Smart Agriculture" was organized at ICAR- Sugarcane Breeding Institute, during 11-12 March 2021 by Indian Society for Plant Physiology-South Zone, in collaboration with National Academy of Agricultural Science (NAAS), Coimbatore Chapter, Society for Sugarcane Research and Development (SSRD), Coimbatore & State Agriculture Universities of South Zone.

Seed Day

ICAR-SBI has observed 18 March 2021 as 'Seed Day' to mark the end of the seed crop season 2020-21. The successful record production and supply of about 1697 tons of quality seed through farmers' participatory mode was the highlight of the achievements and about 8 seed farmers were felicitated as 'Progressive seed farmers'.

World Water Day

World Water Day was celebrated on 22 March 2021 at ICAR-Sugarcane Breeding Institute, Coimbatore to raise awareness of the global water crisis, and to support Sustainable Development Goal (SDG) 6: Water and sanitation for all by 2030. As a part of awareness Dr. S. Panneerselvam, Director, Water Technology Centre, TNAU addressed the staff (Fig. 145).

Fig. 145. Dr. S. Panneerselvam, Director, Water Technology Centre, TNAU delivering the World Water Day lecture

CaneCon 2021

The International Conference on Sugarcane Research (CaneCon 2021), a Virtual Event held during 19-22 June 2021, organized by ICAR-Sugarcane Breeding Institute, Coimbatore. In the conference conducted under seven themes, over 1000 participants joined the Inaugural session of the conference through various modes such as Conference portal, Video conferencing platform, Facebook live and YouTube links. Sixty-eight Scientist of ICAR-SBI attended the Conference and presented research papers in different technical sessions.

Independence Day celebration

Independence Day was celebrated in the Institute on 15 August 2021. Dr. G. Hemaprabha, Director (Acting) hoisted the National Flag and addressed the staff (Fig. 146a). A special lecture was arranged to inaugurate the celebration of 'Bharat Ka Amrit Mahotsav' (Fig. 146b).

Fig. 146a. Dr. G. Hemaprabha, Director (Acting) addressing the staff on Independence Day

Fig. 146b. Special lecture to launch Bharat ka Amrit Mahotsav

Parthenium Awareness week

Parthenium Awareness week observed under Swachchh Bharat Mission activities during 16-22 August 2021. The pamphlets on 'Integrated Parthenium management' in English and Hindi were displayed in the notice board and Parthenium uprooting and cleanliness drives were conducted in the institute premises. All staff members involved in the activities (Fig. 147).

Fig. 147. Parthenium Awareness Campaigns 16-22 August 2021

Hindi Day

Hindi Day was celebrated at ICAR SBI, Coimbatore and at SBI-RC, Karnal on 28 September 2021 (Fig. 148). Various competitions were conducted and the winners were awarded. The Hindi magazine 'Ganna Prakash' was released during the Hindi Day by the Chief Guest, Dr. G. Hemaprabha, Director, ICAR-SBI.

Dr.G.Hemaprabha, Director (Acting) addressing during Hindi Day celebration on 28 September 2021

Release of Ganna Prakash during Hindi Day celebration

Students program at Karnal on 29 September 2021

Fig. 148. Hindi Day Celebrations

Foundation Day

The Foundation Day 2021 was celebrated on 25 October 2021 at ICAR-Sugarcane Breeding Institute, Coimbatore. During the occasion, SIR T.S. Venkatraman award for Outstanding research in sugarcane agriculture and SIR T.S. Venkatraman award Best Ph.D. thesis in sugarcane agriculture 2018-19 for the Biennium 2018-19 were distributed. As a part of celebration, Foundation Day Awards of the year 2021 were distributed to the awardees for their outstanding contribution under scientific (Principal Scientist and Senior Scientist), technical, administrative staff and supporting staff category (Fig. 149).

Fig. 149. Foundation Day celebration (25 October 2021)

Fig. 150. Cane-ovate workshop (26 October 2021)

Cane-ovate

Cane-ovate (portmanteau of Cane + innovate), a National-level workshop held on 26 October 2021, had provided a platform for select innovate sugarcane farmers of Karnataka, Andhra Pradesh, Odisha, Telengana, Uttar Pradesh, Punjab, Bihar, Maharashtra and Tamil Nadu to share their valuable experiences in developing and practicing innovative methods in sugarcane agriculture (Fig. 150).

Vigilance Awareness week

A vigilance awareness week was observed for a period of seven days from 26 October to 1 November 2021 (Fig. 151).

World Soil Day

World Soil Day was celebrated on 6 December 2021 indicating the importance of soil as a critical component of nature system and to connect people with soil and to raise awareness among the staff a special lecture by Kumari Rajeswari on 'Yogic kheti for soil health improvement' was organized.

