वार्षिक प्रतिवेदन 2020

Annual Report

भा.कृ.अनु.प. गन्ना प्रजनन संस्थान
कोयम्बत्तूर 641 007

ICAR - Sugarcane Breeding Institute
(ISO 2001:2008 Institution)

Coimbatore - 641 007

ICAR-Sugarcane Breeding Institute
Coimbatore - 641 007, Tamil Nadu, India
Tel. No. : 0422 - 2472621
Fax No. : 0422 - 2472923
E-mail : director@sugarcane.res.in
Website : http://sugarcane.icar.gov.in

Correct citation
ICAR-SBI Annual Report 2020
ICAR-Sugarcane Breeding Institute, Coimbatore
Tamil Nadu, India

ISSN 0973-8177

Editorial Committee
Dr. Bakshi Ram
Dr. T. Rajula Shanthy
Dr. R. Viswanathan
Dr. G. Hemaprabha
Dr. C. Palaniswami
Dr. R. Valarmathi
Dr. K. Elayaraja

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

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

Contents

Preface

Evolution of sugarcane varieties for different regions of the country is the most important mandate of the Institute. The wonder variety Co 0238 continues its extra ordinary contribution in subtropical India with increase in area from 2.59 million ha during 2019-20 to 2.79 million hectare (84.2 %) during 2020-21. During the season, "Co" varieties evolved by the Institute alone covered about 4.12 million hectare area (60.4 % in tropical region and 90.2% in sub-tropical region) which is 78.9% of the total area under sugarcane in the country. Sugarcane area under Co varieties has increased by 2.4 times over the area during 2014-15, i.e. from 32.96% to 78.9% during 2020-21 season. Co 0238 and Co 86032 continued to be the predominant varieties with about 84.2% and 47.7% area coverage in sub-tropical and tropical regions, respectively. For the first time in the history of sugarcane cultivation, single variety (Co 0238) has spread to the extent of 53.4% area in the country. Co 0238, which occupied 2.38 million hectare or 86.7% of the sugarcane area in the UP state, has resulted in improvement in cane yield (by 19.5 t/ha) and sugar recovery by 2.55 units (from 9.18 to 11.73%) since its recommendation in the state during 2012.

Co 11015, a high quality short duration variety released in the TN state during 2020, is spreading fast and has already covered about 9,500 hectare area in the state. A large number of big mill tests conducted by different sugar factories indicated more than 1 unit higher sugar recovery in comparison with other varieties / mill recovery. Production and supply of large quantity of quality seed of Co 11015 is the reason for its faster spread with in a year.

Co 12009, a midlate maturing variety for Peninsular Zone and Co 13035 (Karan 14), a midlate maturing clone from Institute's Regional Centre at Karnal, in North West Zone have been released and notified for commercial cultivation. Co 13013, a midlate maturing variety, and Co 15023, an early maturing variety, have been identified for release in Peninsular Zone and North West Zone, respectively. Co 15023 has been released one year in advance as a special case owing to its extra-ordinary early maturity and resistance to red rot disease. The Institute is grateful to Dr. T.R. Sharma, DDG (CS) and the Chairman, CVRC for accepting the proposalof the Institute to release Co 15023 as a special case.

Collaborative research activities with different sugarcane research stations and sugar factories showed considerable progress for identifying promising location specific varieties in the states of Maharashtra, Karnataka, and Andhra Pradesh. Eighteen test entries were evaluated in four locations facing acute water deficit stress in Maharashtra under a collaborative project between ICAR-SBI and Vasanthdada Sugar Institute, Pune. The pooled mean analysis of two plant and one ratoon trials showed the advantage ofthe clones Co 85019 and Co 98017 with clear improvement over standards Co 86032 and CoM 0265 for both cane yield and sucrose content. At KCP Sugars, Vuyyuru (Andhra Pradesh), four Co canes viz. Co 11015, Co 09004, Co 14002 and Co 15021 were found promising and were promoted for AICRP (S) trials of East Coast Zone.

Institute-Industry Participatory Approach (TN State) entered the final stage of testing with 17 entries. In the first plant crop, Co 17003 and Co 14027 were better than Co 86032 for

quality, whereas Co 12009, Co 14027, Co 17001 and Co 18009 performed better than Co 86032 for yield. In Co-operative sugar factories of Tamil Nadu, the entries Co 09004, Co 11015 and Co 17003 recorded better sucrose % than Co 86032 from 8 months onwards, while eleven entries (Co 11015, Co 12009, Co 15007, Co 15018, Co 16009, Co 16010, Co 16018, Co 17004, Co 17012, Co 18009 and Co 18024) recorded more than 10 tonnes higher cane yield than Co 86032 at harvest

Under Fluff Supply / National Hybridization Programme, 30.15kg of fluff of crosses effected in the National Hybridization Garden at Coimbatore and National Distant Hybridization Garden at ICAR-SBI, RC Agali during 2019 was supplied to 24 fluff receiving stations across the country. Scientists from participating centres could not attend the hybridization programme during 2020 due to Covid 19 pandemic. However, the institute has made 426 crosses for 21 centres during October-December flowering period. The NHG was maintained well as out of 424 parents, 411 flowered with flowering intensity of 96.93 %.

Sugarcane germplasm is maintained at Coimbatore (3,922 accessions), Kannur (3,373 accessions) and Agali (1,271 accessions) stations of the Institute and Wellington Centre of ICAR-IARI (111 accessions). An exploration was conducted in the Western Ghats covering the states of Kerala, Tamil Nadu, Karnataka, Goa and Maharashtra and 39 *S. spontaneum*, 11 *E. arundinaceous,* three *E. bengalense* and two *S. officinarum* were added to germplasm collection.

Development and evaluation of pre-breeding material are carried out with different objectives. Three clones viz. AS04-2097 (INGR20070) a drought tolerant interspecific hybrid with broadened genetic base with *S. spontaneum* SH 216, CYM08-922 (INGR20071), a backcross derivative with *Erianthus* cytoplasm as a potential pre-bred material for drought tolerance (with higher relative water content and lower malondialdehyde content under drought) and AS04-1687 (INGR20110) was registered for drought tolerance and water logging tolerance.

Breeder seed multiplication was taken up from micropropagated plantlets as the initial source. Farmers' participatory quality seed production was implemented effectively in about 38 acres for supply during February 2021. Based on the seed requests, about 1200 tons of quality seed production was targeted for supply and was supplied as per allotments received from Directorate of Sugar, Government of Tamil Nadu. A total of 1,62,275 tissue culture plants were produced and supplied and an amount of Rs.16,22,750 has been generated through supply of tissue culture plantlets and Rs. 1,75,000 was earned through supply of 70 mother culture flasks. At Karnal, a total of 34,301.71 quintals seed cane of varieties Co 0118, Co 0238, and Co 12029 was supplied during the crop year 2019-20. From the sale of seed revenue worth Rs. 21,91,387/- was generated. A total of 1,80,240 settlings of varieties Co 0118, Co 0238, Co 12029 were produced and sold to various stakeholders for promoting the Settling Transplanting Technique and mechanization of sugarcane agriculture.

The co-expressed stress responsive miRNAs in the wild and cultivated sugarcane cultivars were grouped into nine clusters. Three miRNA families involved in sucrose metabolism were identified in *S. spontaneum.* Validation of differentially expressed *miRNA* based on expression profiles obtained using RT-PCR showed similar expression profiles with that of the NGS in six *miRNAs. NAC* genes expression profiles showed upregulation and downregulation for different NAC genes in Co 86032, *E. arundinaceus and S. spontaneum.*

In a study on weed management in sugarcane planted with setts, seedling and settling, the treatment hand weeding at 30, 60, and 90 days after planting was the best followed by early post emergence spray of Topramezone + Atrazine followed by hand weeding at 80 DAP were found effective and was comparable with the EPOE (early post emergence) spray of Tembotrione + Atrazine followed by one hand weeding at 80 DAP.

Effect of NPK level was studied on SPAD index, plant height, number of tillers, leaf area, shoot dry weight, root volume, root dry weight, root-to-shoot ratio and total biomass, but not root depth. With increasing N, SPAD chlorophyll index, leaf area and shoot height varied from 18.6 to 38.1, 181.9 to 548.8 cm^2 and

36.7 to 94.9 cm, respectively. With increasing P levels, SPAD index, leaf area and shoot height ranged between 41.0 to 32.0, 119.4 to 548.8 cm^2 and 48.2 to 95.6 cm, respectively. With increasing K levels, SPAD index, leaf area and shoot height varied from 28.3 to 33.3, 122.0 to 536.8 cm^2 and 57.4 to 91.3 cm, respectively. Deficiencies of macronutrients significantly reduced shoot dry weight which varied from 2.20 to 23.27 g, 3.96 to 18.03 g and 3.68 to 18.44 g in response to increasing levels of N, P and K, respectively.

Soil inference system (SIS) software with soil constraint identification and management measures was developed in Microsoft Visual Studio Professional 2017 in C#. Management measures for subsurface hardening, sulphur nutrition and calcareousness were incorporated apart from regular nutrient recommendations and problem soil management measures in the SIS software. The developed SIS software provides soil health card with soil constraint management and nutrient recommendations in Tamil.

About 3061 clones from different trials of Crop Improvement Division comprising clonal trials, PZVT, elite hybrids, parental clones from NHG, allied genera, inbreds, genetic stocks etc. were screened for red rot resistance under controlled conditions against CF06 (*Cf*671) pathotype and identified ~1524 resistant clones.

Preliminary results of evaluation of field efficacy of Nano formulations of Benzothiadiazole (BTH) and Salicylic acid (SA) clearly indicated that the nano formulations of SAR inducer molecules, particularly the BTH nano formulation is consistently highly effective in inducing the host resistance of sugarcane crop against red rot, smut and wilt diseases.

Whole transcriptome sequencing was carried out to decipher the transcriptome of two *Sporisorium scitamineum* isolates varying distinctly in their virulence pattern by RNA- seq analysis employing Next Generation Sequencing technology. Approximately 324 million reads (97 GB) and 653 million reads (196 GB) were generated in total for *in vitro* and *in planta* samples, respectively.

As a part of the Virus indexing service, about 677 tissue culture raised plants from different tissue culture production units viz., M/s EID Parry, Pugalur, M/s RSCL, Theni and ICAR-SBI tissue culture lab were indexed for SCYLV, SCMV, SCSMV and grassy shoot phytoplasmas by following SOPs. A revenue of Rs 1,28,900/- was generated under virus indexing charges from the private tissue culture labs.

Shelf life of novel talc formulation of fifteen EPN (seven *Heterorhabditis* spp and eight *Steinernema* spp) isolates stored at 22-25 °C was evaluated against 2nd instar white grub. All EPN caused 100% mortality of white grub at 6th month storage. *S. glaseri* caused 100% mortality till 12 months.

The full length sequence of two *cry* genes, viz. *cry1D* and *cry1E* isolated from the *Bacillus thuringiensis* isolate SBI-KK27 after cloning was found to be 3501 and 3531 bp respectively.

Analysis of the whole genome sequence of SBI-Bt41 revealed the presence of a novel *cry8* gene and SBI-Bt721 had the presence of a full length *cry3* gene. Similarly, another Bt isolate SBI-M6 was found to harbor a new holotype *cry 66* gene whose function is yet unknown.

Three technologies of the Institute viz. Soil Moisture Indicator, ICAR-SBI EPN Biopesticide Formulation and ICAR-SBI Standardized Liquid Jaggery Process were commercialized by licensing the manufacturing rights to 5, 3 and 6 firms, respectively.

It is my pleasure to present the Annual Report of the ICAR-Sugarcane Breeding Institute, summarizing the salient achievements of the institute during the year 2020. I thank all the scientists and other staff of the institute who helped in the successful conduct of research and members of the editorial board for their tremendous efforts in bringing out the Annual Report. Continuous encouragement and guidance received from Dr. T. Mohapatra, Secretary, DARE and DG, ICAR, Dr. T.R. Sharma, DDG (CS) and Dr. R.K. Singh, ADG (CC), ICAR are gratefully acknowledged.

Bakshi Ram

Director

2. THE ORGANIZATION

Background

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

Location

The Institute is located 8 km from the Coimbatore railway station and 19 km from the Coimbatore airport. Geographically it is located at 77^0 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 31.12.2020

Category	Sanctioned	Filled	Vacant
Director	1	1	-
Scientific	78	70	8
Technical	73	52	21
Administrative	40	23	17
Supporting	56	50	06
Total	248	196	52

Financial Statement

Table 2. Abstract of expenditure during January – December 2020

Head	Amount in Lakhs (Rs.)
Government Grant	3251.28
Plan Schemes	5.28
Externally funded schemes	321.32
Total	3577.88

Organizational setup

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).

.

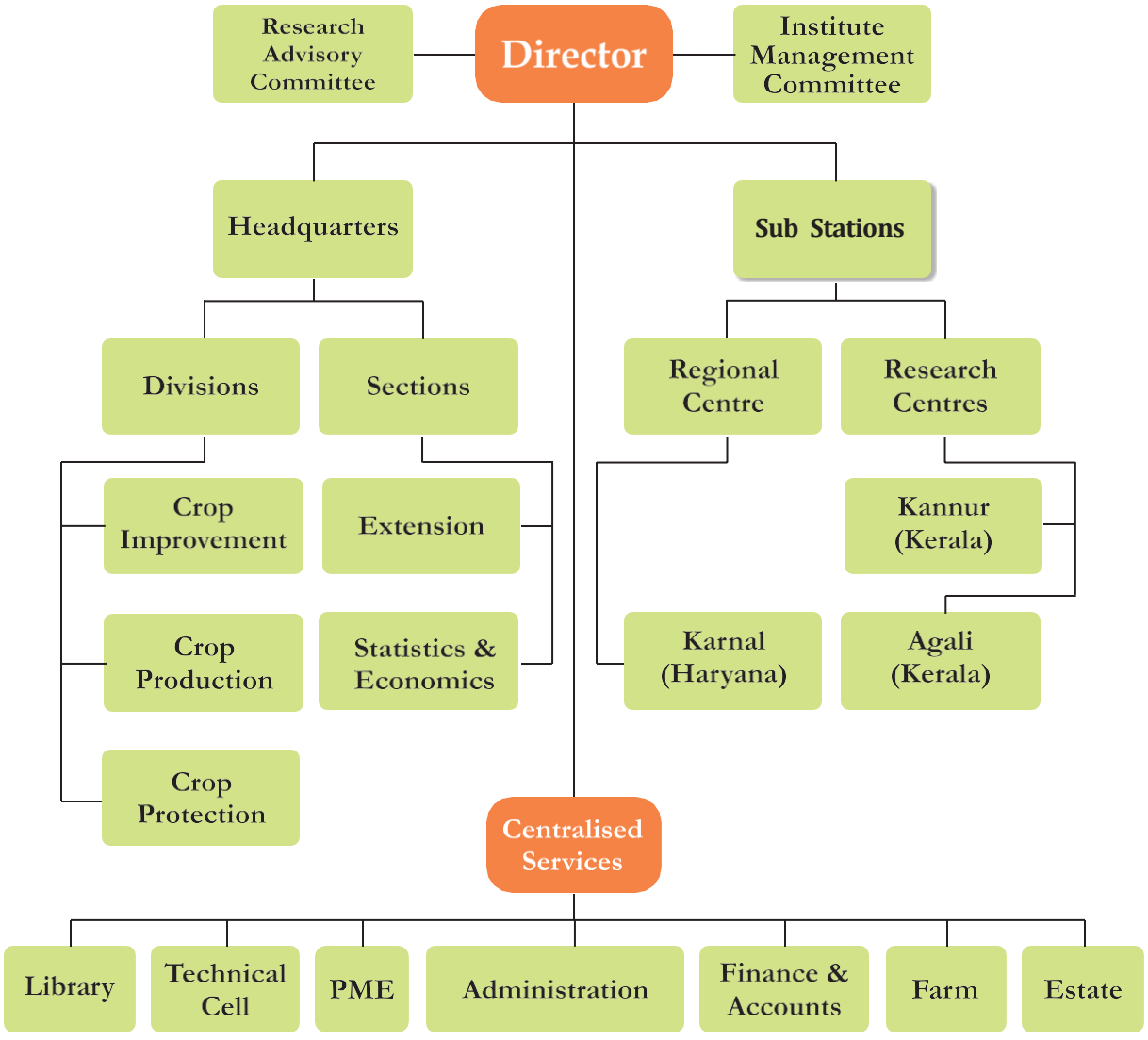


Fig. 1. Organizational structure of ICAR-SBI

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

TThe library provides information support to the Research and Development activities of the Institute. It has a collection of 13,623 books including bound volumes of journals. Library incurred an expenditure of Rs. 2,29,257 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. 12,430.

Weather data

Table 3. Weather data for January 2020 to December 2020

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 2020	31.3	20.2	86.9	53.6	1	3.2	0	0
February	33.2	20.5	84.2	45.7	1.7	4.8	0	0
March	35.0	23.2	85.6	47.3	1.2	5	76.8	2
April	35.0	23.2	84.4	45.1	0	5.2	30	2
May	33.2	24.8	86.7	52.3	1.2	4.7	40.6	3
June	32.2	22.7	84.8	63.3	2.1	4.5	10.8	1
July	31.8	22.6	86.5	71.2	1.2	4.2	56.7	4
August	31.0	22.7	86.3	65.2	1.7	3.9	40.4	5
September	31.1	22.0	87.7	68.0	1.7	4.4	115.8	12
October	31.6	21.9	89.2	65.4	1.1	4.1	37.6	5
November	30.1	21.4	90.6	64.5	0.4	2.7	118.4	9
December	28.3	20.1	87.3	67.8	0.4	2.2	16.7	2
Mean / Total	31.98	22.11	86.68	59.12	1.14	4.08	543.8	45

Total rainfall received during 2020 was 543.8 mm while the 60 years (1930-1990) average rainfall was 674.2 mm.

कार्यकारी सारांश

प्रस्तावना

yd e/;e nsjh ls idus okyh iztkfr dks- 12009 ¼ladYi½ iztkfr dks Hkkjr ds izk;}hih; {ks= esa [ksrh ds fy;s vf/klwfpr fd;k x;k gSA bl iztkfr esa lsdsje~ LikWUVsfu;e inkjksg.k yl-b-yl- 91 dk u;k vkuqokaf'kd vk/kkj gSA yd vU; e/;e nsjh ls idus okyh iztkfr dks- 13013 ¼v{k;½ dk] xUuk yoa phuh mRiknu esa lq/kkj dh n`f"V ls] vf[ky Hkkjrh; leUo; vuqla/kku ifj;kstuk ¼xUuk½ dh iztkfr igpku lfefr }kjk izk;}hih; {ks= ds fy;s igpku fd;k x;k gSA yd ubZ de vof/k esa idus okyh iztkfr dks- 11015 ¼vrqY;½ dks tuojh 2020 esa rfeyukMq ds fy;s vf/klwfpr fd;k x;k] tks 9]570 ydM+ Hkwfe esa eq[;r% O;kolkf;d cht mRiknu ds fy;s QSy pqdh gSA fofHkUu phuh feyksa esa py jgh iztkfr;ksa dh rqyuk esa bl iztkfr ds dkj.k phuh ijrk esa vkSlru yd bdkbZ dh o`f) fjiksVZ dh tk jgh gSA

O;kolkf;d Lrj ds fy;s dks- 13001 vkSj dks- 14016 dks Hkk---vuq-i- & yu-ch-ih-th-vkj- }kjk fof'k"V teZIykLe ds :i esa iath—r fd;k x;k gSA dks- 13001 ¼vkb-yu-th- vkj-20068½ dks de vof/k esa idus] 240 fnuksa ij mPp 'kdZjk okys yd vkuqokaf'kd LVkWd ds :i esa iath—r fd;k x;k gSA dks- 14016 ¼vkb-yu-th-vkj20069½ dks mPp xUuk la[;k vkSj dq'ky isM+h Qlysa nsus okys LVkWd ds :i esa iath—r fd;k x;k gSA o"kZ 2020 ds nkSjku 14 u;s dks- xUuksa ¼dks- 20001 ls 20014½ dh igpku dh xbZ gS ftuesa ls 10 —Urdksa] uke'k% dks- 20001] dks- 20002] dks- 20003] dks- 20004] dks- 20005] dks- 20006] dks- 20007] dks- 2000] dks- 20010 vkSj dks- 20011 dks inksUur dj v-Hkk-l-vuq-i- esa vkxs ds ijh{k.k ds fy;s Hkstk x;k gSA

dqy 20]000 okLrfod cht ls tfur ikS/ks] ftUgsa 90 f}iSr`d ØkWlsl] 4 iksyh ØkWlsl vkSj 6 lekU; ØkWlsl ls izkIr fd;k x;k] tuojh 2012 ds nkSjku Hkwry ulZjh esa isM+h dh Qly ds :i esa p;u ds fy;s miyC/k gSaA o"kZ 2019 ds nkSjku cuk;s x;s 125 ØkWlsl ls izkIr cht ls tfur 25]000 ikS/kksa ds yd lewg dks Hkwry ulZjh esa iqu%jksfir fd;k x;k ftlls ikS/kksa dh yd cM+h tula[;k dh miyC/rk dks p;u ds fy;s lqfuf'pr fd;k tk ldkA izfof"V;ksa dh fofHkUu Lrj ij tk¡p ls egRoiw.kZ lafRr;ksa ds lkFk lkFk vk'kktud iSr`dksa vkSj ØkWl la;kstuksa dh igpku gks ikbZA dks- 11015] dks-lh- 671] dks- 86032] dks- 08016 vkSj lh-ih-61&23 dh Hkxhnkjh ls izkIr izk:iksa esa tYn mPp 'kdZjk lap;u ntZ fd;k x;k tcfd dks- 06010 x dks- 11015] dks- 11015 x dks- 0314 vkSj dks- 86032 x 85 vkj- 186 ØkWlsl ls vf/kd la[;k esa p;u izkIr gqyA f}rh; —Urd ijh{k.kksa ds 1]464 —Urdksa esa ls 35 % dks yky lM+u jksx izfrjks/kh ik;k x;k tks yky lM+u jksx izfrjksf/krk ds fy;s vkuqokaf'kd mUufr dk ladsrd gSA dks- xUuksa dh igpku dqy 166 mR—"V p;uksa dks dks;EcYkwj ls vkSj x-iz-la- {ks=h; dsUnz] dUuwj ls 4 —Urdksa dks mPp xUuk mRiknu] jl dh xq.koÙkk vkSj yky lM+u jksx izfrjksf/krk ds fy;s iwoZ {ks=h; iztkfr ijh{k.k 2020 Ja[kyk ds vUrjxr ewY;kafdr fd;k x;kA —Urd ulZjh ls 2 p;uksa