Fig. 151. Vigilance Pledge at Karmal

Fig. 151. Director and staff taking Vigilance Pledge at Coimbatore

Activities under 'Azadi Ka Amrut Mahotsav'

Lecture Title/conference	Delivered /Organized by	Date	Mode
International Conference on Sugarcane Research: Sugarcane for sugar and Beyond (Cane-Con-2021)	ICAR-Sugarcane Breeding Institute, Coimbatore	19-22 June 2021	Online-1000 participants and 56 speakers /invited guests attended the conference
A green awareness campaign of planting saplings in front of the new crop improvement building was organized.	ICAR-Sugarcane Breeding Institute, Coimbatore	15 July 2021	-
A channel programme on the germplasm conservation and the liquid jaggery processing.	Dr. K. Chandran	15 July 2021	It was recorded and telecasted in news channel Prime Media 21 in Malayalam
Planting of saplings at ICAR-SBI, RC Karnal	ICAR-SBIRC, Karnal	16 July 2021	Physical mode
Participatory programme for increasing greenery on bunds during crop fallow season at Kannur.	ICAR-SBIRC, Kannur	28-30 July 2021	Physical mode
Lecture on 'Role of Ayurvedic treatment methods for Covid 19'	Dr. Binitha, National Ayurveda Research Institute for Panchakarma, Cheruthuruthy, Kerala	4 August 2021	Webinar
Lecture on 'Epidemic diseases, control and defence'	Dr. Satheesan Kashtoori District Covid control cell, Kannur	10 August 2021	Webinar
Lecture on Control and defense methods for communicable diseases through Homeopathy	Dr.K..Dhanya, Ayush Primary health Centre, Homeopathy, Kasaragod, Kerala.	11 August 2021	Webinar
An inaugural lecture on 'The path of India's freedom struggle'	Dr.S. Rajasugunasekar, Scientist F, from Institute of Forest Genetics and Tree Breeding, Coimbatore	15 August 2021	Physical mode
Lecture on 'Entrepreneurship opportunities in nutrition for farmers' as a part of ICAR National Level Campaign on 'Food and nutrition for farmers'	Dr. S. Balasubramanian, Principal Scientist & Head, ICAR-CIAE Regional Centre, Coimbatore	26 August 2021	Webinar - Hybrid mode
Lecture on Sugarcane cultivation and sugar production	Dr. K. Chandran	27 August 2021	All India Radio talk under the programme Science coffee in Malayalam
Lecture on 'Economizing water signature in agriculture: Sugarcane – A Case study'	Dr. S. Paneerselvam, Director, WTC, TNAU, Coimbatore	31 August 2021	Hybrid mode
Lecture on 'Sugarcane-based entrepreneurship development: A profitable venture'	Mr. Vipan Sarin, Director, Celebrating Farmers Edge International Pvt. Ltd, Nasik	18 September 2021,	Webinar meeting Organized by Agri Business Incubator, ICAR-SBI, Coimbatore

Lecture Title/conference	Delivered /Organized by	Date	Mode
Lecture on 'Quarantine procedures for the national and international exchange of plant materials'	Dr. Girish A. G, NIPHM, Rajendranagar, Hyderabad	12 August 2021	Webinar
Product launching and Entrepreneur meet: "Kannur Sarkara", a powder jaggery product developed using Organic clarificant	Launched by Shri. Frony John, District Lead Bank Manager, Canara bank, Kannur	13 August 2021	Physical mode
Lecture on 'Safe food now for a healthy tomorrow'	Dr. G. Hemalatha, TNAU Maduari	16 October 2021	Webinar
Lecture on 'Enzymes for second generation ethanol: Addressing the challenges'	Dr. Rajeev K Sukumaran, Senior Principal Scientist & Head, Microbial Processes and Technology Division, CSIR-NIIST, Thiruvananthapuram	18 November 2021	Webinar
Planting of fruit / forest tree saplings	-	06 December 2021	Physical mode All staff of ICAR-SBI
Collective cleaning of Parthenium weed in the Institute premises	-	21 December 2021	Physical mode All staff of ICAR-SBI

At Karnal

Van Mahotsav aws celebrated and planted 46 plants at ICAR-SBI, RC Karnal on 16 July 2021 (Fig. 152).

Celebrated 75 years of India's Independence at Karnal on 15 August 2021 (Fig. 153).

Parthenium Awareness Week was celebrated at the Centre during 16-22 August 2021 (Fig. 154).

Participated in Krishi Goshthi at Village Bhetia, Indian Sucrose ltd, Mukerian, Punjab on 03 Sepember 2021 and delivered lectures on IPM in sugarcane and management of red rot in sugarcane to over 200 farmers (Fig. 155).

Participated in Krishi Gosthai at Jind Co-op sugar mills, Jind and addressed to cane staff and about 150 sugarcane farmers on 10 Septemmber 2021.2021 (Fig. 156).

Participated in Kishan goshthi at village Kangarh, Shahabad sugar mills, Shahabad and addressed 110 sugarcane farmers and cane development officials in on 13.09.2021 (Fig. 157).

Participated in Vichar Gosthi at village Khera Mastan and imparted training to cane development officials and farmers at Triveni Eng. & Ind. Ltd. Sugar Unit -Khatauli (UP) on 14 September 2021 (Fig. 158).

Participated in Kishan Gosthi at village Balikutabpur of Sonipat Sugar mill, Sonipat, Haryana and delivered lectures on IPM and IDM in sugarcane on 15 September 2021.

Ganna Vichar Gosthi: Organized for 60 farmers of Hafed Sugar Mills, Assandh, Haryana on sugarcane protection and production technologies on 17 September 2021 (Fig. 159).

Participated in 'Ganna Vikas Gosthi' at village Tyontha under Kaithal Sugar mill, Kaithal, Haryana and imparted training on IPM & IDM in sugarcane to a group of 250 farmers on 24 September 2021 (Fig. 160).

Fig. 152. Van Mahotsav at Karnal

Fig. 153. Independence Day celebration(15 August 2021)

Fig. 154. Parthenium awareness week

Fig. 155. Krishi Gosthi (3 September 2021)

Fig. 156. Farmers meeting (10 September 2021)

Fig. 157. Farmers Meet (13 September 2021)

Fig. 158. Vichar Gosthi (14 September 2021)

Fig. 159. Ganna Vichar Gosthi (17 September 2021)

Fig. 160. Ganna Vikas Gosthi (24 September 2021)

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. Visits were made to the adopted villages and technical guidance was provided to the farmers for improving their livelihood (Fig. 161).

Group meetings and demonstrations on important technologies were organized in the adopted villages. Extension literature on 'Sugarcane varieties', 'Organic farming in sugarcane', '101 Agricultural technologies', 'Wid boar management' was distributed. Several meetings, campaigns and training programs were organized in the adopted villages in Coimbatore, Karnal and Kannur.

Fig. 161. Activities in adopted villages

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 and Research Centres with special cleanliness drive campaigns during Swachchhta Pakhwada 16-31 December 2021 (Fig. 162).

Fig. 162. Swachchh Bharat Abhiyan activities

14. COMMITTEES

Institute Management Committee Meeting

The 97th Institute Management Committee Meeting of ICAR-Sugarcane Breeding Institute was held on 3 September 2021.

Institute Research Committee (IRC)

IRC meeting was held during 13-16 September 2021 at to review the progress of ongoing research projects and finalize the technical program for 2022.

Research Advisory Committee (RAC)

The XXVI RAC was held during 11-12 October 2021 through hybrid mode (Fig. 163). Dr. S. Solomon, Former Vice Chancellor of CSA University of Agriculture & Technology, Kanpur & Former Director, ICAR-Indian Institute of Sugarcane Research, Lucknow and Chairman, RAC attended in physical mode and chaired the meeting. The following members of the committee participated in the meeting.

Physical mode: Dr. R.K. Singh, ADG (Commercial Crops), ICAR, New Delhi; Dr. H.K. Senapati, Ex-Dean - Post Graduate Faculty, OUAT, Bhubaneswar; Dr. G. Hemaprabha, Director(A), ICAR-Sugarcane Breeding Institute, Coimbatore; Dr. P. Govindaraj (Member Secretary), Principal Scientist (Plant Breeding), ICAR-SBI. Heads of Divisions, Sections and Research Centres of ICAR-SBI.

Fig. 163. RAC meeting in progress

Virtual mode: Dr. S.R. Bhat, Ex-Emeritus Scientist, ICAR-NIAB, IARI, New Delhi; Dr. (Ms.). Chandish R Ballal, Former Director, ICAR-NBAIR, Bangalore; Dr. Jiju P. Alex, Member, Kerala State Planning Board, Trivandrum.

Recommendations made were:

1. Co 0238, the wonder variety is still occupying a vast share of area under sugarcane in subtropical India but the incidence of red rot poses great threat to sustain the area under this variety. A holistic approach including clean seed production to replace the seed in affected areas, in combination with chemical and biological control measures to prevent the spread of the disease, mandatory use of sett treatment device etc. should be intensified and taken in war-footing to extend the shelf life of variety Co 0238, until a suitable substitute is available. A meeting of the pathologists of the subtropical research institutes/ stations in collaboration with the industry should be convened to chalk out the action points for containing the red rot spread. Red rot resistant *Saccharum* species clones should be deployed in breeding programmes to derive a new set of red rot resistant selections.
2. Reduction in cost of cultivation will improve the profitability of the farmers and to achieve "Doubling of Farmers Income". New research initiatives integrating improved varieties, multi-ratooning and green technologies should be intensified in collaboration with other sugarcane research institute like ICAR-IISR, Lucknow to develop package of practices for reducing cost of cultivation. Success stories of doubling the farmer's income already available with the institute should be documented and disseminated among the farming communities.
3. Poor ratoon yield is the major concern and the farmers in India usually take one ratoon, although profitable cultivation of 2-4 ratoons has been demonstrated. ICAR-SBI scientists should initiate a multidisciplinary research project involving breeders, agronomists, soil scientists, pathologists, physiologists, entomologists etc., to develop a low cost package of practices for profitable multi-ratooning, especially for the farmers of Tamil Nadu & A.P. in collaboration with

the progressive sugar mills. This should include all components of green technology, nutrients & water management and mechanization.