¼y-th-12018&4 vkSj y-th-12018&35½ us Øe'k% 20-58 % vkSj 19-27 % 'kdZjk 8osa eghus esa ntZ dh ftUgsa Hkkoh] de vof/k esa idus okys —Urdksa ds :i esa lkspk tk ldrk gSA

egkjk"V"] dukZVd vkSj vkU/kz izns'k jkT;ksa esa vk'kkoku LFkku fof'k"V iztkfr;ksa dh igpku dh fn'kk esa fofHkUu xUuk vuqla/kku LVs'kuksa vkSj phuh feyksa ds lkFk lg;ksxkRed vuqla/kku xfrfof/k;ksa esa dkQh izxfr ns[kh xbZA Hkk---vuq-i-& xUuk iztuu laLFkku vkSj olUrnknk 'kwxj laLFkku] iwuk ds chp lg;ksxkRed ifj;kstuk ds vUrjxr 18 ijh{k.k izfof"V;ksa dks vR;kf/kd ty ruko okys egkjk"V" ds pkj LFkkuksa ij ewY;kafdr fd;k x;kA nks ikS/kk Qly vkSj yd isM+h Qly ds ijh{k.kksa ds la;ksftr vkSlr fo'ys"k.k esa dks- 85019 vkSj dks- 98017 —Urdksa esa ekudksa dks- 96032 vkSj dks-ye- 0265 ds eqdkcys xUuk mRiknu vkSj 'kdZjk dh ek=k esa Li"V lq/kkj ns[kk x;kA dksgykiqj esa ijh{k.k izfof"V;ksa esa ls dks- 06022] dks- 15007 vkSj dks- 15021 dks ikS/kk vkSj isM+h Qly ds izn'kZu ds vk/kkj ij csgrj ik;k x;kA ds-lh-ih- 'kwxj] og;g# ¼vkU/kz izns'k½ esa 4 dks- xUuk iztkfr;ksa] uke'k% dks- 09004] dks- 11015] dks- 14002 vkSj dks- 15021 dks vk'kktud ik;k x;k] vr% mUgsa iwoZ rV~Vh; {ks= ds v-Hkk-l- vuq-i- ¼xUuk½ ijh{k.kksa ds fy;s inksUur fd;k x;kA phuh fey us dks- 09004] dks- 11015 vkSj dks- 15007 dks cM+s lykVksa esa cgqxqf.kr fd;k gSA yl-yu-yl-vkb- csykxoh] dukZVd esa ijh{k.kksa dks yxk;k x;k gSA nks ikS/kk Qly vkSj yd isM+h Qly ds ijh{k.kksa ds la;ksftr vkSlr fo'ys"k.k ds vk/kkj ij 2012&147] 2014&99 vkSj dks- 18024 dks ekudksa ls csgrj ik;k x;kA mÙkjh dukZVd ds cgqLFkkuh; ijh{k.k esa dks- 18024 us yd mUur —Urd ds :i esa {ks= ds fy;s vk'kk txkbZ gSA lw[ks ds gkykrksa esa 21 izfof"V;ksa dk ewY;kadu djus ij dks- 85019 dks phuh ijrk mRiknu ds fy;s csgrj ik;k x;kA lw[ks ds gkykrksa esa dks- 09004] dks- 10033] dks- 12007 vkSj dks- 13003 izfof"V;ksa us ekud dks- 86032 ls csgrj izn'kZu fd;kA rfeyukMq —f"k fo'ofo|ky; ds lg;ksx ls fd;s x;s vuqdwyd vuqla/kku ijh{k.k esa 14 ijh{k.k izfof"V;ksa esa ls dks- 11015 dks lcls vf/kd 'kdZjk dh ek=k ntZ djrs

ik;k x;kA pkj izfof"V;ksa] ftuesa dks- 14016 vkSj dks- 15007 rFkk 2 izfof"V;ka rfeyukMq –f"k fo'ofo|ky; ls 'kkfey Fkh] dk ijh{k.kksa ds fy;s p;u fd;k x;kA vuqla/kku LVs'kuksa ij cgqLFkkuh; ijh{k.kksa ds fy;s dks- 14004] dks- 14012] dks- 18023 ¼2020&22½ vkSj dks- 15020 ¼2021&22½ dk p;u fd;k x;k gSA

v-Hkk-l-vuq-i- ds vUrjxr 'kq#vkrh iztkfr ijh{k.k vkSj mUur iztkfr ijh{k.k ds izFke ikS/kk] f}rh; ikS/kk vkSj isM+h Qly ijh{k.kksa dks rduhdh dk;ZØe ds vuqlkj iwjk djfy;k x;k gSA 'kq#vkrh iztkfr ijh{k.k esa dks- 11015 izfof"V us mPpre phuh ijrk mRiknu ¼23-19 Vu@gs-½ vkSj mPpre 'kdZjk ek=k ¼22-58 %½ ntZ dj lokszPp LFkku ik;kA mUur iztkfr ijh{k.k ds izFke ikS/kk ijh{k.k esa nksuks dks- 14004 vkSj dks- 14027 dks mRiknu vkSj xq.koÙkk ds vk/kkj ij lkFkZd :i ls csgrj ik;k x;kA

laLFkku&m|ksx Hkkxhnkjh i|fr ¼flLek fuf/kc)½ ds vUrjxr 17 izfof"V;ksa ds lkFk ijh{k.k vius vfUre pj.k ij igq¡p x;k gSA izFke ikS/kk Qly esa dks- 17003 vkSj dks- 14027 dks ekud dks- 86032 ls xq.koÙkk dh n`f"V ls csgrj ik;k x;k tcfd dks- 12009] dks- 14027] dks- 17001 vkSj dks- 18009 us ckgjosa eghus esa ekud dks- 86032 ls csgrj mRiknu n'kkZ;kA rfeyukMq dh lgdkjh phuh feyksa esa dks- 09004] dks- 11015] vkSj dks- 17003 izfof"V;ksa us 8osa eghus ds ckn ekud dks- 86032 ls csgrj 'kdZjk % ntZ dh tcfd 11 izfof"V;ksa ¼dks- 11015] dks- 12009] dks- 15007] dks- 15018] dks- 16009] dks- 16010] dks- 16018] dks- 17004] dks- 17012] dks- 18009 vkSj dks- 18024½ us dVkbZ ds le; dks- 86032 ds eqdkcys 10 Vu vf/kd xUuk mRiknu n'kkZ;kA

dks;EcÙkwj vkSj vxyh esa Mh-;w-yl- ijh{k.k ds vUrjxr 233 m".kdfVca/kh; {ks= dh rhu fdlku iztkfr;ksa vkSj xUuk lanHkZ iztkfr;ksa dks [ksr esa vuqjf{kr fd;k tk jgk gSA rhu fdlku iztkfr;ksa] uke'k% nslh 1] nslh 2 vkSj esbrsb pw vuxaxck] dk Mh-;w-yl- ijh{k.k iwjk djfy;k x;k gS ftUgsa mudh lanHkZ iztkfr;ksa ls fHkUu ik;k x;k gSA blh izdkj fdlkuksa dh nks vU; iztkfr;ksa] uke'k% thr dVkjh vkSj lqxe dVkjh dks Hkh fHkUu ik;k x;k gSA

xUus dks vc yd cgq&mi;ksxh Qly ds :i esa ns[kk tkrk gS ftlesa ¼fctyh Hkki ds :i esa csdkj tk jgs rki l½s mRiknu o bFksukWy mRiknu Hkh 'kkfey gSaA blh izdkj ÅtkZ xUuksa dh cxkl dk] dPps eky ds :i esa u;s mRiknksa] tSlsfd dPpk rsy cukus esa] isij m|ksx ds fy;s yqxnh ds :i esa vkSj ifj/kku m|ksxksa esa cukoV js'kksa ds :i esa iz;ksx djus dh dksf'k'ksa dh xbZ gSaA ÅtkZ xUuksa dh cxkl dk dPps eky ds :i esa tSo&dPpk rsy mRiknu ds fy;s lQyrk feyh gS tcfd bldh yqxnh dh vPNh xq.koÙkk gksus ds dkj.k cxkl dks yd csgrj fodYi ds :i esa ns[kk tk jgk gSA pkjs ds :i esa iz;ksx fd;s tk ldus okys 72 –Urdksa ij iks"k.k xq.koÙkk vkSj Lokfn"Vrk lEcaf/kr v/;;u Hkk-–-vuq-i- & vkb-th-yQ- vkj-vkb-] >kalh esa fd;s tk jgs gSaA buesa ls pkj –Urdksa-] uke'k% y-th12019&14] y-th12019&51] y-th12019&56 vkSj y-th12019&82] dks jksi.k ds 150 fnu ckn nwljksa dh rqyuk esa mPp tSoHkkj mRikfnr djrs ik;k x;kA

QYQ vkiwfrZ@ jk"Vªh; ladj.k dk;ZØe ds vUrjxr 30-15 fdyksxzke QYQ jk"Vªh; ladj.k m|ku dks;EcÙkwj vkSj Hkk-–-vuq-i-&xUuk iztuu laLFkku] {ks=h; dsUnz] vxyh dsjk"Vªh; lqnwj ladj.k m|ku] esa 2019 ds nkSjku cuk;s x;s ØkWlsl ls izkIr gqvk Fkk dks ns'k Hkj fLFkr 24 QYQ izkIr djus okys dsUnzksa dks Hkstk x;kA o"kZ2020 esa ladj.k ds dk;ZØe dks dksfoM 19 ds pyrs] ;k=k lEca/kh cnys fu;eksa ds dkj.k] vyx gh :i esa gh pykuk iM+kA jk"Vªh; ladj.k m|ku dks vPNh izdkj ls vuqjf{kr fd;k tk jgk gSA dqy 424 iSr`dksa esa ls 411 esa iq"i.k ns[kk x;k ftudh iq"i.k rhozrk 93 % FkhA vDrwcj ls fnlEcj ds iq"i.k ekSle ds nkSjku dqy 426 ØkWlsl 21 dsUnzksa }kjk cuk;s x;sA

lw[kk lgu'khyrk yoa yky lM+u jksx izfrjksf/krk ds fy;s ekjdj dh lgk;rk ls p;u izfØ;k dh 'kq:vkr tqykbZ 2020 esa dh xbZ rkfd p;u izfØ;k dks rst o mUur fd;k tk ldsA lw[kk lgu'khy vkSj laosnu'khy –Urdksa ds yd lewg dks 2021&2022 ds nkSjku ewY;kfdr djus ds fy;s igpkuk x;kA cÙkhl lw[kk fof'k"V izR;k'kh thu ekjdjksa dks muds igys ds v/;;uksa ls izkIr MkVk ds vk/kkj ij pquk x;kA yd vU; ubZ xfrfof/k ftldh 'k:vkr bl o"kZ dh xbZ] og Fkh xUus esa rhoz iztuu ds }kjk xfreku iq"i.k dks ekufd–r djukA izdk'k vof/k dks 16 ?kaVs rd 50]000 yDl }kjk 90 fnuksa rd dUVªksy ds eqdkcys c<+kus ls dYyksa dh la[;k]tM+ dk tSo Hkkj vkSj dqy lw[kk inkFkZ esa ldkjkRed o`f) ns[kh xbZA

xUus ds teZlykLe dks c<+kuk yoa iztuu ls igys vko';d lexzh dk fodkl djuk laLFkku ds fy;s yd izkFkfed xfrfof/k jgh gSA rhu iztuu iwoZ lefxz;ksa dk iathdj.k Hkk-–-vuq-i- & yu-ch-ih-th-vkj- }kjk fof'k"V teZlykLe ds :i esa fd;k tkuk eq[; miyfC/k;ksa esa 'kkfey gSA ;g gSa yd lw[kk lgu'khy vUrjtkrh; ladj y-yl-04&2097 ¼vkb-yu-th-vkj-20070½ ftlds vkuqokaf'kd vk/kkj dks yl-LikWUVsfu;e yl-yp- 216 }kjk foLr`r fd;k x;k gS] yd

vU; lw[kk lgu'khy ¼lw[ks ds gkykrksa esa vf/kd lkis{k ty ek=k vkSj de esyksuMkbyyMhgkbM ek=k okyk½ lh-okb-ye-08&922 ¼vkb-yu-th-vkj-20071½ bfjyUFkl lk;VkslykLe okyh cSdØkWl ls fodflr lexzh] tks yd {kerkoku iztuu iwoZ lw[kk lgu'khy lexzh gS] vkSj y-yl-04&1687 ¼vkb-yu-th- vkj-20110½ dks lw[kk yoa ty lykou ds gkykrksa ds fy;s iath—r fd;k x;k] ftls ch-vks- 102 x vkb-yu-Mh- 84&337 ¼2yu ¾ 56½ ls fodflr fd;k x;k Fkk vkSj ftldk vk—frdh foKkfud] lL; foKkfud vkSj vk.kfody{k.k o.kZu fd;k x;kA vkj-Vh-&ih-lh-vkj- fo'ys"k.k ls eq[; thuksa dk lw[kk o yo.krk lgu'khyrk ds fy;s fofHkUurk ls izdVu ns[kk x;kA

taxyh teZlykLe dk vuqjf{k.k dks;EcŸkwj yoa osfyaxVu fd;k tk jgk gSA dks;EcŸkwj esa lsdsje LikWUVsfu;e] bfjyUFkl thul~ vkSj lEcaf/kr tsujk dh 2130 teZlykLe vfHkizkflr;ksa dks vuqjf{kr fd;k tk jgk gS tcfd v#.kkapy izns'k ls ydf=r dh xbZ 47 vfHkizkflr;ksa dks vkb-y-vkj-vkb- ds {ks=h; dsUnz] osfyaxVu esa vuqjf{kr fd;k tk jgk gSA uy laxzg.kksa dks laxjks/ku esa j[kk x;k gSA blh izdkj 1998 ds laxzfgr —Urdksa] ftlesa dks- xUus] fons'kh ladj vkSj nwljs tsusfVd LVkWDl 'kkfey gSa] dks Hkh vuqjf{kr fd;k tk jgk gSA bu lHkh vfHkizkflr;ksa dh fofHkUu iq"i.k ekidksa ds fy;s tk;p dh tk jgh gSA iatkc] gfj;k.kk vkSj >kj[kaM ls ydf=r fd;s x;s lsdsje LikWUVsfu;e dk dksf'kdk foKkfud v/;;u tkjh gSA blls tks egRoiw.kZ tkudkjh izkIr gqbZ og gS lk;VksVkbi vkb-yu-Mh- 17&1852 esa vlk/kkj.k vkSj lcls de 2yu ¾ 40 xq.klw=ksa dk ik;k tkukA laLFkku esa yl- LikWUVsfu;e ds laxzg.k ds 26 lk;VksVkbiksa ds 2yu ¾ 40 ¼8x½ ls 2yu ¾ 112 ¼14x½ xq.klw=ksa dks ik;k x;k gSA mi fgeky; {ks= dh Hkkjrh;&xaxk ?kkVh vkSj nf{k.k&iwohZ frdksus {ks= dks] fofHkUu xq.klw=ksa dh la[;kvksa ds dkj.k] dksf'kdk&Hkwxksyh; fnypLi {ks=ksa ds :i esa ns[kk x;k tcfd mŸkj vkSj mŸkj&iwohZ Hkkjrdks dksf'kdk&:ikRed ifjorZu'khyrk dh vuqdwyu {kerk ds y{k.kksa ds lap;u dks c<+kok nsrs ns[kk x;k] tks buds xfr'khy Øfed fodkl izfØ;k ds LFkku gksus dk b'kkjk djrh gSA bfjyUFkl —Urdksa ds fy;s igpku dqath oxhZdj.k ds fy;s fooj.k Hkk"kk ¼Mh-b-yy-Vh-y-½ ds lkWQVos;j dks fodflr dj 52 —Urdksa dks y{k.k of.kZr fd;k x;kA jk"V³h; xfr'khy teZlykLe cSad esa dqy 271 vf/klwfpr vkSj iath—r tsusfVd LVkWDl dks vuqjf{kr fd;k x;k vkSj muesa ls 16 —Urdksa dks lwpdkad uEcj fn;s x;sA

pj.kc) rjhds ls xUuk teZlykLe dks tSfod vkSj vtSfod rukoksa ds izfr dks;EcŸkwj esa ewY;kafdr fd;k x;kA yl- LikWUVsfu;e —Urdksa] uke'k% yl-b-yl- 45] yl-b-yl- 49] yl-b-yl- 297 y-] yl-b-yl- 162ch-] xykxkg vkSj yp- 60&4&5 rFkk bfjyUFkl v#afMusf';l vfHkizkflr;ksa] uke'k% yl-b-yl- 75] yl-b-yl- 149] yl-b-yl- 293] yl-b-yl- 347] vkb-yu-Mh-10&1594] vkb-yu-Mh-99&886] vkb-yl-76&158] vkb-yl-76&205 vkSj vkb-ds-76&62 us lw[ks ds gkykrksa esa csgrj izn'kZu fd;kA

vUrjtkrh; vkSj vUrjtsufjd ladjksa dh uohu mRifŸk dj mUgsa ewY;kafdr fd;k x;kA yl- vkWfQ'usje dh vf/kd fofo/krk dks Hkfo"; esa vkus okyh iztkfr;ksa esa lekosf"kr djus ds fy;s] bl vof/k ds nkSjku 10 fof'k"V ukscy xUuksa dks ØkWflax ds fy;s iz;ksx esa ykdj] mPp lk;VksVkbi ¼2yu ¾ 72 vkSj 80½ O;qRiUu larkuksa ds lkFk 30 cSdØkWlsl cuk;s x;sA lw[kk lgu'khyrk ds fy;s cgqiSr`d mUur larfr vUrj&ØkWl tula[;k ds fodkl ds fy;s 8 fofHkUu tsusfVd lalk/kuksa dk la;kstu vfUre pj.kksa esa ig;aqp pqdk gSA ipiUu v"VekxhZ@ vUrj ØkWlsl ls izkIr 1]550 cht tfur ikS/kksa dks [ksr esa xUuk mRiknu] jl dh xq.koŸkk] lw[kk vkSj yky lM+u jksx izfrjksf/krk ds ewY;kadu ds fy;s yxk;k x;kA nks ekxhZ ØkWl tula[;k ls N% lw[kk lgu'khy —Urdksa dh vkSj pkj ekxhZ ØkWl tula[;k ls 15 yky lM+u izfrjks/kh —Urdksa dh tk;p dh tk jgh gSA lsdsje vkSj bfjyUFkl ds vUrjtkrh; vkSj vUrjtsufjd ladjksa dk vk.kfoddksf'kdkvkuqokaf'kd y{k.k o.kZu dk dk;Z tkjh jgkA dks- 15015] ftlesa bfjyUFkl ds 4 xq.klw= fo|eku Fks] dk dks- 11012 ls ØkWl djus ij mRiUu larfr esa th-vkb-yl-yp- rduhd }kjk bfjyUFkl ds 2 xq.klw=ksa dh mifLFkfr ns[kh xbZA yd vUrjtkrh; dks- 285 ladj ¼yl- vkWfQ'usje] xzhu LikVZ 2yu = 80 x yl- LikWUVsfu;e] dks;EcŸkwj 2yu = 64½ dk yl- LikWUVsfu;e] dks;EcŸkwj fpfUgr lykbZ dh lgk;rk ls th-vkb-yl-yp-}kjk fo'ys"k.k djus ij 32 xq.klw= yl- LikWUVsfu;e ls vkSj 7 iqu% la;ksftr xq.klw= yl- LikWUVsfu;e vkSj yl- vkWfQ'usje ds ik;s x;sA O;kolkf;d ladjksa esa th-vkb-yl-yp- }kjk yl-LikWUVsfu;e ds iwjd ds :i esa mifLFkfr dk ewY;kadu djus ij yksdfiz; iztkfr dks- 86032 esa yl- LikWUVsfu;e ds 12 xq.klw=ksa dks ik;k x;kA bfjyUFkl x yl- LikWUVsfu;e dk v/;;u djus ij nwljh] rhljh vkSj pkSFkh larfr;ksa esa bfjyUFkl ds 30 xq.klw=ksa dk thu gLrkUrj.k izpyu Øe'k% ?kVrs 24] 12 vkSj 7 ik;k x;kA

mUur lsdsje tsusfVd vk/kkj ds lkFk lkFk fof'k"V xq.k okys tsusfVd LVkWDl vkSj cgqxq.kh tsusfVd LVkWDl fodflr djus ds lkFk lkFk muesa lw[kk lgu'khyrk yoa mPp xUUkk mRiknuo jl dh xq.koŸkk ekidksa ds Lrj esa lq/kkj ykus dk dk;Z izxfr ij gSA lsdsje dh 8 vfHkizkflr;ksa] uke'k% ukjxksjh] esaxkfld] eusfjvk vkb-ye-ih- 1552] nkSj fdukjk] fpu] eqaxks 254] [ksyh vkSj jsgk] rFkk rhu iq"i.k nsus okys vUrjtkrh; ladjksa dks dUuwj dsUnz ij fodflr fd;k x;k ftuesa yky

lM+u izfrjksf/krk dh izfrfØ;k ns[kh xbZ] vkSj lq/kkj ds fy;s izfrjks/kh :iksa dks mPp xq.koŸkk okys O;kolkf;d xUuksa ds lkFk ØkWflax ds fy;s iz;ksx fd;k x;kA lw[kk yo.krk vkSj phuh mRiknu ds fy;s vkSj vf/kd ladjksa dk ewY;kadu fd;k x;kA fof'k"V xq.k okys teZlykLe ds fodkl ds fy;s vis{kk—r yd ubZ bfjyUFkl tkfr] b- izkslsjl dk iz;ksx gky gh esas fd;k tk jgk gS vkSj bl tkfr dh Hkkxhnkjh okyh ch-lh-1 larfr;ksa dk iz;ksx dj 35 cSd ØkWlsl cuk;s x;sA O;kolkf;d Lrj ds 15 csgrj vUrjtsufjd ladj latkrksa dks iwoZ {ks=h; iztkfr ijh{k.k ds fy;s vxzlj fd;k x;kA

xUuk ftuksfeDl vkSj vk.kfod ekjdjksa ds {ks= esa vuqla/kku djrs gqy fofHkUu xq.kksa dks lEcksf/kr fd;k x;kA tyok;q esa pyrs ifjorZu ds ifjn`'; esa bfjyUFkl tkfr vkSj lsdsje LikWUVsfu;e esa vkWfDlMsfVo ruko lgu'khyrk ds fy;s thu dh [kkst vkSj fofu;eu dk dk;Z vius fu"d"kZ ij igqjp x;k gSA taxyh vkSj [ksrh dh tk jgh iztkfr;ksa esa lg O;Dr djus okys ruko mŸkjnk;h yevkbvkj-yu-y-vksa dks 9 legksa esa foHkDr fd;k x;kA yl- LikWUVsfu;e esa lqØksl p;kip; esa Hkkx ysus okys 3 yevkbvkj-yu-y- ifjokjksa dks igpkuk x;kA vkj-Vh-&ih-lh-vkj-}kjk vfHkO;Dr izksQkbyksa ds vk/kkj ij fofHkUurk ls izdVu fn[kkus okys yevkbvkj-yu-y- dk ekudhdj.k fd;k x;k tks 6 yevkbvkj-yu-y-vksa esa yu-th- yl- ds vfHkO;Dr izksQkbyksa ds leku FksA yu-y-lh- thuksa ds vfHkO;Dr izksQkbyksa us dks-86032] b- v#afMusf';l vkSj yl- LikWUVsfu;e esa yu-y-lh-thuksa ds fy;s Åij o uhps dh rjQ fofu;eu fn[kk;kA xUus esa iq"i.k O;ogkj dks cnyus ds fy;s ftukse lEiknu ds fy;s lh-vkj-vkb-yl-ih-vkj- & lh–yyl oSDVj dk fuekZ.k fd;k x;kA yd vU; v/;;u dh 'kq:vkr dh xbZ rkfd QkbVksbZu MhlSpwjsl thu dks yf{kr dj lh-vkj-vkb-yl-ih-vkj- & lh-yyl9 dh e/;LFkrk

}kjk thu lEiknu dk ekudhdj.k fd;k tk lds vkSj 4 ekxZn'kZd vkj-yu-y- fuekZ.k rS;kj fd;s x;s vkSj vkuqokaf'kd :ikU=.k izxfr ij gSA dYyksa ds mRiknu ds fy;s dk;kZRed ftuksfeDl n`f"Vdks.k }kjk vk.kfod izfØ;k fofu;eu dks le>us ds dk;Z dh 'kq:vkr Hkh dh xbZA vHkh rd ds v/;;u esa] mPp vkSj fueUu dYyk mRiknu thuizk:iksa ds chp] LVªkbxksySDVksu 'kk[kk vojks/kd thu ds vfHkO;Dr izksQksbyksa esa ldkjkRed fHkUurk ns[kh xbZA

VªkUlfØIVkse funsZf'kr [kuu vkSj ty deh ruko ls lEcaf/kr thuksa] yevkbvkj-yu-y-vksa vkSj muds laHkkfor y{;ksa dk dk;Z izxfr ij gSA lw[ks dh lHkh izoLFkkvksa vkSj mlls mcjus ds nkSjku lgu'khy vkSj laosnu'khy iztkfr esa fofHkUurk ls izdV djrh thuksa ds VªkUlfØIV Lrjksa dk v/;;u fd;k x;kA lgu'khy vkSj laosnu'khy iztkfr;ksa esa lkFkZd :i ls mPp o fueUu fofu;eu fn[kkrh egRoiw.kZ thuksa ds lkFk lkFk yevkbvkj-yu-y-vksa] ftUgksaus cgqr vf/kd O;Dr fd;k] dh igpku dh xbZA laosnu'khy iztkfr esa 145 yevkbvkj-yu-y-vksa us fofHkUurk ls O;Dr fd;k tcfd lgu'khy iztkfr esa 143 yevkbvkj-yu-y-vksa usA lqØksl fu;U=d thuksa ds le&lEHkkfork sa vkSj VªkUlfØIV izdkjkarjksa rFkk mPp ty iz;ksx dq'kyrk ds lkFk lEcaf/kr thuksa ds y{k.k o.kZu dk dk;Z Hkh tkjh gSA

xUus esa egRoiw.kZ xq.kksa ds fy;s ftuksfed p;u ds vUrjxr vkSj fof'k"V Hkkjrh; vkSj vkWLVªsfy;k okys teZlykLe] yky lM+u jksx] lw[kk o 'kdZjk ds fy;s tula[;kvksa ds y{k.klef"Vdj.k ds dk;Z dks iwjk fd;k x;kA blds lkFk vkuqokaf'kdrk ekuksa dk vkdyu fd;k x;k ftUgsa ftuksfed p;u ds fy;s mi;qDr ik;k x;kA N% lkS pkyhl —Urdksa ds thu iz:i.k ls 15]040 yl-yu-ih-vksa dks ydy [kqjkd ekdZjksa ds :i esa izklr fd;k x;kA lHkh thu izk:fir —Urdksa dk iz;ksx ftuksfed p;u@iwokZuqekfur ekWMyksa dks fodflr djus ds fy;s fd;k x;kA cs;l~ y- vkSj cs;l~ ch- ekWMyksa us lqØkslvkSj yky lM+u jksx xq.kksa ds fy;s lkFkZd yl-yu-ih-vksa dks n'kkZ;kA

bfjyUFkl vkuqokaf'kd fofo/krk ls izklr MkVk vkSj lw[kk y{k.klef"Vdj.k MkVk ds vk/kkj ij 96 bfjyUFkl teZlykLe ds iSuy dk thu izk:i vuqØe.k }kjk fuekZ.k fd;k x;kA yl-yu-ih-vksa dk ekufp=.k djus ds ckn vuqØe esa fofo/krk dk fo'ys"k.k fd;k x;k vkSj djhc 50]000 ls 1]60]000 yl-yu-ih-vksa dk izR;sd uewus esa irk pykA vkxs tM+jfgr eqdqV vkSj ekSfyd tM+ksa lEcaf/kr yd izR;k'kh thu] tks yy-vks-ch-dk;Z{ks= ds VªkUlfØl'ku ?kVdksa dk yd lnL; gS] vkSj 'kk[kk ls iSnk gksus okyh tM+ksa dh 'kq:vkr ds fy;s eq[; fu;ked gS dks b- v#afMusf';l ls y{k.k of.kZr fd;k x;k gSA b-v#afMusf';l ls uohu ruk fof'k"V izksRlkgd ds izFkDdj.k] dyksfuax vkSj y{k.ko.kZu ls bldh la?kVd vfHkO;fDr dk irk pykA tM+ fof'k"Vrk ds fy;s foyksiu fuek.kksZa dks fodflr fd;k x;k vkSj Mh-2] Mh-3 vkSj Mh-5 fuekZ.kksa dk vkuqokaf'kd :ikU=.k ds fy;s iz;ksx fd;k x;k vkSj Vh-O ijkthfu;ksa dks fodflr fd;k x;kA yl- LikWUVsfu;e dks nksckjk yo.krk ruko lgu'khyrk ds fy;s yf{kr fd;k x;k vkSj yo.krk ruko mŸkjnk;h thuksa ds vk.kfod izksQkbfyax ds fy;s vkb-yu-Mh-16&1762 vfHkizkflr dks pquk x;kA rhu thu ifjokjksa] tSlsfd yo.krk ruko mŸkjnk;h thuksa] dksf'kdk fnokj lEcaf/kr thuksa vkSj nwljs vtSfod ruko ladsrd thuksa ls lEcaf/kr dqy 21 thuksa@ VªkUlfØl'ku ?kVdksa us ruko ds nkSjku mPp QksYM cnyko n'kkZ;kA yl- LikWUVsfu;e esa xyqVkFkk;ksu iFk ds lkFk lkFk

yl-vks-yl- iFk yo.krk ruko ds nkSjku izeq[k iFk Fks tks izsfjr gqy] ftuesa yl-vks-yl-] Xykb 1] vkj-y-ch- vkSj yu-yp- ydl- eq[; thu FkhA

yo.krk laosnu'khy iztkfr dks- 97010 vkSj yo.krk lgu'khy bfjyUFkl v#afMusf';l vkb-yu-Mh-99&907 dh tM+ksa ds ruko xzLr vkSj lekU; uewuksa ds V~kUlfØlVkse vkSj yevkbvkj-yu-y- vuqØe.k dh rqyuk djus ij yevkbvkj-yu-y-vksa vkSj muds le rqY; fofHkUurk ls vfHkO;Dr djrs thu y{;ksa dks vfr mPp Lrj ij O;Dr djrs ik;k x;kA

xUus esa lQsn fxaMkj ¼gksyksV~kbfdvk lsjsVk½ izfrjksf/krk ds fodkl ds fy;s uohu Økb fo"k gksyksVkbi thuksa dk iz;ksx yd ubZ 'kq:vkr gSA Økb vHkko okyh LV~suksa esa Økb8 fo"k ¼Økb8yl-y 1 vkSj Økb8 vkb-ch½ thuksa dh dyksfuax vkSj vfHkO;fDr dk dk;Z izxfr ij gSA izksfVvksfed i)fr dk iz;ksx dj] xUus ds cxkl ls csgrj dk"BkHku [kRe djus ds fy;s] u;s dk"B vinzO; ¼fyxfuu½ vi?kVu yUtkbeksa dh igpku dh 'kq:vkr dh xbZ ftlds fy;s xUus ds mu —Urdksa dk iz;ksx fd;k x;k ftuesa dk"B vinzO; dh ek=k fHkUu fHkUu FkhA budk ijh{k.k iz;ksx'kkyk ds fof'k"V gkykrksa esa dk"B vinzO; vi?kVu djus okys lw{ethoh dYpjksa dk mi;ksx dj fd;k x;kA dqy feykdj 19 dod LV~suksa dks xUuk ;k bfjyUFkl ds cxkl ls le`) U;wure ek/;e esa loaf/kZr djrs ik;k x;k ftudk vkxs ds v/;;uksa esa mi;ksx fd;k tk;sxkA

iqu;ksZxt izksVhu ds fy;s xUus esa fjfDrdk yf{kr rduhdh dk u;k iz;ksx] ubZ fnYyh fLFkr Mh-ch-Vh-&ch-vkb-vkj-y- lh- dh foŸkh; lgk;rk ls] yd LVkVZvi dEiuh ds lkFk feydj fd;k tk jgk gSA bl dk;Z esa rhu thuksa] uke'k% xyqdkslsfjczkslkbMsl] balqfyu vkSj baVjQsjksu ¼vkb-yQyu2y-½ dk iz;ksx fd;k tk jgk gSA vkuqokaf'kdh :ikU=.k ds fy;s dks- 86032 dk mi;ksx fd;k x;k vkSj blds ?kV~Vs p;u dsfofHkUu Lrjksa ij gaSA

le;qXed iSr`d ykbuksa ds fodkl vkSj yiksfefDll }kjk okLrfod cht mRiknu rduhd ds ekudhdj.k dk;Z 2016 ls izxfr ij gSA Øfed lSfYQax blesa yd eq[; i)fr gSA ladj tula[;kvksa ds fodkl ds fy;s] p;fur bUczSMksa esa ls] iSr`d ykbuksa dk p;u ekjdjksa dh lgk;rk ls fd;k x;k rkfd p;u fd;s x;s bUczSM de ls de fo"ke;qXeth gksaA blh ds vuq:i 14 bUczSMksa dh bl vof/k ds nkSjku p;u fd;k x;k ftuesa ls NVh ih<+h ds lSYQ 1148&13&11&2&237&2&61 us lcls vf/kd le;qXetrk iznf'kZr dhA bldk iz;ksx yl-6 ih<+h ds 2 lSYQksa ds lkFk ØkWfalax ds fy;s fd;k x;kA ØkWls izkIr tula[;k esa xUus ds xq.k ekidksa esa de ls de izFkdRo ns[kk x;kA blds foijhr blds lSYQksa ¼yl-7½ esa mPp Lrj dk vUrxZg.k volkn ns[kk x;kA dVkbZ ds le; ladj cy dk ek=kRed vuqeku yxk;k tk;sxkA bl o"kZ fodflr fd;s vkSj vf/kd lSYQksa dk LVjDpj }kjk fo'ysf"kr dj mu lSYQksa dh igpku dh xbZ ftuesa de dk cgko gqvk vkSj mudk fo"ke;qXeth lwpdkad Hkh de FkkA dqy feykdj 20 lSYQksa dk iz;ksx vkxs lSfYQax vkSj vUrj ØkWflax ds fy;s fd;k x;k rkfd larfr esa le:irk vkSj cy ds Lrjksa dk v/;;u fd;k tk ldsA dks- 86032 ds rFkkdfFkr yUFkl ls O;qRiUu ikS/kksa us n'kkZ;k dh ftu ikS/kksa dks 2 ?kV~Vksa ls fodflr gqy os dks- 86032 ds ley{k.kh ugha gksus ds lkFk de cy'kkyh Hkh FksA mudk dksf'kdkfoKkfud vkSj vk.kfod y{k.k o.kZu dk dk;Z izxfr ij gS ftlls muds xq.klw=ksa dks lqfuf'pr fd;k tk ldsA dks- 775 ds b-ye-yl- mipkfjr mRifjofrZrksa ls fudkys x;s fo"ken~oS/k Mh-yu-y- esa lh-b-yu- yp-3 mRifjorZu vkSj cgq:irk dh igpku dk dk;Z tkjh gSA ckjg mRifjofrZrksa esa ls 5 esa njkj okyh ifV~V;ka ns[kh xbZ vkSj bUgsa [ksr esa jksfir fd;k x;k gS rkfd thu esa mRifjorZu dks lqfuf'pr fd;k tk ldsA O;kid ladj.k vkSj yiksfefDll dh dksf'k'ksa vHkh rd dksbZ fo'ks"k lQy ugha gqbZA vUrjesy ls ls izkIr bUczSM larfr;ksa ds ladjksa us de lsde fofo/krk yl-6 x yl-6 ¼1148&13&11&2&242&2&61 x 1148&13&11&2&242&3&272½ ds la;kstu esa ns[kh xbZA nks ØkWlsl] uke'k% dks- 98008 x dks-iUr 97222 vkSj dks- 8371 x dks-oh-Ih- 14061 ls izkIr larfr;ksa esa 80 % ls vf/kd ikS/kksa us vius ekrk firk tSlk gh rus dk jax n'kkZ;kA

QYQ ls jksvksa dks gVkus ds fy;s cz'kksa ls lapkfyr ewy:i ekWMy dks xUus ds fy;s cht ls jksvksa dks gVkus okyh e'khu dk fuekZ.k Hkk—vuq-i- & lh-vkb-y-b- {ks=h; dsUnz] dks;ECŸkwj ds lkFk feydj fd;k x;kA ?kweus okys xksykdkj uk;yksu ds cz'kksa dks jksvksa dks gVkus ds fy;s yxk;k x;k vkSj chtksa dh lQkbZ ds fy;s nksyuh NfUu;ksa dk iz;ksx fd;k x;k gSA cht dh iqu% izkfIr 50 ls 70 % ds chp ns[kh xbZ tcfd QYQ cht ds eqdkcys cht vadqj.k esa dksbZ fxjkoV ugha ns[kh xbZA

iztud cht mRiknu ds vUrjxr vuqjf{k.k iztuu vkSj cht Ja[kyk dh iztkfr;ksa ¼dks- 86032] dks- 212] dks- 09004 vkSj dks- 11015½ ds ukfHkd —Urdksa ds cgqxq.ku dk dk;Z fd;k tk jgk gSA Ård loaf/kZr ikS/kksa dks 'kq:vkrh L=ksr ds :i esa iz;ksx dj lw{eizof/kZr ikS/kksa ls iztud cht cgqxq.ku ds dk;Z dh 'kq:vkr dh xbZA bl izdkj djhc 124-5 Vu iztud cht dk mRiknu dj pqus x;s fdlkuksa dks forfjr fd;k x;k rkfd muds }kjk tqykbZ 2020 ds nkSjku xq.koŸkk ;qDr cht dk mRiknu fd;k tk ldsA fdlkuksa dh Hkkxhnkjh ls xq.koŸkk ;qDr cht mRiknu dks izHkkoh <ax ls ykxw fd;k x;kA cht ek;x ds vk/kkj ij djhc 1]200 Vu xq.koŸkk ;qDr cht mRiknu dk y{; forj.k ds fy;s j[kk x;k vkSj

bls rfeyukMq ljdkj ds 'kwxj funs'kd ls izkIr vkoaVu vuq lkj iwjk fd;k x;kA rfeyukMq ljdkj dh yu-y-Mh-ih- lfCIMh Ldhe ds vUrjxr 1]500 Vu xq.koŸkk ;qDr cht dh 2020&21 ds nkSjku ekax dh xbZ gS vkSj Qjojh 2021 ds nkSjku viwfrZ ds fy;s 38 ydM+ esa cht mRiknu fd;k tk jgk gSA dks-11015 dk [ksr fnol 29 tuojh] 2020 dks euk;k x;kA dqy 1]62]275 Ård loaf/kZr ikS/kksa dk mRiknu fd;k x;k vkSj bls cspdj 16]22]750 #i;s izkIr gqy tcfd enj dYpj QykLdksa dks cspdj 1]75]000 dh vkenuh gqbZA

Qly mRiknu

gkbM²ksiksfudl fof/k }kjk xUus ds ehfM;k dks fofHkUu lw{etho foyxuksa bukD;wysV djus ij mPp tM+ vkSj 'kk[kk tho Hkkj mRiknu izkIr gqvkA dks- 09004 vkSj dks- 86032 esa xyqdksuyflvkscSDVj Mkbyt+ksV²ksfQdl ¼iky&5½] yt+ksfLifjye czSflysal ¼ds-y-lh-lh- 13364½] yflVkscSDVj tkfr ¼yl-ch-vkb- &y-lh-b-&01½ ds lkFk bukD;wys'ku djus ij lkFkZd :i ls csgrj thoHkkj mRiknu ntZ fd;k x;kA tM+ fu%L=ko uewuksa ds yp-ih-yy-lh- }kjk fo'ys"k.k djus ij muesa fQuksfyd vEyksa] vkWjxsfud vEyksa vkSj QkbVksgkjeksuksa dh mifLFkfr ntZ dh xbZA tc 12 eghus iqjkus xUus ls ydy dfydk vkSj dfydk fpi ij cbtsfjafd;k dk iz;ksx fd;k x;k rks Øe'k% 69-5 % vkSj 66-5 % lkFkZd mPp vadqj.k ntZ fd;k x;kA

dh-jks-lw- ¼dhVjksxtud –fe lw=½ la:i.k dks Mkyus ds fy;s gLr pfyr dh-jks-lw- vuqiz;kstd dk fMT+kkbu vkSj fodkl fd;k x;k gSA fefu V²SDVj lapkfyr dh-jks-lw- vuqiz;kstd dk ladyiukRed fMT+kkbu vkSj fuekZ.k fd;k x;kA Hkk-–-vuq-i- & vkb-vkb-yl-vkj- y[kuÅ }kjk fodkIr e'khufj;ksa] uke'k% vkb-vkb-yl-vkj- ekWMy] fMLd Vkbi jVwu izca/ku midj.k vkSj vkb-vkb-yl-vkj- nksgjh iafDr xgjh ukyh xUuk dV~Vj iykUVj dk ijh{k.k mudh m".kdfVca/kh; gkykrksa esa mi;qDrrk ds fy;s Hkk-–-vuq-i- & xUuk iztuu laLFkku] dks;EcŸkwj esa fd;k tk jgk gSA

xUuk vk/kkfjr [ksrh iz.kkyh esa lkEck ekSle ds nkSjku /kku ¼iztkfr dks- 51½ dh Qly mxkdj 5-75 Vu@gs- mit izkIr gqbZA Hkkjr ds m".kdfVca/kh; gkykrksa esa Hkk-–-vuq-i- & xUuk iztuu laLFkku] dks;EcŸkwj esa fd;s x;s ijh{k.k esa [kknksa dh 100 % vuq'kafIr ek=kvksa ¼280 % 62-5 % 120 fdyksxzke us=tu % ih-2vks-5 % iksVk'k½ ij xUus ds fof'k"V thuizk:iksa dks- 13008 us 134-00 Vu@gs- vkSj dks- 13020 us 133-62 Vu@gs- xUuk mRiknu ntZ fd;k tks vU; ijhf{kr fof'k"V thuizk:iksa ls csgrj izn'kZu FkkA jksi.k lexzh;ksa esa ls okLrfod cht tfur ikS/kksa us mPpre 1-58 dk ch- % lh- ¼ykHk % ykxr½ vuqikr ntZ fd;k vkSj bUgksaus dfydk fpi vkSj nks dfydkvksa okys cht VqdM+ksa ls mRikfnr Qlyksa ds cjkcj xUuk mRiknu ntZ fd;kA