4. A joint meeting of the scientists of the Institute with those from the ICAR-IISR / UPCSR/ Cane Development Dept of Uttar Pradesh should be convened to formulate appropriate varietal mix/composition for Central, Western & Eastern Uttar Pradesh to tackle the problems associated with monoculture of a single variety, breakdown of disease resistance, retaining the high sugar recovery, problem associated with seed movement & red rot and sustaining the profitability of the farmers.
5. Development of climate resilient/ smart varieties should be given priority. Research work on utilization of trait specific basic species, ISH and IGH clones especially for tolerance/resistance to biotic stresses like red rot and borers and abiotic stresses including drought and water logging in the pre breeding and economic breeding programmes for the development of climate resilient genetic stocks and varieties respectively should be carried out.
6. New approaches should be adopted for the construction of core collections as the models available for the diploids may not be suitable for the polyploidy crop like sugarcane. Genomic selection will be effective only after construction of linkage maps utilizing SNP and SSR markers which show Mendelian segregation. Similarly cytological investigation on chromosome pairing in sugarcane hybrids may be taken up.
7. Effective bio-pesticides developed at the institute must be registered after required toxicological studies. The product should be commercialized through Agrinnovate and private industries after working out the profit sharing as per ICAR guidelines. Successful technologies developed by the institute including the EPN should be demonstrated/validated in the farmer's field and factory farms and popularized. Drone based insecticide application may be standardized and popularized.
8. Natural predators in the sugarcane ecosystem should be identified in collaboration with ICAR-NBAIR and commercially exploited for the control of sugarcane pests/ new invasive pests.
9. New sugarcane varieties should be evaluated under controlled conditions to identify physiological traits *vis-a-vis* yield under different macro, secondary and micro nutrient management system.
10. Research may be intensified in conservation agriculture including tillage management, residue management & recycling, weed management and organic farming involving carbon sequestration and application of bio-inoculants and bio-fertilizers to minimize the cost of cultivation. Explore feasibility and possibility of liquid bio-decomposer in trash/ farm residue management.
11. Integrated farming system should be perfected and the technology should be disseminated for increasing the income of the farmers and retaining them in farming. ICT modules integrating artificial intelligence should be developed for effective transfer of technologies. Interactive Mobile apps will be an effective extension system in the future hence the current mobile app should be updated periodically for the benefit of the farmers. Socio economic studies should focus on marginal and small farmers.
12. Declining area under sugarcane and reduction in sugar production to the extent of 50% in Tamil Nadu between 2015-16 and 2020-21 is of greater concern which should be addressed immediately. The same trend was observed in Andhra Pradesh also. A brain storming session should be organized by ICAR-SBI involving scientists, cane development staff of the sugar factories, cane commissioner's office to analyze the problems. IAR-SBI should identify low cost water saving, green and location specific technologies (high tonnage & low input varieties / multi rationing varieties / small harvesters / profitable intercrops / green technologies) as well as other researchable issues to address this problem.

15. PARTICIPATION IN CONFERENCE, MEETINGS, WORKSHOPS, SYMPOSIA AND SEMINARS

Title	Date	Participant (s)
IPS (Central Zone) National symposium (virtual) on Advances in Phytopathology	6-7 January 2021	Dr. R. Viswanathan Dr. B. Parameswari Dr. K. Nithya Dr. A. Anaadurai Dr. M.L. Chhabra
Webinar on Discussion on priorities in sugarcane varietal improvement, crushing schedule, germplasm acquisition and seed production organized by PAU, Ludhiana.	8 January 2021	Dr. S. K. Pandey Dr. M.L. Chhabra Dr. Ravinder Kumar Dr. M R Meena
Training programme cum seminar conducted in coordination with ICAR-SBI, Karnal and PAU Ludhiana at CSM, Ajnala.	16 January 2021	Dr. S. K. Pandey Dr. Ravinder Kumar Dr. M. R. Meena
Zonal Breeders and Pathologists meet- 2021 of AICRP (Sugarcane) by virtual mode, at ICAR- IISR, Lucknow.	25 January 2021	Dr. G. Hemaprabha Dr. R. Viswanathan Dr. P. Govindaraj Dr. S. K. Pandey Dr. M. L. Chhabra Dr. Ravinder Kumar Dr. M.R. Meena
SAC meeting at Sri Avinashilingam KVK, Coimbatore	29 January 2021	Dr. T. Rajula Shanthy
Virtual Agri India Meets and Agri India Hackathon" organized by Pusa Krishi, ICAR-IARI, ICAR & Department of Agriculture, Cooperation & Farmers' Welfare, Ministry of Agriculture & Farmers' Welfare	3-5 February 2021	Dr R. Selvakumar
SAC meeting of Dharmapuri KVK	11 February 2021	Dr. T. Rajula Shanthy
Orientation Workshop on Innovation Excellence Indicators for Public Funded R&D Organizations: Webinar for ICAR Labs	12 February 2021	Dr. C. Palaniswami
International Conference on Intelligent sustainable systems (ICISS 2021) organized by SCAD College of Engineering and Technology, Tirunelveli	26-27 February 2021	Dr. T. Arumuganathan
51st Sugarcane R&D Workshop of Tamil Nadu and Puducherry held at KSR Institute of Technology, Tiruchengode	26-27 February 2021	Dr. Bakshi Ram Dr. G. Hemaprabha Dr. C. Palaniswami Dr. P. PuthiraPrathap Dr. C. Appunu Dr. P. Geetha Dr. R. Valarmathi