'kq:vkrh QqVko ds ckn jksi.k ds 10 fnu ckn esfVfjcqft+u 1-25 fdyksxzke xzke lfØ; rRo@gs- ds ckn] QqVko ds ckn ds nkSj esa] [kjirokjukf'k;ksa dk mi;ksx tSlsfd Vksijkeht+ksu 29-4 xzke lfØ; rRo@gs- $ yV²kft+u 656-25 xzke lfØ; rRo @gs- ;k gsyksIYQ;wjkWu 67-5 xzke esfVfjcqft+u 750 xzke lfØ; rRo@gs-;k VsEcksfV²vksu 120 xzke lfØ; rRo@ gs- $ yV²kft+u 656-25 xzke lfØ; rRo @gs- jksi.k ds 65 fnu ckn] tks rhu ckj [kjirokj fudkys tkus ds cjkcj Fks] tcfd buls mPp xUuk mRiknu] csgrj [kjirokj fu;U=.k dq'kyrk] 'kq) vk; vkSj ch-% lh- ¼ykHk % ykxr½ vuqikr ns[kk x;kA xUuk cht VqdM+ksa] cht tfur ikS/kksa vkSj xUuk cht VqdM+ksa tfur ikS/kksa ls jksfir Qlyksa esa [kjirokj izca/ku dsfy;s jksi.k ds 30] 60 vkSj 90 fnu ckn gkFkksa ls fudkys x;s [kjirokjksa okyh Qly ls 137-04 Vu@gs- dk mPp xUuk mRiknu ns[kk x;k tcfd [kjirokj fu;U=.k dq'kyrk 45 vkSj 120 fnu ckn Øe'k% 91-98 % vkSj 81-28 % ns[kh xbZA 'kq:vkrh QqVko ds ckn Vksijkeht+ksu $ yV²kft+u ds Lijs ds ckn jksi.k ds 80 fnu ckn gkFkksa ls [kjirokjksa ds fudkyus dh izfØ;k dks [kjirokj izca/ku ds fy;s izHkkoh ik;k x;k vkSj blls 133-63 Vu@gs- dk xUuk mRiknu ns[kk x;k vkSj QqVko ds ckn tYn gh VsEcksfV²vksu $ yV²kft+u ds Lijs ds ckn jksi.k ds 80 fnu ckn gkFkksa ls [kjirokjksa ds fudkyus dh izfØ;k lsizkIr 133-63 Vu@gs- dk xUuk mRiknu blds cjkcj gh FkkA

rjy xqM+ izkS|ksfxdh dk O;kolkf;dj.k Hkk-–-vuq-i- & xUuk iztuu laLFkku }kjk fd;k x;k tcfd vU; 5 dk O;kolkf;dj.k yxzhbUvksosV bafM;k fyfeVsM }kjk fd;k tk;sxkA e`nk ueh ladsrd izkS|ksfxdh dk ykblsal 5 QeksZa dks] dh-jks-lw-tSogkfudkjd thoekjd la:i.k dk ykblsal 3 QeksZa dks] rjy xqM+ izkS|ksfxdh dk ykblsal 5 QeksZa dks vkSj V²SDVj }kjk [khaps tkus okys edSfudy lykaVj dk ykblsal 1QeZ dks fn;k x;kA Hkk-–-vuq-i- & xUuk iztuu laLFkku dh izkS|ksfxdh;ksa ds O;kolkf;dj.k ls dqy 19]83]782 #i;s dk jktLo izkIr gqvkA

fuekZ.kkRed izoLFkk ds nkSjku lhfer flapkbZ mipkjksa ds dkj.k dyksjksfQy LiSM lwpdkad eku esa vkSlru 18 % dh fxjkoV ns[kh xbZ] tcfd dks- 15007] dks- 15018] dks- 13014 vkSj dks-12009 esa vkb-1 ¼flapkbZ ikuh dh ek=k dks vk/kk fd;k x;k½ rFkk vkb-2 ¼flapkbZ dh la[;k dks vk/kk fd;k x;k½ esa mPp LiSM lwpdkad eku ntZ fd;s x;sA LiSM lwpdkad eku dks tkfr –Urdksa ds chp esa vkSj flapkbZ mipkjksa ds chp esa lkFkZd :i ls cnyrs ugha ns[kk x;k tks tkfr –Urdksa ij flapkbZ esa vkbZ deh ds dkj.k dyksjksfQy ij dksbZ fo'ks"k

izHkko ugha iM+k tcfd dks- ladjksa esa yslk ugha FkkA dVkbZ ds le; xUuk mRiknu esa dUV$ksy ds Åij vkb-1 ds dkj.k 17-7 % vkSj vkb-2 ds dkj.k 24-4 % dh fxjkoV ntZ dh xbZA lekU; flapkbZ ds gkykrksa esa vkSlr xUuk mRiknu 93-3 Vu@gs- ifjdfyr fd;k x;k tks dks- 0212 esa 53 Vu@gs- lsdks- 12009 esa 158 Vu@gs- ds chp Fkk tcfd 50 % de ty dh ek=k nsus ls vkb-1 esa dks- 62175 esa 53 Vu@gs- lsdks- 14002 esa 116-7 Vu@gs- ds chp bls ntZ fd;k x;k ogha vkb-2 esa dks- 62175 esa 54 Vu@gs- ls dks- 15021 esa 93-5 Vu@gs- ds chp ntZ fd;k x;k tcfd vkSlr xUuk mRiknu 70-4 Vu@gs- ifjdfyr fd;k x;kA dks- ladjksa esa ls dks- 12009] dks- 14002] dks- 15015] dks- 15018 vkSj dks- 15021 us nksuks lhfer flapkbZ ds gkykrksa esa csgrj izn'kZu fd;kA

vfFkZd gkSnh ¼rus½ esa tSoHkkj dh foHkktu n{krk m".kdfVca/kh; oxZ dh izthfr;ksa ls ¼78-43 %½ miks".kdfVca/kh; oxZ dh izthfr;ksa ds ¼74-45 %½ eqdkcys mPp ns[kh xbZA

lkoZf/kd o`f) dh izoLFkk esa dks- 86249 vkSj dks- 62175 esa90 vkSj 75 lsaVhehVj iafDr ls iafDr dh nwjh ij jksi.k djus ls csgrj lw[kk tSo Hkkj mRiknu vkSj izdk'k vojks/ku ns[kk x;k tcfd dks- 86032 esa 150 lsaVhehVj iafDr ls iafDr dh nwjh ij jksi.k djus ls csgrj lw[kk tSo Hkkj mRiknu ns[kk x;kA izdk'k vojks/ku esa fofHkUu nwfj;ksa ij jksi.k djus ij ldkjkRed vUrj ns[kk x;k] ;kfu ds ikl ikl ¼75 lsaVhehVj½ iafDr;ksa esa jksi.k djsu ij vf/kd nwjh ¼150 lsaVhehVj½ ds eqdkcys vf/kd izdk'k vojks/ku ns[kk x;kA

ukbV$kstu dh c<+rh ek=k ds lkFk LiSM dyksjksfQy eku] ikni Å¡pkbZ] dYyksa dh la[;k] iÝkksa dk {ks=Qy] 'kk[kkvksadk lw[kk Hkkj] tM+ vk;ru] tM+ lw[kk Hkkj] tM+ dk 'kk[kk ds lkFk vuqikr vkSj dqy ikni tho Hkkj us lkFkZd :ils lkekU; c<+rh izo`fr n'kkZbZ tcfd tM+ dh xgjkbZ ds lkFk yslk ugha FkkA ukbV$kstu dh c<+rh ek=k ds lkFk LiSM dyksjksfQy eku dks 18-6 ls 38-1 rd] iÝkksa dk {ks=Qy dks 181-9 ls 548-8 oxZ lsaVhehVj rd vkSj 'kk[kkvksa dh Å¡pkbZ dks 36-7 ls 94-9 lsaVhehVj rd c<+rs ns[kk x;kA blhizdkj QkLQksjl ds iks"k.k ds lkFk Hkh lHkh v/;;u fd;s x;s ekudksa] tM+ dk 'kk[kk ds lkFk vuqikr dks NksM+dj] ij lkFkZd izHkko ns[kk x;kA QkLQksjl dh c<+rh ek=k ds lkFk LiSM dyksjksfQy eku dks 32-0 ls 41-0 rd] iÝkksa dk

{ks=Qy dks 119-4 ls 548-8 oxZ lsaVhehVj rd vkSj 'kk[kkvksa dh Å¡pkbZ dks 48-2 ls 95-6 lsaVhehVj rd c<+rs ns[kk x;kA dYyksa dh la[;k] tM+ksa dh xgjkbZ] tM+ksa dk vk;ru vkSj tM+ dk 'kk[kk ds lkFk vuqikr dks NksM+ ckfd lHkh ekidksa ij iksVk'k dh c<+rh ek=k dk lkFkZd izHkko ns[kk x;kA iksVk'k dh c<+rh ek=k ds lkFk LiSM dyksjksfQy eku dks 28-3 ls 33-3 rd] iÝkksa dk {ks=Qy dks 122-0 ls 536-8 oxZ lsaVhehVj rd vkSj 'kk[kkvksa dh Å¡pkbZ dks 57-4 ls 91-3 lsaVhehVj rd c<+rs ns[kk x;kA lw{e rRoksa dh deh ds dkj.k 'kk[kkvksa dslw[kk Hkkj esa lkFkZd :i ls deh ns[kh xbZ ftls ukbV$kstu dh c<+rh ek=k ds lkFk 2-20 ls 23-27 xzke rd] QkLQksjl ds lkFk 3-96 ls 18-03 xzke rd vkSj iksVk'k ds lkFk 3-68 ls 18-44 xzke rd ntZ fd;k x;kA ukbV$kstu dh c<+rh ek=k ds lkFk tM+ dk 'kk[kk ds lkFk vuqikr lw[kk Hkkj ds vk/kkj ij 0-201 ls 0-226 ds chp vuqekfur fd;k x;kA

yl- vkWfQ'usje –Urdksa esa eksVs xUus] mPp ydy xUuk Hkkj vkSj lqØksl p;kip; yUtkbeksa ds csgrj Lrj ik;s x;sA budh tM+ iz.kkyh e/;e Lrj rd fodflr ikbZ xbZ ftuesa dkWjVSDl ls LVhy dk vuqikr lcls mPp Fkk ogha esVkXt+k;ye rRo U;wure la[;k esa FksA yl- ckjcsjh –Urdksa esa Hkh tM+ iz.kkyh e/;e Lrj rd fodflr ikbZ xbZ ftlus bUgsa U;wure iÝkksa dk {ks=Qy ds dkj.k de tSo Hkkj mRiknd Hkh cuk fn;kA bldk izHkko xUuk mRiknu ekidksa] uke'k% xUuksa dh eksVkbZ] Å¡pkbZ] iksfj;ksa dh la[;k o mudh yEckbZ ij Hkh ns[kk x;kA yl- LikWUVsfu;e –Urdksa esa iryh tM+sa xgjkbZ esa tkrh ikbZ xbZ ftuesa fuekZ.kkRed izoLFkk esa dkWjVSDl ls LVhy dk vuqikr lcls de Fkk ijUrq lkoZf/kd o`f) dh izoLFkk esa tM+ksa dk vk;ru mPp Lrj dk FkkA bldsxUus irys o yEch iksfj;ksa okys Fks] vr% budk ydy xUuk Hkkj Hkh U;wure FkkA b- v#afMusf';l vkSj b- csaxkysafll –Urdksa vkSj yl- jkscLVe vkSj cecwlk tkfr ds esy ls mRiUu vUrj&tsufjd ladjksa us csgrj tM+ iz.kkyh] vk–frdh foKkfud vkSj 'kkjhfjd fo'ks"krk;sa n'kkZbZ ftuesa dkWjVSDl ls LVhy dk vuqikr U;wure Fkk ogha esVkXt+k;ye rRo vf/kd la[;k esa FksA iÝkksa vkSj 'khFk esa vf/kd tSoHkkj laxzg.k ik;kx;k ogha buesa ydy xUuk Hkkj e/;e Lrj dk FkkA

QqVko ls igys gsyksIYQ;wjkWu feFkkby 75 % MCy;w-th- vkSj esfVfjcqft+u 70 % MCy;w-ih- dks 67-5 xzke vkSj 1]000 xzke fØ;k'khy rRo@gs- jksi.k ds 42 fnu ckn nsus ij uhps okys iÝkksa esa Lijs ds 5 fnu ckn dqN thu izk:iksa esa {kfr ns[kh xbZA ikni vkfo"kkyqrk dh jsfVax n`"; ds vk/kkj ij 0 ls 10 dh Ldsy ij Lijs ds 7] 15 vkSj 21 fnu ckn ntZ dh xbZA ikni vkfo"kkyqrk dh jsfVax 31 thu izk:iksa esa dh xbZ ftls 0 ls 4 ds chp ik;k x;kA ukS thu izk:iksa esa dksbZ {kfr ughans[kh xbZ tcfd 8 esa e/;e Lrj dh vkfo"kkyqrk ¼jsfVax 4½ ns[kh xbZA lHkh 14 thu izk:iksa us cgkyh fn[kkbZ] dsoy dks- 06027 us Lijs ds 30 fnu ckn] ftudh vkfo"kkyqrk jsfVax 1 ls 3 ds chp Fkh] tcfd dks- 09008 dks NksM+ lHkh e/;e Lrj dh vkfo"kkyqrk fn[kkus okyksa iwjh cgkyh ugha n'kkZbZA mu thu izk:iksa us 1 ls 4 rd dh vkfo"kkyqrk jsfVax n'kkZbZ

ftuesa de ls de yd iSr`d dks- 7201 ;k dks- 775 FkkA dks- 06030] dks- 86032] dks- 11015] dks- 92005 vkSj dks- 09004 thu izk:iksa us dksbZ ikni vkfo"kkyqrk ugha fn[kkbZ tcfd muds iSr`d dks-lh- 671 esa ikni vkfo"kkyqrk ds y{k.k ns[ks x;sA

lw[kh e`nk esa jksi.k ls igys dkcZu MkbvkWDlkbM izokg 2-4 eksyj@oxZehVj@lsdsaM vkSj jksi.k ds rhu fnu ckn xhyh e`nk ls 14-68 eksyj@oxZehVj@lsdsaM ds chp ntZ fd;k x;kA isjkbZ ;ksX; xUuksa dh la[;k thu izk:iksa ds chp lkFkZd :i ls fHkUu ¼ih ¾ 0-05½ tcfd dkcZu MkbvkWDlkbM izokg] e`nk ihyp-] fo|qr lapkyDrk] e`nk esa vkWjxsfud dkcZu esa dks lkFkZd vUrj ugha ns[kk x;kA

e`nk fu"d"kZ iz.kkyh lkWQVos;j] ftlesa e`nk dh deh dh igpku vkSj izca/ku mik; 'kkfey Fks] dks ekbØkslkWQV fo;qvy LVwfM;ks izksQS'kuy 2017 esa lh-# Hkk"kk esa fodflr fd;k x;kA pwusnkj e`nkvksa vkSj dBksj milrg ds izca/ku ds fy;s xU/kd ls iks"k.k dks lekU; iks"k.k flQkfj'kksa ds lkFk bl lkWQVos;j Mkyk x;k] ogha leL;k okyh e`nkvksa ds izca/ku dks Hkh blesa 'kkfey fd;k x;kA bl fodflr fd;s x;s e`nk fu"d"kZ iz.kkyh lkWQVos;j ls e`nk LoLFk; dkMZ cukus ds lkFk lkFk e`nk dh dfevksa dk izca/ku vkSj iks"kd rRoksa dh flQkfj'kksa dks rfey Hkk"kk esa fn;k x;k gSA

isM+h dh nwljh Qly esa vkSlr xUus dh Å¡pkbZ 183-98 lasVhehVj] xUus dh eksVkbZ 27-74 fefyehVj] ydy xUuk Hkkj 1-11 fdyksxzke] iksfj;ksa dh la[;k 20] isjkbZ ;ksX; xUuksa dh la[;k 85]036@gs-] xUuk mRiknu 93-22 Vu@gs- vkSj lh-lh-yl- 12-14 Vu@gs- mRiknu Fkk tcfd vUr%Qlyhdj.k mipkjksa ds chp] isM+h dh Qly dh 'kq:vkr ls 270 fnu ckn] buesa dksbZ lkFkZd vUrj ¼ih ¾ 0-05½ ugha ns[kk x;kA vUr%Qlyhdj.k us jl dh xq.koÙkk ekidksa ij Hkh dksbZ lkFkZd izHkko ugha n'kkZ;k vkSj 270 fnu ckn vkSlr fczDl 20-91 %] 'kdZjk 18-67 %] 'kq)rk 89-28 % vkSj lh-lh-yl- 12-14 % vuqekfur dh xbZA e`nk ds uewuksa dk fo'ys"k.k djus ij e`nk vkWjxsfud dkcZu esM+ksa esa 0-78 % vkSj ukfy;ksa esa 0-57 % ikbZ xbZA vUr%Qlyhdj.k mipkjksa esa ls dkyh mM+n ds mipkj ls e`nk vkWjxsfud dkcZu dk mPp Lrj 0-74 % ntZ fd;k x;kA

o"kZ 2019 vkSj 2020 ds iq"i.k ekSle ds chp] vyx vyx –Urdksa esa iq"i.k ds fy;s vk/kkj rkieku dk vuqeku th-Mh-Mh- esa] U;wure 'kq) fopyu ds vk/kkj ij yxk;k x;k]tgk¡ vk/kkj rkieku dh lhek 1 ls 39 fMxjh lsaVhxzsM th-Mh- Mh- dks ifjdfyr djus ds fy;s j[kh xbZA iq"i.k fn[kkus okys –Urdksa ls 39 –Urdksa dk vk/kkj rkieku 15 ls 20 fMxjh ds chp vuqekfur fd;k x;kA xUus esa iq"i.k fn[kkus okys –Urdksa esa ls 3-5 % dk vk/kkj rkieku 5 ls de] 6-4 % dk 5&10 ds chp] 9-4 % dk 10&15 ds chp] 22-8 % dk 15&20 ds chp] 5-3 % dk 20&25 ds chp] 4-7 % dk 25&30 ds chp] 7-0 % esa 30&35 ds chp vkSj 1-2 % dk 35 ls vf/kd ik;k x;kA bl fof/k ls djhc 68 –Urdksa dk vk/kkj rkieku vuqekfur ugha fd;k tk ldkA vf/kdrj lekU; vkSj rhoz iq"i.k fn[kkus okys –Urdksa ij vk/kkj rkieku esa cnyko dk dksbZ izHkko fn[kkbZ ugha fn;kA djhc 12 –Urdksa] ftuesa ls vf/kdrj m".kdfVca/kh; {ks= ls Fks] esa vk/kkj rkieku esa cnyko ds izfr QySV izfrfØ;k ns[kh xbZA vk/kkj rkieku esa cnyko ds izfr izfrfØ;k n'kkZus okyksa esa ls lcls vf/kd 21 dk vk/kkj rkieku 20 fMxjh ds vklikl FkkA djhc 25 % –Urdksa esa vk/kkj rkieku esa cnyko 20 fMxjh ls uhps vkSj vU; 25 % esa ;g 20 fMxjh ls Åij FkkA miks".kdfVca/kh; {ks= ls mRiUu gqy –Urdksa dk iq"i.k ds fy;s vf/kdrj vk/kkj rkieku 20 fMxjh ds vklikl Fkk ;k fQj mudh vk/kkj rkieku esa cnyko ds izfr dksbZ izfrfØ;k ugha FkhA

dks- 11015 ds fy;s iks"k.k izca/ku dk iSdst ekudh–r djus dsfy;s v/;;u esa 300 fnuksa ij jl dh xq.koŸkk ij mipkjksa dksbZ lkFkZd ugha ns[kk x;kA bl le; vkSlr fczDl 22-39 %] 'kdZjk 20-73 %] 'kq)rk 92-60 vkSj lh-lh-yl- 14-65 % ifjdfyr dh xbZA dqy dyksjksfQy vkSj LiSM eku ds chp egRoiw.kZ ldkjkRed lglEca/k ns[kk x;k vkSj djksjksfQy dh ek=k vuqekfur djus ds fy;s LiSM eku dk iz;ksx fd;k tk ldrk gS D;ksafd nwljs vkMZj dk iksyhuksfevy lehdj.k Bhd fQV cSBk ¼vkj ¾ 0-6255½A iks"kd rRoksa ls mipkj djus ij iq"i.k O;ogkj ij izHkko ns[kk x;kA

vkeys dk jl xUus ds jl esa feykdj rjy xqM cukus ls lQkbZ esa eqf'dy dk lkeuk djuk iM+k ftlls lqØksl dh ek=k dks iksysfjehVj ls vuqekfur djus esa ck/kk vkbZA ftu uewuksa esa vkeys ds jl dks 112 xzke@fdyksxzke ;k blls vf/kd ek=k esa feyk;k x;k rks fQYVj djus ij jl xanyk ns[kk x;kA rjy xqM+ vkeys ds jl dh fofHkUu ek=k;sa feykdj cuk;k x;kA HkaMkj.k ds 0 vkSj 30 fnu ckn rjy xqM+ esa fczDl] 'kdZjk vkSj fjM;wflax 'kxlZ dh ek=k fo'ysf"kr dh xbZA HkaMkj.k ds 30 fnu ckn rjy xqM+ dh lqØksl esa fxjkoV vkSj fjM;wflax 'kxlZ dh ek=k esa o`f) ns[kh xbZA rjy xqM+ esa 11 % Hkkj@Hkkj ;k vf/kd vkeyk jl feykus ls lqØksl dh ek=k fudkyus ds fy;s ihyp-eku dks lek;ksftr djuk vko';d gSA djhc 450 fdyksxzke xqM+ fofHkUu izdkj ds xUus ds jl ls cuk;k x;kA cnke xqM+ vkSj vaxwj jl xqM+ cukus dh fof/k;ksa dk ekudhdj.k iz;ksx'kkyk ds Lrj ij fd;k x;k ftls cM+s Lrj ij cukus ds fy;s dk;Z tkjh gSA

Qly lq/kkj

Qly lq/kkj foHkkx ds fofHkUu ijh{k.kksa] ftuesa —Urd ijh{k.k] iwoZ {ks=h; iztkfr ijh{k.k] fof'k"V ladj] jk"Vªh; ladj.k m|ku ls iSr`d —Urd] lEcaf/kr tsujk] bUczSM~l] tsusfVd LVkWDl] bR;kfn feykdj djhc 3]601 —Urdksa dh yky lM+u jksx izfrjksf/krk ds fy;s fu;fU=r gkykrksa esa lh-yQ-06 ¼lh-yQ671½ jksxtud ds fo#) tkap dj djhc 1]524 —Urdksa dks yky lM+u jksx izfrjks/kh ik;k x;kA

fofHkUu teZIykLe vkSj iSr`d ykbuksa dh ihyh ifŸk jksx dh rhozrk ds izfr ewY;kadu djus ij lsdsje tkfr;ksa ds vf/kdrj —Urd iwjh rjg jksx ls Lora= fn[kkbZ fn;sA jk"Vªh; ladj.k m|ku esa iSr`d —Urdksa esa ls 18-63 % izfof"V;ksa dks ihyh ifŸk jksx ns[kk x;kA

yky lM+u jksx izfrjksf/krk ds fofHkUu Lrjksa okyh 11 iztkfr;ksa dh [ksr ds gkykrksa esa lgu'khyrk ds Lrj dh tkap 12 dod foyxuksa] ftudk mxzrk dk Lrj foLr`r Fkk] dk iz;ksx dj dh xbZA vf/kdrj foyxuksa ls dfydkvksa ds QqVko esa fxjkoV ns[kh xbZ vkSj vkSlru lkoZf/kd jksx dh ?kVuk;sa dks- 94012 esa] ftlds ckn dks- 6304] dks-lh- 671 vkSj dks- 86032 esa ns[kh xbZA dks- 6304 dks NksM+ bu lHkh iztkfr;ksa dks lHkh foyxuksa ls laØfer ik;k x;k vkSj buls fodflr jksx dk Lrj fHkUu fHkUu FkkA

ihyh ifŸk jksx dk vk—frd&dk;Zd vkSj mRiknu ekidksa ij izHkko [ksr esa fd;s x;s ijh{k.kksa }kjk ewY;kafdr fd;k x;kA xUuk cht VqdM+ksa ls QqVko esa lkFkZd fxjkoV ns[kh xbZA vkj-Vh-&D;wih-lh-vkj- ij[k esa jksx lwpd ikS/kksa esa vkSj ih<+h nj ih<+h cgq&ijr VkbVj ns[kk x;k tcfd fo"kk.kq VkbVj fo"kk.kq eqDr ikS/kksa esa c<+rs ns[kk x;kA dqy feykdj bl ekSle yfQM dk mifuos"k.k de jgk tks ijhf{kr iztkfr;ksa esa Hkh de gh ns[kk x;kA

yu-th-yl- lysVQkeZ dks viukdj xUus esa yevkbvkj- yu-y-vksa dk laxr vkSj vlaxr var%fØ;k ds nkSjku Hkwfedk dk leh{kkRed fo'ys"k.k djus ij xUus ds yevkbvkj- yu-y-vksa dh Hkwfedk dk irk pyk vkSj mudh yf{kr thuksa dk xUuk & lh- QkYdsVe dh vUr%fØ;k ds nkSjku Hkwfedk us yevkbvkj-yu-y-vksa dk xUus ds lqj{kk ra= izfØ;k esa ubZ vUrn`Zf"V iznku dhA

cSat+ksFkk;kMk;kt+ksy vkSj lSfyflfyd vey ds uSuks la:i.kksadk [ksr ds gkykrksa esa izHkkoksRiknDrk ds ewY;kadu ds 'kq:vkrh ifj.kkeksa esa yl-y-vkj- izsjd uSuksd.kksa] fo'ks"kdj dkbVkslku ls <ds cSat+ksFkk;kMk;kt+ksy usuksd.kksa ds la:i.kksa dks Li"V :i ls yxkrkj xUus esa yky lM+u] daaMqvk vkSj foYV jksxksa ds fo#) izfrjksf/krk mRizsj.k esa vfr izHkko'kkyh ik;k x;kA

egkekjh foKkfud v/;;uksa esa foYV dh ?kVukvksa ls irk pyk fd jksx dh 'kq:vkr 3 eghus ckn gqbZ vkSj bldk lkoZf/kd laØe.k 5 ls 6 eghus ij ns[kk x;kA e`nk tfur bukD;wye us QqVko dks de dj fn;k ftlls lykVksa esa Qly LVSaM izHkkfor gqvkA e`nk tfur bukD;wye ls foYV jksx dk fodkl bl ekSle ds nkSjku ?kkrd ugha Fkk tSlk fd xUUkk cht VqdM+k tfur bukD;wye ls laØfer lykVksa esa ns[kk x;kA

e'khuh—r doduk'kh mipkj ¼izksfidksukt+ksy 0-4 fefyfyVj@ fyVj] 250 fefyehVj ejdjh nkc 15 feUV ds fy;s½ foYV ls izHkkfor xUuk cht VqdM+ksa esa dfydk QqVko esa lq/kkj 6 esa ls 4 iztkfr;ksa ns[kk x;k tcfd Qly LVSaM dsoy 2 esa csgrj FkkA bl mipkj ls vk—fr ekidksa esa dUVªksy lykWVksa ds eqdkcys csgrj izn'kZu ns[kk x;kA

yl-lh-th-yl QkbVksIykLek tfur xUus esa ?kklh; jksx dk Årdfo—frfoKkfud fo'ys"k.k LdSfuax bySDVªksu lw{en'khZ dh lgk;rk ls fd;k x;kA yl-lh-th-yl QkbVksIykLek vaMkdkj@xksykdkj Fks tks eksfr;ksa dh Ja[kyk dh rjg Qyks;e dh lho V;wcksa esa ns[ks x;s tcfd QkbVksIykLek dh dksf'kdkvksa dk foHkktu cfMax }kjk Qyks;e ds vklikl {ks= esa ns[kk x;kA

xUuk cht VqdM+ksa dk e'khuh—r mipkj dj doduk'kh dh vVyrk Fkk;ksQsusV feFkkby dh e`nk tfur bukD;wye ds fo#) yky lM+u jksx ls xUuk cht VqdM+ksa dks jksi.k ds 90 fnu ckn rd cpkus dh n{krk ds igys ds ifj.kkeksa dh laiqf"V djrk gSA

yd rkRdkfyd xUuk cht VqdM+k mipkj midj.k dk fuekZ.k fd;k x;k ftlesa xeZ ikuh ls mipkj ds fy;s fgykus dh dh lqfo/kk Fkh vkSj yd leku mipkj ds fy;s mi;qDr lSalj yxk;k x;k rkfd dod jksxksa ds vykok yl-lh-th-yl QkbVksIykLek vkSj jVwu LVafVax cSDVhfj;k dk izca/ku fd;ktk ldsA ifj.kkeksa ls bl ckr ds ladsr feys dh xSj&dod jksxtudksa dh fuf"Ø;rk rki mipkj ls {kf.kd Fkh vr% rduhdh fodkl dh izfØ;k dks tkjh j[kuk gksxk ftlls yf{kr jksxtud dks gVkus ds dk;Z dks lQyrk iwoZd fd;k tk ldsA

xUus ds iPphdkjh fo"kk.kq vkSj xUus ds ihyh ifŸk fo"kk.kqds iqu%la;ksftr dksV izksVhu dh vfHkO;fDr dk dk;Z fd;k x;k rkfd lEcaf/kr fo"kk.kqvksa ds fy;s iksyhDyksuy yUVhckWMh fodflr dh tk ldsA ifj.kkeksa ls irk pyk dh dksV izksVhuksa dks cM+s Lrj ij izsfjr dj v'kksf/kr izksVhuksa dks lekos"kh fudk;ksa ds :i esa fu"df"kZr dj mUgsa vkxs yu-vkb&yu-Vh-y- yxkjksl vk/kkfjr vkd"kZ.k djksesVksxzkQh }kjk 'kq) fd;k x;kA xUus ds iPphdkjh fo"kk.kq vkSj xUus ds ihyh ifŸk fo"kk.kq

izksVhuksa dk iz;ksx Lru/kkjh iz.kkyh esa iksyhdyksuy yUVhckWMh mRiknu ds fy;s fd;k tk;sxkA

eDdk dk ihyk iPphdkjh fo"kk.kq ¼iksysjksvk;jl] ywVsvksfofjMs½] yd xUus dks laØfer djus okys u;s fo"kk.kq dks vkj-Vh&ih- lh-vkj- ij[k }kjk lqfuf'pr fd;k x;kA xUus ds ihyh ifŸk fo"kk.kq dks tokj vkSj eDdk ds uewuksa ls lqfuf'pr fd;k x;k tks bl fopkj ds lkFk lgefr n'kkZrk gS fd xUus ds fo"kk.kq lEcaf/kr est+cku tkfr;ksa ij Hkh ik;s tkrs gSaA

laiw.kZ V³kUlfØIVkse dk vuqØe.k fd;k x;k rkfd nks Liksfjlksfjve lkbVsfefu;e foyxuksa dks le>k tk lds] ftUgsa] vxyh ih<+h dh vuqØe.k izkS|ksfxdh dk iz;ksx dj] vkj-yu-y-&vuqØe.k fo'ys"k.k }kjk vius fo"kSysiUu esa Li"V :i ls fHkUu ik;k x;k FkkA dqy feykdj iz;ksx'kkyk ds uewuksa esa djhc 3240 yk[k jhM~l ¼97 th-ch-½ vkSj ikS/ks ds uewuksa esa 6530 yk[k jhM~l ¼196 th-ch-½ mRikfnr fd;s x;sA

xUus esa th-yQ-ih-&fpfUgr yl- lkbVsfefu;e us laosnu'khy iztkfr] dks- 97009] laØe.k izfØ;k dks iznf'kZr djus esa lgk;rk dh ftls ikS/ks esa mifuos'ku dh Li"V izoLFkkvksa dks lVhd vkSj lh/ks rjg ls igpkuk tk ldkA

yl- lkbVsfefu;e ds foyxuksa dk yl-vkj-ih-y- ekjdjksa ds iz;ksx }kjk vk.kfod fo'ys"k.k v/;;u ls muds y{k.kiz:ih O;ogkj ds vk/kkj ij muds Li"V oxhZdj.k ds ladsr feysA

yd ilanhnk ih&lh-y-ye-ch-vkb-y-1302 ckbujh osDVj dk fuekZ.k fd;k x;k ftlesa th-yQ-ih- Mkyk x;k Fkk rkfd rqyukRed izksfVvksfeDl v/;;u dh tkjp ls izkIr lEHkkfor izR;kk'kh yikslykfLVd izksVhuksa dks lR;kfir fd;k tk ldsA

ikS/ks esa lh-yQb-ih-yy-1 vkSj lh-yQih-Mh-vkb-ih-1 ds LFkku dks lqfuf'pr djus ds fy;s izR;k'kh thuksa dks muds ns'kh ladsrd isIVkbM dksfMax vuØe ds lkFk] —f"kvUr%L;anu ¼yxzksbufQYVjs'ku½ djus vkSj rEckdq esa {kf.kd vfHkO;fDr ds fy;s] ih&lh-y-ye-ch-vkb-y-1302 ckbujh osDVj esa dyksu fd;k x;kA ifj.kkeksa ls ladsr feys dh lay;u izksVhu b-ih-yy-1 % th-yQ-ih- vkSj ih-Mh-vkb-ih-1 % th-yQ-ih- lk;VksIyke ds ckgj lhfer Fkh] tcfd ih&lh-y-ye-ch-vkb- y-1302&th-yq-ih-¼[kkyh osDVj dUV³ksy½ dks U;wdfyl vkSj lk;VksIykLe esa ik;k x;kA bu flfydks ;U=] yikslykLV ih- oh 1-0-1-] dk iz;ksx dj lh-yQb-ih-yy-1 vkSj lh-yQih- Mh-vkb-ih-1 dh yikslykLV esa gksus dh O;Dr dh xbZ lEHkkouk dks gekjs ifj.kke leFkZu iznku djrs gaSA

vadqfjr gksrs dksfufM;k ls izksVksIykLV dks foyfxr djus ds fy;s vkSj lh- QkYdsVe jksxtud lh-yQ671 ds fuekZ.kksa esa mPp n{krk okys :ikU=.k ds fy;s yd uohu izksVksdkWy fodflr fd;k x;kA b- dksykb&yLijftyl~ 'kVy osDVj] ihy-ylih dk iz;skx djrs gqy ih-b-th- dh e/;Lrrk ls izksVksIykLVksa dk :ikU=.k fd;k x;k vkSj gkbxzksekbflu&izfrjks/kh :ikU=.kksa dh lR;rk th-yQ-ih- dh QyqvkSjslsal dks QyqvkSjslsal lw{en'khZ ds iz;ksx ls ns[kdj lqfuf'pr dh xbZA

fodflr fd;s x;s thu mRifjorZu osDVjksa ¼lh-yQb-ih-yy-1 vkSj lh-yQih-Mh-vkb-ih-1½ vk.kfod izekf.kdj.k izfrcaf/kr ikpu vkSj gkbxzksekbflu thu ¼yp-ih-Vh-2½ vkSj thu&;w- yQ-vkj-&Mh-yQ-vkj- vuqØe fof'k"V ekjdjksa dk iz;sx dj ih-lh-vkj-}kjk fd;k x;kA xUus esa lh-yQb-ih-yy-1 @ lh-yQih-Mh-vkb-ih-1 dk ih-Vh-vkb-@b-Vh-vkb- e/;Lrrk ls gqbZ izfrj{kk izfrfØ;kvksa dk v/;;u djus ds fy;s yd uohu MSDlkehFkkIksu vk/kkfjr izsj.kh; osDVj] ihlh-1302Mh- b-yDl- dk fuekZ.k fd;k x;k vkSj bldh rEckdq esa th-yQ-ih- vfHkO;fDr ds fy;s jlk;fud mRizsj.k dks —f"kvUr%L;anu }kjk ewY;kafdr fd;k x;kA

teZlykLe uewuksa ls yl-lh-ch-oh- esa ftusfed fofo/krk ds ifj.kkeksa ls irk pyk fd Hkkjr ls yl-lh-ch-oh-&ch-vkj-;w- vkSj yl-lh-ch-oh-&ch-vks-91 ds lkFk] yl-lh-ch-oh-&lh-yp- yu-2 phu ls vkSj yl-lh-ch-oh-&vkb-ye- vkWLV³sfy;k ds lkFk 85 % le:irk ns[kh xbZA

nks V³kbdksMekZ foyxuksa] uke'k% Vh- gkjthyUe vkSj Vh-vkmjsvksfofjMs dk p;u vUr%dksf'kdh; vkSj vfrfjDr dksf'kdh; fu"d"kZ.kksa p;kip;ksa ds fu"d"kZ.k ds fy;s fd;k x;k rkfd muls uSuksd.kksa dk tSo la'ys"k.k fd;k tk lds ftUgsa xUus esa yky lM+u jksx ds izca/ku ds fy;s uSuks lexzh;ksa ds tSotuu ds fy;s iz;ksx esa yk;k tk;sxkA

fo"kk.kq vuqØe.k lsok ds vUrjxr djhc 677 Ård laof/kZr ikS/kksa] ftUgsa fofHkUu mRiknu bdkb;ksa] uke'k% eSllZ b-vkb- Mh-iSjh] iqxkyqj] eSllZ vkjyl-lh-yy-] Fksuh vkSj laLFkku dh Ård lao/kZu iz;ksx'kkyk ls izkIr fd;k x;k Fkk] dks yl-lh-okb-yy-oh-] yl-lh-ye-oh-] yl-lh-yl-ye-oh- vkSj ?klSyk jksx QkbVksIykLekvksa ds fy;s ekud izpkyu fof/k;ksa dk iz;ksx djrs gqy vuqØfer fd;k x;kA izkbosV Ård lao/kZu iz;ksx'kkykvksa ls fo"kk.kq vuqØe.k lsok ds vUrjxr 'kqYd ds :i esa 1]28]900@& #i;s izkIr gqyA

iksjh cs/kd ds vkØe.k ds dkj.k gqy xUus ds mRiknu esa dehls ladsr feys dh dsoy ikjh cs/kd dh dsoy rhu ihf<+;ksa ds vkØe.k ls gh lkFkZd gkfu gqbZA

yky fNyds okys 20 lSdsje jkscLVe —Urdksa dh [ksr ds gkykrksa esa iksjh cs/kd ds fo#) izfrjksf/krk dh tkjp djus ij th-;w-ds- 14&129 vkSj th-;w-ds- 14&836 dks de ls de laosnu'khy ik;k x;kA

[ksr ds gkykrksa esa 'kk[kk cs/kd ds izfr bjfyUFkl v#afMusf'k;l ds ftu 8 thuizk:iksa dks izfrjks/kh ik;k x;k Fkk muesa ls lcls de fMEHkksa vkSj l;wikvksa dh mŸkjthfork vkb-ds- 76 78] vkb-ts- 76 364 vkSj vkb-ts- 76 370 esa iz;ksx'kkyk esa tk;p ds nkSjku ns[kh xbZA

[ksr esa vkmxesa VsfVo ijh{k.k ds nkSjku Vsfyuksel tkfr ds iSjkflVks;Mksa dh ek=k 4]500@gs- nsus ls iksjh cs/kd ds vkØe.k dh ?kVukvksa vkSj rhozrk fjyht+ ds 30 fnu ckn] fjyht+ fd;s x;s lykWV esa dUV$ksy ds eqdkcys dkQh de FkhA

dhVjksxtud dod ds mPp Lrj ij mRiknu dks de [kphZyk cukus ds fy;s fcukSys dh [kyh dks eSVkfjft+;e yfulksify ds fy;s] fry dh [kyh ds vdZ dks C;wosfj;k csflvkuk vkSj xsgwj ds pksdj vkSj pkoy ds pksdj ls izklr vdZ dks ch-czksaxfuvkjVh ds fy;s] fctk.kq mRiknu ds vk/kkj ij] loksZŸke ik;k x;kA

ye- yfulksify LV$su ¼yl-ch-vkb-ye-y-&16½ dk cgqxq.ku rjy fd.ou }kjk fd;k x;kA yd mUur ehfM;k ftlesa xqM+ dh lkUnzrkvksa dks c<+k;k x;k ¼10 vksj 15 % ftudks Øe'k% yl-ch-vkb-&1 vkSj 2 uke fn;k x;k½ vkSj laiwjdkax ds lkFk la'kksf/kr dj dhV jksxtud lw=&fevksa ¼dh-jks-lw-½ ds dYpj ds fy;s ewY;kafdr fd;k x;k vkSj bldh rqyuk laiwjdkax ds fcuk xqM+ okys ehfM;k ls dh xbZA yl-ch-vkb-&1 ehfM;k ds lkFk lkoZf/kd e`R;q'khyrk 94-44 % ns[kh xbZ tks yl-ch-vkb-&2 ds 91-67 % ds lerqY; Fkh exj okb-ih-yl- yl- ds 83-33 % ls vf/kd FkhA Bksl ehfM;k ij dbZ dh-jks- lwvksa dh dkWyksuh dh o`f) vkSj fctk.kqvksa dh thou{kerk us yl-ch-vkb-&1 ehfM;k dks csgrj n'kkZ;kA

ylpjIksfu;k iyslsaVk ds fy;s cM+s iSekus ij mRiknu rduhdksa] tks lQsn eD[kh ij yd dh-jks-lw- gS] dks ekudh—r fd;k x;k vkSj yl-ch-vkb-&1 vkSj &2] nksuks ehfM;k ij bldh o`f) vkSj fctk.kq mRiknu] miyC/k ekud ehfM;kvksa ds rqyuh;FksA

xeyksa esa fd;s x;s ijh{k.kksa esa ch- czksaxfuvkjVh] ch- csflvkuk] ye-yfulksify] yp- bafMdk] yl- xyklsjh vkSj 6 p;u fd;s x;s dhVukf'k;ksa dks] [ksr esa mipkj ds fy;s iz;ksx fd;s thus okyh vuqlaf'kr ek=kvksa ij] fofHkUu la;kstuksa ds :iesa fn;k x;kA lHkh dhVjksxtudksa us laQsn fxaMkj esa mPp e`R;q'khyrk n'kkZbZA

nks ØkbZ thuksa] uke'k% ØkbZ1Mh- vkSj ØkbZ1b-] ftUgsa csflYl Fkqfjaftyafll foyxu yl-ch-vkb-&ds-ds-27 ls foyfxr fd;k x;k Fkk] dh iwjh yEckbZ ds vuqØeksa dks dyksfuax ds ckn Øe'k% 3501 vkSj 3531 chih dk ik;k x;kA

yl-ch-vkb-&ch-Vh41 ds iwjs ftukse vuqØe ds fo'ys"k.k ls yd uohu ØkbZ8 thu dk irk pykA yl-ch-vkb-&ch-Vh721 ds iwjs ftukse vuqØe ds fo'ys"k.k ls irk pyk ØkbZ3 thu dh iwjh yEckbZ dh mifLFkr FkhA blh izdkj yd vU; ch-Vh foyxu yl-ch-vkb-&ye-6 ds iwjs ftukse vuqØe ds fo'ys"k.k ls irk pyk dh blus yd u;s gksyksVkbi ØkbZ 66 thu dks vkJ; fn;k gqvk gS] ftlds dk;Z dk vHkh rd irk ugha gSA

dkbyks bUQldSVsyl] lkbjiksQsxk yDljiVsfyl] lslvfevk bUQsjsal] ijkWfVLVk eksyLVk] ikbfjYyk ijiqflyk] esykukfQl lSdsjkb] VsVjkU;wjk tsosafll] uhvkseldsfyvk cjtkb] yY;wjksykscl ckjksMsafll] LVqjfevksifll bUQsjsal] yfifjdkfuvk esykuksY;wdk vkSj fMQk yfQfMoksjk ds Mh-yu-y-ckjdksM~l fodflr fd;s x;s] ftlds fy;s budk iz;ksx izkbejksa dks fMT+kkbu djus ds fy;s fd;k x;k] rkfd dhV tkfr;ksa ds lh-vks-vkb- thu ?kVdksa dks ifjof/kZr fd;k ldsA lh- bUQldSVsyl ds yf{kr ?kVdksa dk vkdkj 204 chih vkSj yl-bUQsjsal dk 599 chih FkkA

xUus ds jl dks ukbV$kstu ifjiwjdksa ls n`<+h—r dj ch-Vh&62 LV$su ds mRiknu dks c<+kus ds fy;s budk ewY;kadu djus ij lkoZf/kd fctk.kq mRiknu 6-12 x 1012 lh-yQ-;w-@fefyfyVj xUus ds jl esa bZLV vdZ ls feykdj iz;ksx djus ij ik;k x;k ftlds ckn dSyf'k;e dyksjkbM ds feykus ls 3-50 x 1012 lh-yQ-;w-@fefyfyVj ntZ fd;k x;kA

ch-Vh 62 ds cM+s Lrj ij mRiknu dks ekudh—r djus ds fy;s bl cSDVhfj;k dks LVSaMMZ Vh-3 ehfM;k vkSj 3 % 'khjs ds lkFk] cht fd.od ij cgqxqf.kr fd;k x;kA Vh-3 ehfM;k ls vf/kd cSDVhfj;k dk mRiknu 'khjs ds eqdkcys ns[kk x;kA