Title	Date	Participant (s)
International Plant Physiology Virtual Symposium (IPPVS-2021) organized at ICAR- Sugarcane Breeding Institute by Indian Society for Plant Physiology-South Zone, in collaboration with National Academy of Agricultural Science (NAAS), Coimbatore Chapter, Society for Sugarcane Research and Development (SSRD), Coimbatore & State Agriculture Universities of South Zone	11-12 March 2021	Dr. G. Hemaprabha Dr. R. M. Shanthi Dr. R. Viswanathan Dr. S. Alarmelu Dr. P. Govindaraj Dr. A. Selvi Dr. A. RameshSundar Dr. V.P. Sobhakumari Dr. A. Suganya Dr. C. Sankaranarayanan Dr. R. Gomathi Dr. R. Manimekalai Dr. R. Selvakumar Dr. A. S. Tayade Dr. C. Appunu, Dr. K. Mohanraj Dr. R. Arun Kumar Dr. P. T. Prathima Dr. K. Lakshmi Dr. K. Devakumar Dr. P. Mahesh Dr. P. Geetha Dr. R. Valarmathi, Dr. C. Mahadevaiah Dr. K. Nithya, Dr. V. Krishnapriya Dr. G. S. Suresha Dr. K. Elayaraja, Dr. S. Sheelamary Dr. S. Anusha Dr. V. Vinu Dr. T. Lakshmipathy Dr. B. Parameswari Dr. M.L. Chhabra Dr. Pooja
International conference on Industrial perspective, challenges and strategies in the novel biopesticides: Its implication in sustainable pest and disease at TNAU through virtual mode	11-12 March 2021	Dr. R.Viswanathan Dr. R. Gopi Dr. P. Malathi Dr. N. Geetha
On-line conference on Proteomics in agriculture and health care organized by School of life sciences, Hyderabad	13-14 March 2021	Dr. P. Malathi
National conference on priorities in crop protection for sustainable agriculture at CAU, at Central Agricultural University, Lamphelpat, Imphal, Manipur	16-18 March 2021	Dr. N. Geetha

Title	Date	Participant (s)
Doordarshan Kisan, Hello Kisan pogramme 'Sugarcane sowing and improved varieties' of the Ministry of Agricultural and Farmers Welfare under the scheme Mass Media support to Agriculture Extension	17 March 2021	Dr. M. R. Meena
International Webinar on Transplanting physiological tools to augment crop breeding organized by ICAR-IIWBR, Karnal	17-19 March 2021	Dr. Pooja
ICFRE-ICAR Consultative online Workshop on 'Developing Molecular breeding technologies for enhancing plant productivity in degraded lands' organized by Institute of Forest Genetics and Tree Breeding, Coimbatore	24 March 2021	Dr. A. Suganya Dr. A. Selvi
National e-Conference on plant health & food security: Challenges & opportunities organized by Indian Phytopathological Society, New Delhi	25-27 March 2021	Dr. R. Viswanathan
International webinar on Exchanges of Post Plant Varieties Protection control measures organized by PPV&FR Authority, New Delhi in collaboration with Department of Agriculture, Co-operation and Farmers' Welfare, MOA and Farmers' Welfare, Govt. of India and Federal Ministry of Food, Agriculture (BMEL), Germany under Indo-German Cooperation on Seed Sector Development	08 April 2021	Dr. M. R. Meena
International symposium on Advances in Plant Biotechnology and Genome Editing, through online mode organized by ICAR-Indian Institute of Agricultural Biotechnology, Ranchi	8-10 April 2021	Dr. R. Valarmathi Dr. C. Appunu Dr. C. Mahadevaiah
National e-Conference on Recent Trends in Plant Pathology, organized by INSOPP, PAU, Ludhiana	04 May 2021	Dr. M.L. Chhabra
Webinar on Revisiting MSP-Remunerative pricing for crop and livestock produce in Haryana and Rajasthan region organized by NAAS, Karnal Regional Chapter	22 May 2021	Dr. M.L. Chhabra
Online krishi goshthi organized by M/s Dhanuka agrochemicals as an expert	26 May 2021	Dr. S.K. Pandey Dr. M.L. Chhabra
Webinar on Translating genomics for next-generation crop improvement organized by Tata Institute for Genetics and Society (TIGS) in partnership with BCIL, New Delhi.	10 June 2021	Dr. M.R. Meena
Meeting regarding Seed Development programme with Hon'ble Cooperation and Jail Minister of Punjab at Sugarfed, Mohali, Punjab	17 June 2021	Dr. S. K. Pandey