LVsbujusek tkfr dk cM+s Lrj ij mRiknu dks eksuksDt+hfud rjy dYpfjax ehfM;k ij dksf'k'k dh xbZ vkSj —felw= dk cM+s iSekus ij mRiknu rjy ehfM;k ij lQy jgkA

uohu VsYd la:i.k] 15 dh-jkslw-vksa ¼7 gSV~jksjgSCMkbfVl vkSj 8 LVsbujusek tkfr;ksa ls½ ds 22&250 lh- ij HkaMkj.k vkSj mi;ksx dh vof/k ds fy;s xysfj;k fMEHkksa ds fo#) ewY;kafdr fd;k x;kA lHkh dh-jkslw-vksa us xysfj;k fMEHkksa dh 100 %e`R;q'khyrk HkaMkj.k ds 8osa eghus tcfd 10osa eghus ij 10 dh- jkslw-vksa us xysfj;k fMEHkksa dh 100 % e`R;q'khyrk ntZ dh xbZA rhu dh-jkslw-vksa us 12osa eghus ij xysfj;k fMEHkksa dh 100 % e`R;q'khyrk ntZ dhA

rfeyukMq ds fofHkUu ft+yksa esa eDdk vkSj xUus ds Qky vkehZ okWeZ laØfer [ksrksa dk losZ{k.k fd;k x;k vkSj 14 dh-jkslw-vksa dks eDdk ds [ksrksa ls foyfxr fd;k x;kA

Qky vkehZ okWeZ laØfer [ksrksa ls ubZ foyfxr dh xbZ dh-jkslw-vksa dh tula[;k ij Ja[kykc) rjhds ls tSoij[k djus ij 5 LVsbujusek L;kedk;kb foyxu] 7 gSV~jksjgSCMkbfVl

bafMdk] 13 yp- cSDVhfjvksQksjk vkSj 8 yl- xykIsjh dks Qky vkehZ okWeZ esa e`R;q'khyrk dk csgrj dkj.k ekuk x;kA

Hkk-—-vuq-i- & xUuk iztuu laLFkku }kjk cuk;k x;k gkfudkjd thoekjd la:i.k izkS|ksfxdh dk O;kolkf;dj.k fd;k x;k ftls yxzhbUuksosV }kjk lapkfyr fd;k tk jgk gS vkSj ftls rhu ck;kisLVhlkbM dEifu;ksa] uke'k% eSllZ Vh-LVsUl y.M dEiuh fyfeVsM] dks;EcŸkwj] eSllZ o"kkZ yxzksVsd] fot;kiqjk] dukZVd vkSj eSllZ bfUMxks yxzks] vdksyk] egkjk"Vª dks 2]00]000 #i;s dh ykblsal Qhl ij fn;k x;k gSA

Hkkd`-vuqi-&xUuk iztuu laLFkku] dks;EcŸkwj] dksad:] d.kkZVd

dks- 13035] yd e/;e nsjh ls idus okyh iztkfr dks mŸkj if'peh {ks= ¼ftlesa dsUnzh; vkSj if'peh mŸkj izns'k] mŸkjk[kaM] gfj;k.kk] iatkc] fnYyh vkSj jktLFkku 'kkfey gSa½ esa O;kolkf;d [ksrh ds fy;s jkti= vf/klwfpr ¼uEcj 3482 frfFk 07-10-2020-½ fd;k x;kA dks- 15023] yd vxsrh iztkfr dks v-Hkk-l-vuq-i- ¼xUuk½ dh 33oha f}okf"kZd dk;Z'kkyk] ftls 19&20 vDrwcj] 2020 esa igpku x;kA

—f"k Qlyksa ds fy;s iztkfr vf/klwpuk vkSj fjyht+ ds fy;s Qly ekudksa ij dsUnzh; mi&lfefr dh 9 uoEcj 2020 dks vk;ksftr 85oha ehfVax esa bl iztkfr ds tkjh djus dk+ izLrko vuqeksfnr fd;k x;kA rhu dks- xUuksa dks] uke'k% dks- 20016 ¼vxsrh½] dks- 20017 ¼e/;e nsjh ls idus okyh½] dks- 20018 ¼e/;e nsjh ls idus okyh½ mŸkj if'peh {ks= ds fy;s tcfd dks- 15023 ¼vxsrh½] mŸkjiwohZ vkSj mŸkj dsUnzh; {ks= ds fy;s] v-Hkk-l-vuq-i- ¼xUuk½ dh 33oha f}okf"kZd dk;Z'kkyk esa {ks=h; iztkfr ijh{k.k esa ijh{k.kksa ds fy;s 'kkfey djus ds izLrko Lohdkj dj fy;k x;kA

Hkwry ulZjh ls 4]960 cht tfur ikS/kksa dks lfnZ;ksa esa fnlEcj 2020 ds rhljs lIrkg esa jVwu fd;k x;kA Hkwry ulZjh ls 90 ¼ds-18&01 ls ds- 18&90½ —Urdksa dk p;u dj lh-&1 ewY;kadu ds fy;s pkj ekudksa ¼dks- 0238] dks-ts- 64] dks- 05011 vkSj dks-'kk- 767½ ds lkFk [ksr esa iqu%jksfir fd;k x;kA izFke —Urd p;uksa ¼ds- 16 Ja[kyk½ ds 494 esa esa ls108 dks 'kq:vkrh ijh{k.k ds fy;s vkxs c<+k;k x;kA Qly ds 8osa eghus esa jl esa lqØksl % ds fy;s ds- 16&144 esa 19-65] ds- 16&01 esa 18-34] ds- 16&43 esa 17-91] ds- 16&99 esa 17-86 vkSj ds- 16&475 esa 17-79 % ds lkFk bUgsa loksZŸke ekud dks-ts- 64 esa 17-56 dh rqyuk esa vk'kktud ekuk x;kA izFke —Urd ijh{k.k esa loksZŸke ekud dks- 0238 esa 19-1 % yp-vkj- fczDl dh rqyuk esa ds- 17&001 esa 20-2] ds- 17&037 esa 19-7 vkSj ds- 17&038 esa 19-4 % ds vkadM+s csgrj FksA xUuk mRiknu] jl dh xq.koŸkk vkSj yky lM+u jksx izfrfØ;k ds vk/kkj ij nks vxsrh ds 14&219 ¼dks- 20015½ vkSj ds- 14&425 ¼dks- 20016½ —Urdksa vkSj rhu e/;e nsjh ls idus okys ds- 14&352 ¼dks- 20017½] ds- 14&410 ¼dks- 20018½ vkSj ds- 14&501 ¼dks- 20019½ dks ;g dks- uEcj fn;s x;s FksA QSDVjh ijh{k.kksa esa ijhf{kr izfof"V;ksa esa ls dks- 15023 dksjl dh xq.koŸkk ekidksa ds vk/kkj ij] lHkh ijh{k.k LFkkuksa] uke'k% vtckiqj] :ikiqj] gfj;kou] yksuh] cyjkeiqj] jkex<+] ;equkuxj vkSj nkÅjkyk] ij lcls csgrj izn'kZu djus okyk ik;k x;kA

lh-&1] 'kq:vkrh vkSj iwoZ {ks=h; iztkfr ijh{k.k ls dqy 278 —Urdksa dks yky lM+u jksx izfrjksf/krk ds fy;s ewY;kafdr djus ij 115 us izfrjks/kh@e/;e izfrjks/kh] 50 us e/;e laosnu'khy vkSj 113 us laosnu'khy@vfrlaosnu'khy izfrfØ;k n'kkZbZA

dks- xUuksa ds ewY;kadu ijh{k.k esa izfof"V;ksa esa ls 10osa eghus esa dks-15023 us 21-37 %] dks- 17016 us 21-21 %] dks- 14034 us 20-84 %] dks- 0118 us 20-44 % vkSj dks- 0116 us 20-22 % jl esa 'kdZjk ntZ dh tcfd 12osa eghus esa dks- 15023 us 22-56 %] dks- 14034 us 21-95 %] dks- 17015 us 21-74 %] dks- 0116 us 21-43 % vkSj dks- 17016 us 21-42 % jl esa 'kdZjk ntZ dj lcls Å¡pk izn'kZu fd;kA

lw[ks ds gkykrksa esa xUus ds teZIykLe dks ijhf{kr djus ij xUuk mRiknu esa 41 % dh fxjkoV ns[kh xbZ tcfd jl dh xq.koŸkk ij dksbZ lkFkZd izHkko ugha ns[kk x;kA lw[ks ds dkj.k xUuk mRiknu esa izfof"Vksa esa ls dsouxsjh] 14&50] 12 lh-ch-b- vkSj lh-yy- 41&141 us U;wure] 10 % ls Hkh de fxjkoV ntZ dhA lw[ks ds dkj.k 2020&21 ds ijh{k.k ds nkSjku 27 ijhf{kr izfof"V;ksa us xUus dh Å¡pkbZ esa 22-39 %dh fxjkoV ns[kh xbZA dyksjksfQy ds fy;s LiSM eku esa 11-36 % dh vkSlr fxjkoV ifjdfyr dh xbZA lekU; gkykrksa esa dyksjksfQy eku 43-21 tcfd lw[ks ds gkykrksa esa ;g 37-84 % ifjdfyr fd;s x;sA lekU; gkykrksa esa isjkbZ ;ksX; xUuksa dh la[;k 1-07 yk[k@gs- vkSj lw[ks ds gkykrksa esa ;g 0-91 yk[k@gs- ifjdfyr dh xbZA ydy xUuk Hkkj esa lw[ks ds dkj.k 17-62 % dh fxjkoV vuqekfur dh xbZA lw[ks ds gkykrksa esa yp-vkj- fczDl 8os eghus esa lekU; ds 15-5 % ds eqdkcys lw[ks ds gkykrksa esa csgrj 17-12 % vuqekfur dh xbZA lw[ks ds gkykrksa esa 8osa eghus esa yl-y- 14&49] yl-y- 14&52 vkSj yl-y- 14&147 us mPp isjkbZ ;ksX; xUuksa dh la[;k vkSj mPp 'kdZjk % ns[kh xbZA

yo.krk ds fofHkUu Lrjksa ij ikni tula[;k esa vkSlr fxjkoV 4 Mslhlheu izfrehVj ij 17-12 %] 8 Mslhlheu izfrehVj ij 34-98 % vkSj 10 Mslhlheu izfrehVj ij 47-94 % vuqekfur dh xbZA izfof"V;ksa esa ls U;wure fxjkoV yp-49&104 esa 23-3 % ftlls vf/kd 14&50 ¼ 24-4 %] th-;w- 00&139 ¼ 25-8 %

vkSj dsouxsjh esa 29-3 % vuqekfur dh xbZ tcfd lkoZf/kd fxjkoV dks- 0238 esa 37-3 % vkSj mlls de 51yu-th-&153 esa 33-3 % vuqekfur dh xbZA

ty deh ruko ds gkykrksa esa dks- –Urdksa] uke'k% dks- 0238] dks- 05011] dks- 12029] dks- 15023 vksj dks- 98014 us mPp la[;k esa dYyksa dk mRiknu vkSj xUuk mRiknu fd;k tcfd isjkb ;ksX; xUuksa vkSj ydy xUUkk Hkkj esa de fxjkoV n'kkZbZA bu –Urdksa us csgrj izdk'k la'ys"k.k nj] dyksjksfQy dh ek=k vkSj lis{k ty ek=k bR;kfn cuk;s j[k dj lgu'khyrk dh csgrj izfØ;k dk izn'kZu fd;kA fuekZ.kkRed izoLFkk esa ty deh dks lgus dh vkUrfjd {kerk Hkh bldk dkj.k gks ldrh gSA lw[ks ds gkykrsa es ewY;kafdr fd;s x;s 27 vkb-yl-yp- –Urdksa esa ls 16 dks ifrjks/kh@e/;e izfrjks/kh] 6dks e/;e laosnu'khy vks 5 dks laosnu'khy@vfr laosnu'khy izfrfØ;k n'kkZrs ik;k x;kA

dkyh dhM+h] dalwwk] pksVh cs/kd vkSj LVkWd cs/kd ds izfrmUur iztkfr ijh{k.k dh 13 vkSj vkb-yl-yp-@vkb-th-yp- dh 266 izfof"V;ksa dks vfr de laosnu'khy igpkuk x;kA

v-Hkk-l-vuq-i- ds 2019&20 ds ijh{k.kksa esa xUuk mRiknu vkSj jl dh xq.koÙkk dks feykdj mUUr iztkfr ijh{k.k dh izFke ikS/kk Qly esa dks- 15023] dks- 15025 vkSj dks- 15027 rFkk f}rh; ikS/kk yoa isM+h dh Qly esa dks 14034 dks vsrh ds vUrjxr csgrj izfo"V;ksa ds :i esa igpkuk x;k tcfd e/;e nsjh ls idus okyh 'kq:vkrh iztkfr ijh{k.k dh izfof"V;ksa esa ls dks- 16030] dks-'kk- 16232 vkSj dks-'kk- 16233 dks csgrj ik;k x;kA

yky lM+u jksxtud lh-yQ-11 dks lcls fo"kkDr ik;k x;k ftlds ckn lh-yQ-01] lh-yQ-02] lh-yQ-08] lh-yQ-07] lh-yQ-09 vkSj lh-yQ-03 tcfd lh-yQ238 ds pkj u;s foyxuksa us 8 ls 10 est+cku foHksndksa ij Hkh laosnu'khy izfrfØ;k n'kkZbZA gfj;k.kk vkSj mÙkj izns'k dh 5 ohuh feyksa ls iztkfr dks- 89003 ds uewuksa esa yky lM+u jksx ds laØe.k dks 30-0 % rd ik;k x;k tcfd daMqvk jksx] iksDdkg cksbax vkSj foYV jksxksa dks {ks= esa mxkbZ tk jgh dqN yksdfiz; iztkfr;ksa esa lcls T;knk ik;k x;kA

VsVjkLVkbDl ikbfjYys dks yd vaMk iSjkflVkW;M vkSj bfifjdkfuvk esykuksY;wdk yd fuEQ ds lkFk lkFk ikbfjYyk ijl;wflYyk ds yd izkS<+ iSjkflVkW;M ds :i esa igpkuk x;kA vkblksfVek tkosafll vkSj LVsuksjdkdksu Mhlky dks pksVh cs/kd ds fMEHk iSjkflVkW;Mksa ds :i esa ntZ fd;k x;kA dksVsflvk Qysfoisl~ dks LVkWd cs/kd ds yd fMEHk ds lkFk l;wik ls igys iSjkflVkW;M ds :i esa igpkuk x;kA losZ{k.k dk;ZØe ds nkSjku pksVh cs/kd vkSj cfyLVj dhM+h ds vkØe.k dh izpaM ?kVuk;sa ns[kh xbZA

jkr Hkj xUus ds cht VqdM+ksa dks 200 vkSj 500 ihihye bFkjy esa fHkxks dj j[kus ls dSfoVh okyh V"s;ksa esa dfydk QqVko dks Øe'k% 30 % vkSj 19 % fcuk mipkfjr dUV"ksy ds eqdkcys lfnZ;ksa esa jksi.k ds 40 fnu ckn jlk;fud ifjorZuksa dks] tSlsfd yflM bUoVsZl dh xfr }kjk fjM;wflax 'kwxlZ dks c<+kdj] O;ofLFkr dj fd;k x;kA exj lfnZ;ksa esa rhu iztkfr;ksa] uke'k% dks- 0118] dks- 0238 vkSj dks- 05011 ds LVCcyksa 100] 200] 500 vkSj 1]000 ihihye bFkjy }kjk ck°; mipkj QqVko dks c<+kus esa izHkko'kkyh ugha ik;k x;kA

dqy 167 miks".kdfVca/kh; xUuk lanHkZ iztkfr;ksa dks [ksresa vuqjf{kr fd;k x;k vkSj lanHkZ iztkfr;ksa ds Mh-;w-yl-o.kZudrkZvksa dks lR;kfir fd;k x;kA izR;{k'kh iztkfr dks- 12029 ds lkFk lanHkZ iztkfr;ksa ¼dks- 05011 vkSj dks-'kk- 97267½ ds ydy dfydk okys xUuk cht VqdM+ksa dks izksV"s;ksa esa mxkdj 30 fnu iwjkus ikS/kksa dks [ksr esa jsaMksekbt+M CykWd fMt+kbu esa iqu%jksfir fd;k x;kA

dks- 0118] dks- 0238 vkSj dks- 12029 iztkfr;ksa dk dqy 34]301-71 dfoaVy xUuk cht 2019&20 ds Qly ekSsle ds nkSjku forfjr fd;k x;kA bl izdkj cht csp dj 21]91]387@& #i;s dk jktLo izkIr gqvkA dks- 0118] dks- 0238 vkSj dks- 12029 iztkfr;ksa ds dqy 1]80]240 xUuk cht VqdM+k tfur ikS/kksa dks mRikfnr dj fofHkUu lk>snkjksa dks cspk x;kA 'kjn _rq ¼2020&21½ ds nkSjku dqy 10]075-69 dfoaVy iztud cht vkSj 2]07]395 xUuk cht VqdM+k tfur ikS/kksa dks mRikfnr fofHkUu lk>snkjksa dks cspk x;kA dqvkrjks xUuk ydy dfydk cht VqdM+k dV~Vj e'khu ds ykblaflax vf/kdkj eSllZ gkUt+jk bathfu;fjax odZl] xkjo ckalk] djuky dks nsdj QeZ ls 40]000 #i;s dh jks;sYVh izkIr gqbZA yl-Vh-Vh- dks izksRlkfgr djus ds fy;s Hkk-~-vuq-i-&xUuk iztuu laLFkku]

{ks=h; dsUnz] djuky ds xUus dh cht Qly ds vuUrjxr lEiw.kZ {ks= dks xUuk cht VqdM+ksa tfur ikS/kksa dks iqu%jksi.k ;U= }kjk iqu%jksfir fd;k x;kA yl-Vh-Vh- dk mi;ksx dj xq.koÙkk;qDr cht dk mRiknu djus ds fy;s funs'kd] Hkk-~-vuq-i-&xUuk iztuu laLFkku] dks;EcÙkwj vkSj 10 phuh feyksa@oxksZa ds lkFk ye-vks-;w gLrk{kfjr fd;s x;sA Hkk-~-vuq-i- xUuk iztuu laLFkku] {ks=h; dsUnz] djuky }kjk izf'kf{kr djhc 10 fdlkuksa vkSj izsfjr m|fevksa us djhc 8]80]000 cht VqdM+ksa tfur ikS/ks mRikfnr fd;s ftUgsa mUgksaus ;k rks [kqn iz;ksx dj fy;k fQj vU; lkFkh fdlkuksa dks llykbZ fd;k x;k rkfd djhc 110 ydM+ esa jksi.k fd;k tk ldsA

djuky {ks= ds fdlkuksa dks vkj-ds-oh-okb- ds vUrjxr [kjhns x;s ;U=ksa] uke'k% fjolZ jksVjh jksVksosVj] xUuk V"S'k eYpj] jVwu izxa/ku ;U= vkSj Vw Vkbu fjoflZcy ye-ch- lyks] xUus esa vo'ks"kksa] isM+h Qly] bR;kfn ds izca/ku ds fy;s fdlkuksa

dks vuqefr nh xbZA nl dqvkrjks xUuk ydy dfydk cht VqdM+k dV~Vj e'khuksa dks gfj;k.kk dh lHkh dks&vkWijsfVo phuh feyksa dks llykbZ fd;s x;sA vkj-ds-oh-okb- ds vUrjxr LFkkfir fd;s x;s ikS/kk o`f) pSEcj esa dks- 15023 ds djhc 70]000 xUuk cht VqdM+ksa tfur ikS/kksa dks pje lfnZ;ksa ds nkSjku mxk;k x;kA iksyhV~s;ksa esa 300lh- rkieku vkSj 90 % lkis{k ueh ij xUuk cht VqdM+ksa esa dfydk QqVko dh 'kq:vkr ns[kh xbZ vkSj 7 ls 8 fnuksa ds Hkhrj buls tfur ikS/ks iqu%jksi.k ds fy;s rS;kj FksA xUuk cht VqdM+ksa ls vU/kdkj esa fudyus okyh tM+ksa esa usxsfVo xq#RokuqorZu ns[kk x;k tcfd ikS/kk o`f) pSEcj esa izdk'k ds gkykrksa esa /kukRed xq#RokuqorZu ns[kk x;kA 'khrdkyhu ekSle ds nkSjku bykds ds fdlkuksa dks fofHkUu Qlyksa] uke'k% puk] xktj] yglqu] ewyh] xsgwa] ljksa] xksHkh] vkyw] bR;kfn ds vUrjQlyhdj.k ds fy;s izksRlkfgr fd;k x;kA cht ds fy;s mxkbZ xbZ Qlyksa dh xkjo dkgux<+] [kqn~nk dyka] [kjdyh] cjkyw] cq/kuiqj] frrkoh] larjh] fjaMy vkSj cky iokuk esa le; le; ij fujh{k.k fd;k x;kA