Title	Date	Participant (s)
16th Annual Review meeting of DUS Centre's by virtual mode under the Chairmanship of Dr. K V Prabhu, PPV&-FRA, New Delhi	17 June 2021	Dr. M.R. Meena Dr. S. Alarmelu Dr. V. Sreenivasa Dr. R. karuppaiyan
International Conference on Sugarcane Research: Sugarcane for sugar and Beyond (CaneCon 2021), ICAR-SBI, Coimbatore	19-22 June 2021	All scientists attended the conference
Board of Director's meeting of Sugarfed, Punjab for finalizing various agenda in respect of Sugarfed Punjab at Sugarfed, Mohali, Punjab	21 June 2021	Dr. S.K. Pandey
Webinar on Promising and emerging varieties for peninsular zone organized by S. Nijalingappa Sugar Institute, Belgavi and ICAR-SBI, Coimbatore	26 June 2021	Dr. M.R. Meena Dr. V. Sreenivasa Dr. H.K. Mahadeva swamy
Webinar on What next and Co 0238 organized by National Sugar Institute, Kanpur	29 June, 2021	Dr. Ravinder Kumar Dr. M.R. Meena
Webinar on Sustainable integrated cropping and farming system models with special reference to banana for enhanced income for farmers- lecture series of AKAM by NRCB, Trichy	05 July 2021	All Scientists
Webinar on Recent Advances in sustainable integrated disease management in plantation crops organized by ICAR-Indian Institute of Oil Palm Research, Pedavagi (AP)	06 July 2021	Dr. M. L. Chhabra
Zoom Meeting on Genomics and breeding innovations in agriculture by Dr. Rajeev K. Varshney, ICRISAT, Hyderabad	06 July 2021	All Scientists
Meeting to draw the road map for implementation of Mission 10+ sugar recovery at Sugarfed, Mohali, Punjab	07 July 2021	Dr. S. K. Pandey
Generic Online Training Course in Cyber Security organized by CDAC (Centre for Development of Advanced Computing)	09 July 2021	Dr. K. Hari
Virtual training programme Plant Genetic Resources Management and Utilization (Webinar) organized by ICAR-NBPGR	19 July to 01 August 2021	Dr. S. Sheelamary
Meeting with CCDO's of all the nine Cooperative Sugar mills of Punjab for discussion on 'Roadmap for mission 10+ to improve sugar recovery in Punjab	19 July 2021	Dr. S.K. Pandey
Meeting with all the Chief Chemists and Chief Engineers for discussion on Roadmap for mission 10+ to improve sugar recovery in Cooperative Sugar mills of Punjab	27 July 2021	Dr. S.K. Pandey

Title	Date	Participant (s)
Mid-Term Review Meeting (online) on the follow-up action/ taken/ initiated on the recommendations made in the XXVI Meeting of ICAR-Regional Committee No. V comprising the States of Punjab, Haryana and Delhi organized by ICAR-IASRI, New Delhi	27 July 2021	Dr. S.K. Pandey Dr. M.L. Chhabra
Meeting of SLSC of RKVY (Through Video Conference)	30 July 2021	Dr. S.K. Pandey
Conference on 7th Green sugar summit 2021 organized by CII, STAI and NFCSF	05-06 August 2021	Dr. P. Murali
Fifth International conference on Advances in Agriculture, Environmental and Biosciences for sustainable Development organized by AEDS	5-7 August 2021	Dr. M. Punithvalli
Webinar on Quarantine procedures for the national and international exchange of plant materials organized by ICAR- SBI, Research Centre, Kannur, Kerala	12 August 2021	Dr. S.K. Pandey Dr. M.L. Chhabra Dr. Ravinder Kumar Dr. M.R. Meena Dr. Pooja
Virtual Orientation Workshop for ICAR Labs organized by Federation of Indian Export Organizations	12 & 13 August 2021	Dr. P. Murali
Webinar on New paradigms in biological control of insect-pests and diseases organized by ICAR- IISR, Lucknow.	16 August 2021	Dr. M. L. Chhabra
The Parthenium weed problem and its management at the global level organized by Indian Society of Weed Science, ICAR – Directorate of Weed Research, Jabalpur.	16 August 2021	All Scientists
Evaluation committee meeting of the technical officer as Chairman in ICAR-Indian Institute of Wheat And Barley Research, Karnal	17 August 2021	Dr. S.K. Pandey
31st ICAE International Conference on the Frontier topic in Economics and management organized by International Association of Agricultural Economists (IAAE).	17-31 August 2021	Dr. P. Murali
Webinar on Recent developments in sugarcane mechanization	19 August 2021	Dr. T. Arumuganathan
Meeting regarding finalization of road map for implementation of Mission 10+ increase sugar recovery at Sugarfed, Mohali, Punjab	20 August 2021	Dr. S.K. Pandey
International Workshop on Emerging trends in plant protection for sustainable vegetable cultivation, organized by TNAU	25-26 August 2021	Dr. D. Puthira Prathap
Webinar on Entrepreneurship opportunities in nutrition for Farmers organized at ICAR-Sugarcane Breeding Institute, Coimbatore as a part of ICAR National Level Campaign on "Food and Nutrition for Farmers"	26 August 2021	Dr. M.L. Chhabra

Title	Date	Participant (s)
First NABS-International Conference on "Life Sciences: Contemporary approaches in Biological Sciences for Food, Health, Nutrition Security and Conservation of Biodiversity" at Annamalai University , Chidambaram, Tamil Nadu, India.	26-28 August 2021	Dr. R. Gomathi
Meeting with MD Sugarfed, Punjab regarding implementation of road map for "Mission 10+" increase sugar recovery at Sugarfed, Mohali, Punjab.	27 August 2021	Dr. S.K. Pandey
Webinar on Economizing water signature in Agriculture: Sugarcane a case study organized to commemorating the 75 years of India's independence by ICAR-Sugarcane Breeding Institute (ICAR-SBI), Coimbatore	31 August 2021	Dr. M. R. Meena
Remedial measures to bring down cost of production of plantation organized by The Asian Association of Sugarcane Technologists (AASCT)	04 September 2021	Dr. C. Palaniswami Dr. P. Murali
Meeting regarding the management of red rot in Co 0238 and varietal development in Punjab with Hon'ble Cooperation and jail Minister at Sugarfed, Mohali, Punjab.	07 September 2021	Dr. S. K. Pandey
National Training-cum-webinar on On-farm and mass production protocols of bioagents and microbial agents for Fallarmy worm management for PZ, IIMR, Hyderabad.	28-30 September 2021	Dr. B. Mahendran
International Webinar in Alternate cropping systems for Climate change and resource conservation organized by ICAR-Indian Institute of Farming Systems Research	29 September to 01 October 2021	Dr. P. Geetha Dr. S. Anusha
50th Golden Jubilee Annual Convention organized by The South Indian Sugarcane and Sugar Technologist's Association at Eagleton-the golf Resort, Bidadi, Bangalore	01 & 02 October 2021	Dr. G. Hemaprabha
79th STAI annual convention – 2021 organized by Sugar Technologists Association of India	04-05 October 2021	Dr. C. Appunu Dr. S. Alarmelu Dr. K. Mohanraj Dr. P. Malathi Dr. Ravinder Kumar
Webinar on Taxonomic Diversity vis a vis functional diversity in insects - Back to basics but looking forward organized by ICAR-National Bureau of Agricultural Insect Resources	06 October 2021	Division of Crop Protection Scientists
International Conference on Future challenges and prospects of Plant Breeding organized by TNAU	06-07 October 2021	Dr. S. Alarmelu Dr. S. Sheelamary Dr. A. Annadurai Dr. R. M. Shanthi Dr. Lakshmi Pathy Dr. M. Nisha Dr. V. Vinu

Title	Date	Participant (s)
World Food day Lecture on "Safe food now for a healthy tomorrow" organized by ICAR-SBI, Coimbatore.	16 October 2021	Dr. M. L. Chhabra
Meeting with all the General Managers of Cooperative Sugar mills of Punjab regarding 10+ recovery mission.	19 October 2021	Dr. S. K. Pandey
33rd Biennial Workshop (Online)/Annual Group Meeting of AICRP (Sugarcane) organized by ICAR-IISR, Lucknow	21 & 22 October 2021	Dr. G. Hemaprabha Dr. R.M. Shanthi Dr. S. Alarmelu Dr. P. Govindaraj Dr. A. Anna Durai Dr. V. Sreenivasa Dr. R. Viswanathan Dr. A. Ramesh Sundar Dr. V. Jayakumar Dr. K.P. Salin Dr. J. Srikanth Dr. A.S. Tayade Dr. P. Geetha Dr. S. K .Pandey Dr. M. L. Chhabra Dr. Ravinder Kumar Dr. M. R. Meena
Review Meeting on Special campaign and pending matters on Swachhta under the chairmanship of Hon'ble MoS (A&FW)	25 October 2021	Dr. G. Hemaprabha
Cane-Ovate 2021 workshop organized by SSRD – SBI at ICAR – SBI, Coimbatore.	26 October 2021	All the scientists of the Institute
The Hindi Rajbhasha meeting at NDRI, Karnal	08 November 2021	Dr. S.K. Pandey
Live TV talk 'Sugarcane cultivation' at DD Hello Kisan channel	12 November 2021	Dr. S.K. Pandey
2nd International Agro-Biodiversity congress alliance of biodiversity and CIAT	15 -18 November 2021	Dr. R. Gopi Dr. K. Chandran Dr. B. Mahendran
As team Leader of AICRP on Sugarcane Monitoring Team of North Western Zone	16-25 November 2021	Dr. S.K. Pandey
Online meeting of a-IDEA Agri Udaan 4.0, NAARM, Hyderbad	17 -18 November	Dr. K Hari
The half-yearly review meeting of TOLIC, held at NDRI	22 November 2021	Dr. Ravinder Kumar
5th International Agronomy Congress on Agri Innovations to combat food and nutrition challenges organized by Indian Society of Agronomy	23-27 November 2021	Dr. P. Geetha Dr. S. Anusha