~~Hkkd~Ñ-vuq-i- & xUuk iztuu laLFkku] vuqla/kku dsUnz] vxyh o"kZ 2020 dk 1380 teZlykLe vfHkizkfIr;ksa dk ls 635] 46-01 %] esa iq"i.k ns[kk x;k] tks 2019 ds 44-28 % ls FkksM+k vf/kd FkkA o"kZ 2020 ds nkSjku djhc yl- vkWfQ'usje ds 65 —Urdksa] yl- jkscLVe ds 6 —Urdksa] yl- lkbusal ds 6 vkSj yl- ckjcsjh ds Hkh 6 —Urdksa us iq"i.k fn[kk;kA iq"i.k] NksVh ckyksa ¼Likbdys V½ ds [kqyus dks 16 flrEcj 2020 ls 7 fnlEcj 2020 ds nkSjku rd ns[kk x;kA yu-th- 174] eksaxsV xk;e] ukt+]vksVkgs;Vh] yy-yl- 89&2064] lqQku&50 okbV V~kUlisjaV vkSj 'kwxj MkWDVj dks flrEcj ds vkf[kjh llrkg~~

bl dsUnz ij lalkj ds lcls cM+s xUuk teZlykLe ds laxzg.k ¼3]373 vfHkizkfIr;ksa½ dks [ksr okys thu cSad esa okf"kZd iqu%jksi.k }kjk vuqjf{kr fd;k tk jgk gSA teZlykLe dks le; le; ij iq"i.k] gkfudkjd thoksa yoa jksxksa ds fy;s fujhf{kr fd;k x;kA [ksr okys thu cSad ds iwjd ds :i esa 110 yl- vkWfQ'usje —Urdksa dks iz;skx'kkyk ds gykrksa esa Hkh vuqjf{kr fd;k tk jgk gSA yl- ckjcsjh ls 42 vkSj yl-lkbusUl ls 30 tkrh; —Urdksa dks 31 'kjhfjd y{k.kksa] xUuk mRiknu vksj jl dh xq.koÙkk ekidksa ds fy;s of.kZr fd;k x;k rkfd laxzg.k esa fofo/kRrk dks le>k tk lds vksj ;fn dksbZ MqifydsV gS rks mls vk.kfod izksQkbfyax }kjk [kkstk tk ldsA vfUre —Urd ewY;kadu ijh{k.k esa 16 —Urdksa dk izk—frd tqlykou ds gkykrksa esa ewY;kadu dj nks —Urdksa MCy;w-yy- 16&457 vkSj MCy;w-yy- 16&498 dks mPp lh-lh-yl- mRiknu ds lkFk yky lM+u jksx izfrjks/kh gksus ds dkj.k iwoZ {ks=h; iztkfr ijh{k.k ds fy;s pqu fy;k x;kA

vU; 130 —Urdksa dks nks izfr—fr;ksa okys ijh{k.kksa esa ewY;kafdr fd;k x;k vkSj vk'kktud —Urdksa dks vkxs ijh{k.kksa ds fy;s c<+k;k x;kA ckjg ØkWlsl ls 1]270 larfr;ksa dks Hkwry ulZjh esa ewY;kafdr fd;k x;k ftlesa 116 dks izFke —Urd ijh{k.k ds fy;s pquk x;k ftlds lkFk 16 u;s ØkWlsl cukus dh dksf'k'k dh xbZA u;s tsusfVd LVkWDl dks fodflr djus ds fy;s vuqokaf'kd lalk/kuksa dk mi;ksx dk;ZØe ds vUrjxr pkj fofo/k vuqokaf'kd i`"VHkwfe okys —Urdksa] uke'k% th-;w-ds- 16&801] th-;w-ds- 16&917] th-;w-ds- 16&967 vkSj th-;w-ds- 16&975] dks tsusfVd LVkWd ds :i esa pSd iztkfr;ksa ds cjkcj ;k vf/kd lh-lh-yl- mRiknu nsus ds dkj.k igpkuk x;kA buesa ls th-;w-ds- 16&967 dks iwoZ {ks=h; iztkfr ijh{k.k ds fy;s pqu fy;k x;kA yd 82 —Urdksa okys lewg dks nks izfr—fr;ksa okys ijh{k.kksa esa ewY;kafdr fd;k x;k vkSj vk'kktud —Urdksa dks vkxs ijh{k.kksa ds fy;s c<+k;k x;kA ikap ØkWlsl ls 556 okLrfod cht tfur ikS/kksa dks Hkwry ulZjh esa ewY;kafdr dj 72 larfr;ksa dks pquk x;kA fofo/k iSr`d —Urdksa dk iz;ksx dj lrjg ØkWlsl] ftuesa cSdØkWlsl Hkh 'kkfey Fks] dh dksf'k'k dj QYQ dh dVkbZ dh xbZA xUus esa foYV o yky lM+u jksx ds izca/ku ds fy;s izfrjks/kh lw{ethoksa dks iz;ksx esa ykus ds fy;s fd;s x;s v/;;u esa dks- 86032 ds xUus ds cht VqdM+ksa dks ih-th-ih-vkj- ds lao/kZuksa] ch-lh- 23] ch-lh- 36] ih-yQ- 4 vkSj ih-yQ- 60 rFkk cSDVhfj;ksa ds ladk; ls mipkjksa us xUus ds dUV~ksy ds eqdkcys csgrj o`f) n'kkZbZA mipkjksa esa esa ch-lh- 36 dks lcls izHkkoh vkSj ftlds ckn ih-yQ-60 dks izHkkoh ik;k x;kA

xUus esa ik;fjYyk ds ekSleh xfrfof/k vkSj tSfod fu;U=.k ds ewY;kadu ds v/;;u esa ik;fjYyk dh tula[;k cqqrk;r] ftlesa fuEQ vkSj izkS<+ nksuks 'kkfey Fks] dks lkoZf/kd yl-vkWfQ'usje vkSj Hkkjr rFkk fons'kh ewy ds ladjksa esa ns[kk x;k ftudh Qlysa vf/kd l?kurk okyh gSa] tcfd vU; de l?kurk okys Qly la;kstuksa] uke'k% yl- jkscLVe] yl-lkbusal vkSj yl- ckjcsjh ds ikfjfLFkfrdh rU= esa de cqqrk;r ikbZ xbZA ih- ij;wfIYyk us vU; est+ckuksa] tSlsfd taxyh xUus] yl- LikWUVsfu;e vkSj xUus ds lEcaf/kr tsujk dh rjQ de ojh;rk n'kkZbZA

cqqr rst+rjkZj dhVjksxtud dod fgjlqfVYyk tkfr] tks ik;fjYyk dks lØfer djrh gS] dks foyfxr dj yl-Mh- y-okb- ehfM;k ij mldh dYpj djus dh dksf'k'k lQy jghA fgjlqfVYyk tkfr ds ylnkj mifuos'kuksa dk mRiknu] ftUgksaus cqqr lkjh [kM+h iztuu lajpuk;sa iSnk dh ftuls lewgksa esa dksfufM;ksQksj izklr gqyA

esa tYn iq"li.k djrs ns[kk x;kA dqy 150 ØkWlsl 2020 ds iq"i.k ekSle ds nkSjku dqM~Mkyksj] y[kuÅ] uolkjh] iwuk] iMsxkao] iUruxj] lads'oj vkSj lsojfg dsUnzksa ds vuqjks/kksa ds vuqlkj fd;k x;kA

dqy 233 lanHkZ iztkfr;ksa dks dks;EcÝkwj o vxyh ds [ksrksa esa jksx jfgr okrkoj.k esa vuqjf{kr fd;k tk jgk gSA fdlkuksa dh 2 iztkfr;ksa] lqxe dVkjh vkSj thr dVkjh rFkk yd ubZ iztkfr dks- 09004 dk Mh-;w-yl- ijh{k.k 2020&21 ds Qly ekSle ds nkSjku vxyh esa fd;k x;kA

foLrkj foHkkx

nwj rd igq¡pus ds dk;ZØeksa esa jk"Vªh; [kk| lqj{kk fe'ku ds vUrjxr 8 jkT; Lrj ds izf'k{k.k dk;ZØeksa] 12 yd fnolh; izf'k{k.k dk;ZØeksa] Mh-yl-Mh- iz;ksftr yd fnolh; izf'k{k.k dk;ZØe vkSj jk"Vªh; foKku fnol mRlo dk vk;kstu fd;k x;kA

olarnknk 'kwxj laLFkku] iwuk esa 31 tuojh ls 2 Qjojh 2020 ds chp vk;ksftr vUrjjk"Vªh; lEesyu esa laLFkku us xUus dh [ksrh ds fy;s izFkkvksa ds iSdst dks n'kkZrs LVky dks yxkdj Hkkx fy;kA laLFkku esa vkus okys 2780 vxUrqdksa] ftuesa 2058 fo|kFkhZ] 591 fdlku vkSj 131 xUuk fodkl deZpkjh 'kkfey Fks] dk lRdkj fd;k x;kA

xUuk lykgdkj] xUus ij yd yUMjkW;M ekscckby yli ftlesa jkT; vuqlkj iztkfr;ksa] Qly mRiknu rduhdksa] Qly lqj{kk rduhdksa ij lwpuk;sa miyC) djkbZ xbZ gSaA ;g yli xqxy lys LVksj ij rhu Hkk"kkvksa esa Lora= MkmuyksM ds fy;s miyC) gSA lalkj Hkj ds 61 ns'kksa esa bls dqy 11550 ckj MkmuyksM fd;k x;k gSA

4. EXECUTIVE SUMMARY

Crop Improvement

Co 12009 (Sankalp), a midlate maturing variety has been notified for cultivation in the Peninsular zone of India. This variety has a new genetic base involving a *Saccharum spontaneum* accession SES 91. Another midlate variety Co 13013 (Akshaya) has been identified by the Varietal Identification Committee of AICRP (S) for Peninsular Zone for its improved cane and sugar yield. The new short duration variety Co 11015 (Atulya) notified in January, 2020 for Tamil Nadu has started spreading and occupies 9,570 acres, mainly as commercial seed, and is reported to yield on average 1 unit higher sugar recovery over the existing varieties in different sugar factories.

Two genotypes of commercial status *viz.,* Co 13001 and Co 14016 have been registered with ICAR-NBPGR as unique germplasm. Co 13001 (INGR20068) is registered as a genetic stock of short duration nature with high sucrose at 240 days. Co 14016 (INGR20069) is registered for its high cane population and higher ratoonability. During 2020, 14 new Co canes (Co 20001 to 20014) have been identified, among which ten clones *viz.,* Co 20001, Co 20002, Co 20003, Co 20005, Co 20006, Co 20007, Co 20009, Co 20010, Co 20011 and Co 20012 were promoted to the AICRP for further testing.

A total of 291 clones of diverse origin were included in the Arrowing Plot to create substantial variability in the progeny. The flowering season witnessed high flowering intensity (above 90%) and breeders made use of high parental diversity in hybridization to effect about 210 crosses.

A total of 20,000 seedlings from 90 biparental crosses, four poly crosses and six GCs were available in the ground nursery ratoon for selection during January 2021. Another set of 25000 seedlings from 125 crosses effected during 2019 were transplanted in the ground nursery, thus ensuring large seedling populations. Screening of the entries in the different clonal stages identified elite progeny as well as promising parents and cross combinations.

Genotypes derived from crosses involving Co 11015, CoC 671, Co 86032, Co 08016 and CP61-23 recorded early sucrose accumulation, while the crosses Co 06010 x Co 11015, Co 11015 x Co 0314, Co 86032 x 85 R 186 produced more number of selections. Out of 1464 clones in the second clonal trials, 35% were resistant to red rot indicating genetic advancement for red rot resistance. A total of 166 elite selections combining high yield, juice quality and resistant to red rot from Coimbatore and four clones from SBIRC, Kannur were screened in PZVT 2020 series lead to the identification of Co canes. Two selections from clonal nursery (Agl2018-4 and Agl2018-35) showed 20.58% and 19.27% sucrose at 8th month as prospective short duration clones.

Collaborative research activities with different sugarcane research stations and sugar factories showed considerable progress for identifying promising location specific varieties in the states of Maharashtra, Karnataka, and Andhra Pradesh. Eighteen test entries were evaluated in four locations facing acute water deficit stress in Maharashtra under a collaborative project between ICAR-SBI and Vasanthdada Sugar Institute, Pune. The pooled mean analysis oftwo plant and one ratoon trials showed the advantage of the clones Co 85019 and Co 98017 with clear improvement over standards Co 86032, CoM 0265 for both cane yield and sucrose content. At Kolhapur, the test entries Co 06022 and Co 15007 and Co 15021 were better on the basis of plant and ratoon crop performance. At KCP Sugars, Vuyyuru (Andhra Pradesh), four Co canes *viz.* Co 11015, Co 09004, Co 14002 and Co 15021 were found promising and were promoted for AICRP (S) trials of East Coast Zone. The factory has multiplied Co 11015, Co 09004 and Co 15007 in large plots. Trials were laid out at SNSI, Belagavi, Karnataka. Based on the two plant and one ratoon pooled analysis, the entries 2012-147, 2014-99 and Co 18024 were better than the standards. Co 18024 has entered multilocation testing in Northern Karnataka and has shown promise as an improved clone for the region. Evaluation of 21 entries under drought situation found Co 85019 with Superior

CCS yield. The entries Co 12007, Co 10033, Co 13003, Co 09004 and the standard Co 86032 also performed well under drought condition. Adaptive Research Trial in collaboration with Tamil Nadu Agricultural University was carried out with 14 test entries, among which the entry Co 11015 registered the highest sucrose content. Four entries, which include Co 14016 and Co 15007 and two entries from TNAU were selected for the trials. The Co canes selected for multilocation testing trials at research stations were Co 14004, Co 14012 and Co 18023 (2020-22) and Co 15020 (2021-22).

Under AICRP Initial Varietal Trial and Advanced Varietal Trial, I Plant, II plant and ratoon were completed as per the technical programme. In IVT, the entry Co 11015 recorded the highest CCS yield (23.19 t/ha) and highest sucrose content (22.58%) and emerged as the best in the trial. In AVT, based on two plant and one ratoon crops, the entries Co 13014 (18.05 t/ha) and Co 13003 were the best for sugar yield; the former was a high yielder and the latter was a high quality clone. In AVT I Plant crop, the entries Co 14004 and Co 14027 were significantly superior for both yield and quality traits.

Institute-Industry Participatory Approach (SISMA funded) entered the final stage of testing with 17 entries. In the first plant crop, Co 17003 and Co 14027 were better than Co 86032 for quality, whereas Co 12009, Co 14027, Co 17001 and Co 18009 performed better than Co 86032 for yield at harvest (12 months). In Co-operative sugar factories of Tamil Nadu, the entries Co 09004, Co 11015 and Co 17003 recorded better sucrose % than Co 86032 from 8 months onwards, while eleven entries (Co 11015, Co 12009, Co 15007, Co 15018, Co 16009, Co 16010, Co 16018, Co 17004, Co 17012, Co 18009 and Co 18024) recorded more than 10 tonnes higher cane yield than Co 86032 at harvest.

Under DUS testing at Coimbatore and Agali, 233 tropical sugarcane reference varieties were maintained in field. DUS test was completed in three farmer's varieties *viz*., Desi 1, Desi 2 and Meitei Chu Angangba, which were found distinct from their respective reference varieties. Similarly two farmer's varieties Jeet Katari and Sugam Katari were also distinct.

Sugarcane is now looked upon as a multipurpose crop including co-generation and ethanol production. Similarly energy cane bagasse as araw material for new product development such as crude oil, pulp for paper industries and texture fibre for garment industries was attempted. Energycane bagasse was found to be a good feedstock for bio-crude oil production and had good pulping qualities as a better alternative for sugarcane bagasse. Nutritional qualities and palatability studies of 72 fodder type clones are being assessed with ICAR-IGFRI, Jhansi and four clones (Agl2019-56, Agl2019-82, Agl2019-51 and Agl2019-14) recorded relatively higher green biomass yield at 150 days after planting.

Under Fluff Supply / National Hybridization Programme, 30.15kg of fluff of crosses effected in the National Hybridization Garden at Coimbatore and National Distant Hybridization Garden at SBIRC, Agali during 2019 was supplied to 24 fluff receiving stations across the country. Hybridization-2020 was in a different mode, without the participation of breeders from the participating centres on account of the travel regulations imposed owing to Covid 19 pandemic. The NHG was maintained well and out of 424 parents, 411 flowered with flowering intensity of 96.93 %. Totally 426 crosses were effected for 21 centres during October-December flowering period.

Marker – assisted selection in sugarcane for drought tolerance and red rot resistance was initiated during July, 2020 to speed up and to improve the selection process. A set of drought tolerant and sensitive clones were identified for evaluation during 2021-2022. Thirty two drought specific candidate gene markers are short listed based on earlier studies to be used as markers. Another new activity initiated was standardization of accelerated flowering in sugarcane through speed breeding. Significant increase in tiller number, root biomass and total dry matter was observed in the extended photoperiod of 16 hrs with 50000 lux for 90 days over the control.

Enhancement of sugarcane germplasm and development of prebreeding material is a priori- ty activity of the Institute. Major achievements involved registration of three pre-bred materi-

al with ICAR - NBPGR as unique germplasm. These are AS04 - 2097 (INGR20070) a drought tolerant interspecific hybrid with broadened genetic base with *S. spontaneum* SH 216, CYM08-922 (INGR20071), a backcross derivative with *Erianthus* cytoplasm as a potential pre-bred material for drought tolerance (with higher relative water content and lower malondialdehyde content under drought) and AS04-1687 (INGR20110) was registered for drought tolerance and water logging tolerance. This is a derivative of BO 102 x IND 84-337 (2n=56) and was subjected to morphological, agronomical and molecular characterisation. RT-PCR analysis revealed differential expression of key genes implicated in drought and salinity tolerance.

Maintenance of wild germplasm is done at Coimbatore and Wellington. At Coimbatore, 2130 germplasm accessions of *Saccharum spontaneum, Erianthus* genus and allied genera were maintained, while 47 accessions from Arunachal Pradesh were maintained at IARI Regional Station, Wellington. New collections were under quarantine. Similarly, a collection of 1998 clones, including 'Co' canes, foreign hybrids and other genetic stocks are maintained. All these accessions were subjected screening for flowering parameters and screening of different parameters was underway. Cytological studies progressed with the *S. spontaneum* collected from Punjab and Haryana, and Jharkhand. The significant finding was the identification of the rare and the lowest cytotype with 2n=40 (IND 17-1852). The *S. spontaneum* collection of the Institute had 26 cytotypes ranging from 2n=40 (8x) to 2n=112 (14x). Indo-Gangetic valley of Sub Himalayan region and deltaic region of South-east zone were seen as regions of cytogeographic interest with different chromosome numbers, while North and North-East India was the location of active evolutionary mechanism and the cyto-morphological variability favoured accumulation of adaptability characters. Identification key for *Erianthus* clones using the DELTA (DEscription Language for TAxonomy) software was developed and 52 clones were characterized. In National Active Germplasm bank, a total of 271 notified and registered genetic stocks were maintained and Index number was assigned to sixteen clones.

Evaluation of sugarcane germplasm for biotic and abiotic stresses at Coimbatore was carried out in a phased manner. The *S. spontaneum* clones *viz.* SES 49, SES 297A, SES 162B, SES 45, Glagah and H60-4-5, and the *Erianthus arundinaceus* accessions *viz.* SES 347, SES 293, IND10 - 1594, IS76 - 158, SES 75, IND99 - 886, IS76 - 205, IK76-62 and SES 149 responded better under drought.

Interspecific and intergeneric hybrids of novel origin were produced and evaluated. In order to introduce more variability of *S. officinarum* in the future varieties, ten typical noble canes were used in crossing and during the period, 30 back crosses were effected with higher cyto- type (2n=72 and 80) derived progenies. Devel-opment of Multiparent Advanced Generation Inter-Cross (MAGIC) Population for drought tolerance is approaching the final stages of pool- ing eight different genomic source. A final pop- ulation of 1550 seedlings from 55 eight way/ intercrosses were planted in the field for further evaluation for yield, quality, drought and red rot resistance. Six drought tolerant clones from two way cross population and 15 red rot resis- tant clones from four-way cross population are under further screening. Molecular cytogenetic characterization of interspecific and interge- neric hybrids of *Saccharum* and *Erianthus* was continued. Co 15015, with four *Erianthus* chro- mosomes, on crossing (Co 15015 x Co 11012) showed a progeny with two chromosomes of *Erianthus* through GISH technique. An interspe- cific hybrid Co 285 (*S. officinarum*, Green sport 2n=80 x *S. spontaneum* Coimbatore, 2n=64) onGISH analysis with labelled probe of *S. spon- taneum*, Coimbatore showed 32 *S. spontaneum* chromosomes and 7 recombinant chromosomes of *S. spontaneum* and *S. officinarum.* Genomic *in situ* hybridization to assess the *S. spontaneum* compliment in commercial hybrids showed that the popular variety Co 86032 had around 12 *S. spontaneum* chromosomes. Introgression pattern of *Erianthus* chromosomes of *Erianthus* x *S. spon- taneum* with 30 *Erianthus* chromosomes showeda gradual decrease of 24, 12 and 7 in the second, third and fourth generations respectively.

Developing trait specific genetic stocks and multi trait genetic stocks with improved *Saccharum* genetic base and with improved yield and

quality parameters and drought tolerance were in progress. Eight *Saccharum* accessions *viz*., Nargori, Mangasic, Maneria IMP 1552, Daur Kinara, Chin, Mungo 254, Kheli and Reha and three flowering interspecific hybrids developed at the Kannur centre showed red rot resistant reaction. The resistant types were utilized in crossing with high quality commercial canes for further improvement. More hybrids were evaluated for drought, salinity and sugar yield. A relatively new *Erianthus* species recently being used in trait specific germplasm development was *E. procerus* and 35 backcrosses were made using BC_1 progenies involving the species. Fifteen superior intergeneric hybrid derivatives were of commercial status and were promoted to PZVT.

Under the research area on sugarcane genomics and molecular markers, different characters were addressed. Gene discovery and regulation by micro RNAs in *Erianthus* sp. and *Saccharum spontaneum* for oxidative stress tolerance in light of climate change was concluded. The co-expressed stress responsive miRNAs in the wild and cultivated sugarcane cultivars were grouped into nine clusters. Three miRNA families involved in sucrose metabolism were identified in *S. spontaneum.* Validation of differentially expressed *miRNA* based on expression profiles obtained using RT-PCR showed similar expression profiles with that of the NGS in six *miRNAs. NAC* genes expression profiles showed upregulation and downregulation for different NAC genes in Co 86032, *E. arundinaceus* and *S. spontaneum. C*onstruction of CRISPR – CAS vector was done for genome editing for altering the flowering behaviour of sugarcane. Another study was initiated to validate CRISPR/ Cas9 mediated gene editing by targeting *Phytoene Desaturase* (PDS) gene and four guide RNA constructs were prepared and genetic transformation was in progress. Functional genomics approach to decipher molecular mechanism regulating tillering was also initiated and the study so far showed significant variation in expression profiles of strigolactone branching inhibitor gene (MAX) among high tillering and low tillering genotypes.

Transcriptome guided mining and validation of genes, miRNAs and their potential targets for water deficit stress was in progress. Transcript levels of differentially expressed genes at all stages of drought and recovery in the tolerant and susceptible cultivar were studied. Import- ant genes with significant upregulation and downregulation as well as miRNAs that are abundantly expressed on the tolerant and sus- ceptible cultivars were identified. There were 145 miRNAs that were differentially expressed in susceptible variety and 143 miRNAs in the tolerant variety. Identification of isoforms and transcript variants of sucrose regulating genes and characterization of genes associated with high Water Use Efficiency were also on.

Under genomic selection for important traits in sugarcane, and comparison of elite Indian and Australian germplasm, phenotyping of the populations for red rot, drought and sucrose were completed and heritability values worked out and were found suitable for employing genomic selection. The genotyping of 640 clones yielded 15,040 SNPs as single dose markers. All the genotyped clones were subjected to develop genomic selection / prediction models. Bayes A and Bayes B models showed significant SNPs for the sucrose and red rot traits.