Title	Date	Participant (s)
Emerging diseases and our immunity - Lecture series by Dr. Chandrima Shaha, organized by ICAR – Ministry of Agriculture and Farmers Welfare	23 November 2021	All scientists
National Symposium on Sustainable plant health management amid Covid pandemic challenges and strategies by ICAR-CPCRI, Kasaragod	1-3 December 2021	Dr. R. Viswanathan Dr. A. Ramesh Sundar Dr. R. Gopi
Attended a lecture on 'Yogic Kheti for Soil Health Improvement' delivered during the World Soil Day at ICAR-SBI, Coimbatore on	06 December 2021	Dr. S.K. Pandey Dr. M.L. Chhabra
Online interaction meeting of DG, ICAR with young scientists	08 December 2021	All young scientists of the Institute
National Conference on Plant Physiology-2021(NCPP-2021) on "Frontiers of Plant Physiology for Climate Smart Agriculture" jointly organized by ICAR-NIASM, Baramati, and Indian Society For Plant Physiology, New Delhi	9 – 11 December 2021.	Dr. R. Gomathi
Webinar on Plant variety protection intricacies and impact on trait development by Dr. R.R. Hanchinal, Ex- PPVFRA chairperson organized by IISR, Indore	10 December 2021	Dr. M.L. Chhabra
Global Perspectives in Crop protection for food security at TNAU, Coimbatore	8-10 December 2021	Dr. R. Viswanathan Dr. A. Ramesh Sundar Dr. P. Malathi
TV talk on 'News-18 channel' on Jaggery products under 'Unndata' program	17 December 2021	Dr. S.K. Pandey
International webinar on Exchange on Biochemical and Molecular Techniques (BMT) guidelines and implementation of BMT in DUS confirmation	16-17 December 2021	Dr. M.R. Meena
Webinar hosted by ICAR on Swachhta Pakhwada - 'Composting and Vermi-compost'	21 December 2021	All scientists of the Institute
Meeting of the Secretary ICAR & AS, DARE with Heads of Administrative & Finance Wings of all ICAR Institutes	23 December 2021	Dr. G. Hemaprabha
Delivered Lectures in 'Ganna Vichar Gosthi' organized by HARCOFED, Panchkula at Karnal	23 December 2021	Dr. S.K. Pandey Dr. M.L. Chhabra Dr. M.R. Meena Dr. Pooja
Meeting of all the Directors/PCs of Crop Science Division scheduled online	27 December 2021	Dr. G. Hemaprabha

16. DISTINGUISHED VISITORS

- Dr. Trilochan Mohapatra, Director General, ICAR and Secretary, DARE on 03 October 2021 and 01 November 2021 (Fig. 164).

Inauguration of Sugarcane based cropping system model unit

Visit to poultry unit

DG releasing fishlings in the fish pond

DG visiting Sett Treatment Chamber

DG visiting National Hybdrization Garden

DG with the staff of ICAR-SBI

Fig. 164. Visit of DG, ICAR and Seceretary DARE

- Five Directors and two officers from The Meham Coop. Sugar Mills Ltd., Meham Dist., Rohtak, Haryana on 6 November 2021.
- Shri. Sambhaji Kadupati (IAS retd.) Officer on Special Duty (OSD) and Dr. R.S. Hapase, Principal Scientist, Plant Breeding Section VSI, Pune during 8-10 November 2021 (fig. 165).

Fig. 165. Visit of Shri Sambhaji Kadupati IAS (Retd), Officer on Special Duty, VSI, Pune on 8 November 2021

17. PERSONNEL

Name	Designation & Discipline	E-Mail ID
Bakshi Ram Ph.D	Director (From 01.01.2021 to 30.06.2021)	Bakshi.Ram@icar.gov.in
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