A Genotype by Sequencing (GBS) panel of 96 *Erianthus* germplasm was constructed based on the data obtained from *Erianthus* genetic diversity and the drought phenotyping data. After mapping the SNP variations were analysed in the sequence and about 50,000 to 1,60,000 SNPs were detected in each sample. Further a candidate gene RTCS (Rootless concerning Crown and Seminal roots), a member of the LOB domain transcription factors, which is a key regulator of shoot borne root initiation was characterized from *E. arundinaceus.*

Isolation, cloning and characterisation of novel stem specific promoter from *Erianthus arundina- ceus* came out with *Erianthus* (*EriPht*) promot- er with constitutive expression. Deletion con- structs are developed for root specificity and D2, D3 and D5 constructs were used in genetic trans- formation and To transgenics were developed. *S. spontaneum* was again targeted for salinity stress tolerance and the accession IND16-1762

was chosen for molecular profiling of salinity stress responsive genes. A total of 21genes/transcription factors representing three gene families such as salinity responsive genes, cell wall related genes, and other abiotic stress signaling genes registered higher fold change during stress. The glutathione pathway along with the SOS pathway were the prominent pathway induced with key gene player (SOS, Gly 1, RAB and NHX) induced during salinity stress in *S. spontaneum.*

The comparative salinity stress transcriptome and small RNA sequencing in stressed and unstressed root samples of salt sensitive cultivar Co 97010 and salt tolerant *Erianthus arundinaceus* IND99-907 showed highly expressed miRNAs and their corresponding differentially expressed gene targets.

Development of white grub (*Holotrichia serrata*) resistance in sugarcane by deploying novel Cry toxin holotype genes is a new initiative. Cloning and expression of cry8 toxin (cry8Sa1 and cry8Ib) genes in cry negative strains is under way. Employing a proteomic approach, identification of new ligninolytic enzymes for improved sugarcane bagasse delignification was initiated using sugarcane clones varying in lignin content and tested with lignin degrading microbial cultures under specific lab conditions. In all, 19 fungal strains could grow in minimal medium enriched with sugarcane or *Erianthus* baggase and were used for further studies.

Novel application of sugarcane vacuolar targeting technology for recombinant protein is in progress with collaboration with a Startup Company with the financial support of DBT-BIRAC, New Delhi using three genes *viz.,* Glucocerebrosidase (GCS), Insulin and Interferon (*Ifn2A*). Co 86032 was used in genetic transformation and calli were in different stages of selection.

Standardization of true seed production technique through developing homozygous parental lines and apomixes is in progress since 2016. Successive selfing is a major approach. Marker assisted selection among the selected inbreds to be used as parental lines for developing hybrid population was carried out to select inbreds with minimum heterozygosity. Accordingly, 14 inbreds were identified during the period of which, a sixth generation self, 1148-13-11-2-237-2-61, exhibited maximum homozygosity. This was used in crossing with two S6 generation selfs. Least segregation in cane characteristics was observed in the crossed population. In contrast its selfs (S7) exhibited high inbreeding depression. The extent of hybrid vigour will be quantified at harvest. More selfs developed during the year were subjected to STRUCTURE analysis and identified selfs with less gene flow and less heterozygosity index. In all 20 selfs were used for further selfing and intercrossing to study the extent of uniformity and vigour in the progeny. Putative anther derived plants from Co 86032 showed that plants derived from two calli were phenotypically distinct from Co 86032 with reduced vigour and cytological and molecular characterizations are in progress to confirm their ploidy. Identification of CENH3 mutation and polymorphisms in heteroduplex DNA of the EMS treated mutants of Co 775 progressed. Among 12 mutants, cleaved bands were observed in five mutants and these are field planted for verifying mutation within the gene. Wide hybridization and apomixes are also attempted with less success so far. Extent of variability in the hybrids of intermated inbred progenies showed least variability in the combination S6 x S6 (1148-13-11-2-242-2-61x 1148-13-11-2-242-3-272). The progenies from two crosses *viz*., Co 99008 x CoPant 97222, Co 8371 x CoVC 14061 had more than 80% individuals exhibiting similar stalk colour as the parents.

For defuzzing the fluff, a prototype model of a brush-operated sugarcane seed defuzzing machine was fabricated in collaboration with ICAR - CIAE Regional Centre, Coimbatore. Rotating, circular nylon brushes were deployed for defuzzing and oscillating sieves for seed cleaning. The seed recovery ranged from 50-70% and no reduction in seed germination has been noticed as compared to seed fluff.

Under Breeder seed production, maintenance breeding and multiplication of nucleus clones of varieties in seed chain (Co 86032, Co 0212, Co 09004 and Co 11015). Breeder seed multiplication was taken up from micropropagated plantlets using the initial source of the tissue culture

plants. About 124.5 tons of breeder seed thus produced have been supplied to the selected farmers to undertake the quality seed production during July 2020. Farmers' participatory quality seed production was implemented effectively. Based on the seed requests, about 1200 tons of quality seed production was targeted for supply and was supplied as per allotments received from Directorate of Sugar, Government of Tamil Nadu. The 2020-21 indent was about 1500 tons of quality seed under subsidy scheme of NADP, Government of Tamil Nadu and seed production was in about 38 acres for supply during February 2021. Co 11015 Field day was held on Jan 29, 2020. A total of 1,62,275 tissue culture plants were produced and supplied an amount of Rs.16,22,750 has been generated through supply of tissue culture seedlings and Rs. 1,75,000 through supply of 70 mother culture flasks.

Crop Production

The hydroponically grown plants of sugarcane inoculated with microbes recorded higher root and shoot biomass. Significantly higher biomass was recorded by *Gluconacetobacter diazotrophicus* (Pal-5), *Azospirillum brasilense (KACC 13364), Acetobacter spp., (SBI-ACE-01)* compared in both Co 09004 and Co 86032. HPLC analysis of root exudates indicated the presence of phenolic acids, organic acids and phytohormones. *Beijerinckia* was found to record significantly higher germination of 69.5% and 66.5% (single bud and chip bud) respectively when 12 months old sugarcane was used.

Design and Development of manually operated EPN (Entomopathogenic nematode) applicator. Conceptual design and fabrication of mini tractor operated EPN applicator. Testing and evaluation of ICAR-IISR, Lucknow developed machineries viz., IISR model disc type ratoon management device and IISR Two row deep furrow sugarcane cutter planter is being tested for their suitability under tropical condition has been started at ICAR-SBI, Coimbatore.

Paddy (Var. Co 51) has been cultivated and harvested with a yield of 5.75 t/ha during samba season in the Sugarcane Based Farming System. Field result of the trial conducted at ICAR-SBI, Coimbatore under tropical Indian conditions revealed that elite sugarcane genotype Co 13008 (134.00 t/ha) and Co 13020 (133.62 t/ha) with 100 % RDF (280:62.5:120 kg NPK) application performed better than the other elite sugarcane genotype under testing. Amongst the planting materials, True Seed Seedling recorded the highest B: C ratio of 1.58 and recorded on par cane yield with bud chip settling and two budded setts.

Early post emergence application of metribuzin @ 1.25 kg a.i. ha^{-1} at ten days after planting followed by post-emergence application of herbicides like topramezone @ 29.4 g a.i. ha^{-1} + atrazine 656.25 g a.i. ha^{-1} or halosulfuron 67.5 g a.i. ha^{-1}+ metribuzin 750 g a.i. ha^{-1} or tembotrione 120 g a.i. ha^{-1}+ atrazine 656.25 g a.i. ha^{-1} at 65 days after planting were comparable with three hand weeding and recorded higher sugarcane yield, better weed control efficiency, net returns and BC ratio. For weed management in sugarcane planted with setts, seedling and settling, the treatment hand weeding at 30, 60, and 90 days after planting recorded the higher cane yield of 137.04 t/ha with the weed con- trol efficiency of 91.98 and 81.28% at 45 and 120 days after planting, respectively. The early post emergence spray of Topramezone + Atrazine followed by hand weeding at 80 DAP was also found effective in managing the weeds and recorded 133.63 t/ha cane yield which was comparable with the EPOE (early post emergence) spray of Tembotrione + Atrazine followed by one hand weeding at 80 DAP (131.43).

Six technologies, the liquid jaggery technology commercialized by ICAR-SBI and other five will be taken up by Agrinnovate India Limited. Licensed the Soil Moisture Indicator technology to five firms, EPN biopesticide formulation to three firms, liquid jaggery technology to five firms and Two Row Tractor drawn mechanical planter to one firm. In total a revenue of Rs. 19,83,782/- has been realised through commercialization of ICAR-SBI technologies.

Chlorophyll SPAD index reduced by 18% 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 &I). 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 unlikeCo hybrids. Cane yield (Year 2021) at harvest reduced by 18% and 24% in I^1 and I^2 as against I^0. Cane yield varied from 53t/ha (Co 0212) to 158t/ha (Co 12009) with a mean of 93.3t/ha in control (I0). In 50% volume restriction irrigation it varied from 53t/ha (Co 62175) to 116.7t/ha (Co 14002) and in I^2 it varied from 54t/ha (Co 62175) to 93.5t/ha (Co 15021) with a mean of 70.4t/ha. Reduction in cane yield was 17.7% and 24.4% in I^1 and I^2 respectively over I0. Among the co hybrids, Co 12009, Co 14002, Co15015, Co15018 and Co 15021 performed better in both the restriction irrigation treatments.

Partitioning efficiency towards economic sink (stem) was high in varieties of tropical group (78.43%) compared to the sub-tropical group (74.45%).

Under 90 cm spacing and 75 cm spacing, the Co 86249 and Co 62175 was recorded with better dry matter production along with light interception at grand growth phase, while under the 150cm row to row spacing the Co 86032 registered better biomass. Significant differences in light interception was observed between different spacing i.e. the clones planted in narrow spacing was recorded with more light interception than other two spacing, while the 150cm was observed with less light interception.

Increasing N levels significantly affected SPAD index, plant height, number of tillers, leaf area, shoot dry weight, root volume, root dry weight, root-to-shoot ratio and total biomass, but not root depth. With increasing N, SPAD chlorophyll index, leaf area and shoot height varied from 18.6 to 38.1, 181.9 to 548.8 cm^2 and 36.7 to 94.9 cm, respectively. Similarly, P nutrition had a significant effect on all recorded traits except root-to-shoot ratio. With increasing P levels, SPAD index, leaf area and shoot height ranged between 41.0 to 32.0, 119.4 to 548.8 cm^2 and 48.2 to 95.6 cm, respectively. Influence of K was significant on all traits except number of tillers, root depth, root volume and root-to- shoot ratio. With increasing K levels, SPAD index, leaf area and shoot height varied from 28.3 to 33.3, 122.0 to 536.8 cm^2 and 57.4 to 91.3 cm, respectively. Deficiencies of macronutrients significantly reduced shoot dry weight which varied from 2.20 to 23.27 g, 3.96 to 18.03 g and 3.68 to 18.44 g in response to increasing levels of N, P and K, respectively. With increasing levels of N, the root-to-shoot ratio on dry weight basis ranged between 0.226 to 0.201.

S. officinarum clones were thick canes, with high single cane weight and superior in terms of sucrose metabolising enzymes. It showed moderately developed root morphology, with highest cortex-to-stele ratio and least number of metaxylem elements. *S. barberi* clones had moderately developed root system whichalso reflected as least leaf area and biomass accumulation, and yield attributing traits such as cane thickness, height, internode number and length. *S. spontaneum* clones showed deep rooted morphology with thin roots, least cortex- to-stele ratio in the formative stage, but high root volume at grand growth stage. It also put forth thin canes with long internodes and least single cane weight. *E. arundinaceus* and *E. bengalensis* clones and inter-generic hybrid of *S. robustum* and *Bambusa spp*. exhibited superior root morphology and anatomical features, with least cortex-to-stele ratio and more metaxylem elements. Biomass accumulation in leaf and sheath was high, with mediocre single cane weight.

Post-emergence application of Halosulfuron Methyl 75% WG and Metribuzin 70% WP at the rate of 67.5 g and 1000 g a.i. per hectare on 42 days after planting (DAP) observed that lower leaves of some of the genotypes were found to show injuries on 5 days after spraying (DAS). Phytotoxicity was recorded in visual scoring scale of 0 to 10 at 7, 15, 21 and 30 DAS. Phytotoxicity rating of the 31 genotypes studied ranged between 0 and 4. Nine genotypes showed no visual injury and found tolerant, while eight genotypes showed moderate toxic effect (rating 4). All the genotypes (14 nos.) that showed phytotoxicity rating of 1 to 3 recovered visually (leaf injuries) except Co 06027 at 30 DAS, while all the genotypes that showed moderate phytotoxicity did not recover completely except Co 94008. The genotypes with Co 7201 and Co

775 as one of the parents showed phytotoxicity rating ranging from 1 to 4. The genotypes, Co 06030, Co 86032, Co 11015, Co 92005 and Co 09004 did not exhibit phytotoxicity symptoms, while their parent, CoC 671 exhibited phytotoxicity.

The average CO_2 flux before planting (dry) and 3 DAP (moist) was 2.4 and 14.68 µM/ m2/s, respectively. NMC differed significantly (p=0.05) among genotypes while CO_2 flux, soil pH, EC and SOC did not differ significantly.

Soil inference system (SIS) software with soil constraint identification and management measures was developed in Microsoft Visual Studio Professional 2017 in C#. Management measures for subsurface hardening, sulphur nutrition and calcareousness were incorporated apart from regular nutrient recommendations and problem soil management measures in the SIS software. The developed SIS software provides soil health card with soil constraint management and nutrient recommendations in Tamil.

The second ratoon crop, cane height, cane diameter, number of internodes, single cane weight, number of millable canes, cane yield and CCS yield did not differ significantly (p=0.05) among intercropping treatments and the mean values are 183.98 cm, 27.74 mm, 20, 1.11 kg, 85036/ha, 93.22 t/ha and 12.14 t/ha, respectively at 270 DARI. The intercropping did not affect significantly the juice quality and the mean Brix, sucrose, purity and CCS was 20.91%, 18.67%, 89.28% and 12.14%, respectively at 270 DARI. The soil samples analysis revealed that ridges (0.78%) had higher SOC than the furrows (0.57%). Among intercropping, black gram treatment (0.74%) showed higher SOC than others.

Base temperature for flowering in individual clone was estimated by minimum absolute deviation in GDD between flowering seasons 2019 and 2020 where a range of base temperature from 1 to 39 °C was used to calculate GDD. Among the flowering clones thirty-nine had the base temperature for flowering between 15-20 °C. Among the flowering sugarcane clones, 3.5, 6.4,9.4,22.8,5.3,4.7,7 and 1.2 per cent clones had the base temperature range <5, 5-10, 10-15, 15-20, 20-25, 25-30, 30-35 and >35 °C, respectively. There about 68 clones for which the base temperature was not able to estimate by this method. Fifty six clones did not respond to the variation in base temperature which included mostly regular and intensive flowerers. About 12 clones mostly of tropical showed flat response to base temperature variation. Amid the clones which responded to the base temperature, highest number of clones (21) were in the range around 20 °C. Around 25 % of the clones responded to the base temperature variation below 20 °C and another 25 % were above 20 °C. The clones originated from subtropical region were mostly concentrated on either in most responsive base temperature category of 20 °C or in the category nonresponsive to variation in base temperature.

In the study to standardize nutrient management package for Co 11015 observed that the juice quality at 300 DAP did not vary significantly among treatments and the mean Brix, sucrose, purity and CCS per cent were 22.39, 20.73, 92.60 and 14.65, respectively. Significant positive correlation between total chlorophyll content and the SPAD Value was observed and the second order polynomial equation fitted well (R^2 = 0.6255) and SPAD Value can be used to predict the chlorophyll content. The nutrient treatments showed differential flowering behaviour.

Liquid jaggery prepared by incorporating amla juice (*Phyllanthus emblica*) in sugarcane juice showed difficulty in clarification for the analysis of sucrose content polarimetrically. The sample added with amla juice @ 112 g/kg or more produced turbid filtrate. Liquid jaggery was prepared using sugarcane juice with the different levels of amla juice addition. Analysed the liquid jaggery for Brix, sucrose and reducing sugar (RS) content at 0 and 30 days of storage (DoS). The sucrose content was found to decrease and the reducing sugars to increase over 30 DoS. It is concluded that adjusting the pH is essential to determine sucrose content of the liquid jaggery incorporated with amla juice 11%w/w or more. About 450 kg of jaggery were produced on various lots of sugarcane juice. Two recipes, i.e. Badam jaggery and Grape juice jaggery were standardised from sugarcane juice on lab scale for upscaling of the methodology.

Crop Protection

About 3061 clones from different trials of Crop Improvement Division comprising clonal trials, PZVT, elite hybrids, parental clones from NHG, allied genera, inbreds, genetic stocks etc. were screened for red rot resistance under controlled conditions against CF06 (*Cf*671) pathotype and identified ~1524 resistant clones.

Yellow leaf severity on various germplasm and parental lines was observed and most of the *Saccharum* spp clones were apparently free from the disease. In NHG, 18.63% of the parental clones exhibited YL incidence.

Field tolerance to red rot was assessed involving 11 varieties varying in red rot resistance and 12 fungal isolates with different virulence spectrum. Most of the isolates caused reduction in sprouting of buds and on an average, maximum disease incidence was recorded in Co 94012, followed by Co 6304, CoC 671 and Co 86032. All these varieties except Co 6304 were infected by all the isolates and caused disease to varying proportions.

Impact of YLD on various morpho-physiological and yield parameters assessed in the field trials revealed significant reductions in sett germination. RT-qPCR assays showed a multi-fold virus titre in the symptomatic plants and over the generations, the virus titre increased in the virus-free plants. Overall, aphid colonization during this year was low during this season and among the test varieties.

A critical analysis of the role of sugarcane microRNAs during compatible and incompatible interactions by adopting NGS platform revealed the role of sugarcane miRNAs and their target genes during sugarcane - *C. falcatum* interaction and provided new insight into the miRNA mediated defence mechanism in sugarcane.

Preliminary results of evaluation of field efficacy of Nano formulations of Benzothiadiazole (BTH) and Salicylic acid (SA) clearly indicated that the nano formulations of SAR inducer molecules, particularly the BTH nano formulation is consistently highly effective in inducing the host resistance of sugarcane crop against red rot, smut and wilt diseases.

Epidemiology studies on wilt incidence indicated that the disease started from three month onwards and progressed to highest incidence by 5 to 6 months. Soil borne inoculum reduced germination and crop stand in the plots. However, wilt development from the soil inoculum was not severe during the season like sett borne infections in the plots.

Mechanized fungicide treatment (Propiconazole; 0.4 ml/L; 250 mm Hg, 15 min) in the wilted setts showed an improvement in bud germination in four of the six varieties and better crop stand in two varieties and also improved various morpho-metric parameters in the treated plots as compared to the control plots.

SCGS phytoplasma causing grassy shoot in sugarcane was subjected to histo-pathological analysis employing scanning electron microscope. The SCGS phytoplasma appeared like oval/ spherical bodies arranged in chain of beads in phloem sieve tubes and cell division of phytoplasma by budding was observed in nearby phloem regions.

Persistence of fungicide in setts by mechanized sett treatment corroborates with the previous finding on the efficacy of thiophanate methyl in protecting the setts against soil borne inoculum of red rot till 90 DAP.

An improvised sett treatment device was fabricated with a provision of hot water treatment, with agitation and suitable sensors to ensure uniform treatment to manage SCGS phytoplasma and ratoon stunting bacteria, besides fungal diseases. Results indicated that the inactivation of the non-fungal pathogens by heat treatment was transient hence the technology development process is to be continued to focus on the physical elimination of the target pathogens.

Recombinant SCMV and SCYLV coat protein expression was carried out to develop polyclonal antibody (pAb) for the respective viruses. Results indicated that coat proteins (CPs) were induced at large scale and the crude proteins were extracted in the form of inclusion bodies (IB) and further purified by Ni-NTA agarose (resin) based affinity chromatography. Both the SCMV and SCYLV purified viral proteins will be used

for the polyclonal antibody (pAb) production in mammalian system.

Maize yellow mosaic virus (MaYMV) (*Polerovirus*; *Luteoviridae*), a new virus infecting sugarcane was confirmed by RT-PCR assay. Infection of SCYLV was confirmed in sorghum and maize samples, which is in line with the prevalence of sugarcane viruses on its closely related host species.

Whole transcriptome sequencing was carried out to decipher the transcriptome of two *Sporisorium scitamineum* isolates varying distinctly in their virulence pattern by RNA-seq analysis employing Next generation sequencing technology. Approximately 324 million reads (97 GB) and 653 million reads (196 GB) were generated in total for *in vitro* and *in planta* samples, respectively.

GFP-tagged *S. scitamineum* in sugarcane facilitated the demonstration of the infection process in a susceptible variety, Co 97009, enabling precise and direct detection of distinct stages of *in planta* colonization.

Molecular analysis to study variability in *S. scitamineum* isolates using SRAP markers indicated distinct grouping of the isolates based on their phenotypic behaviour.

A custom-made pCAMBIA1302 binary vector was constructed with the insertion of GFP gene to validate potential candidate apoplastic proteins screened from comparative proteomics study.

As part of *in planta* localization of CfEPL1 & CfPDIP1, the candidate genes together with their native signal peptide coding sequence were cloned into pCAMBIA1302 binary vector to conduct agroinfiltration and transient expression in *Nicotiana tabacum*. Results indicated the fusion proteins- EPL1:GFP and PDIP1:GFP confined external to cytoplasm, whereas pCAMBIA1302_GFP (empty vector control) was found to be localized in nucleus and cytoplasm. The result corroborates with the predicted apoplastic nature of *Cf*EPL1 and *Cf*PDIP1 using the *in silico* tool, Apoplast P v 1.0.1.

A novel protocol was developed for isolationof protoplasts from germinating conidia and high efficiency transformation of constructs in *C. falcatum* pathotype *Cf*671. PEG mediated transformation of protoplasts was carried out using *E. coli-Aspergillus* shuttle vector, pAsp and the veracity of hygromycin-resistant transformants was confirmed by fluorescence of GFP under fluorescent microscope.

Molecular confirmation of the developed gene mutagenesis vectors (*Cf*EPL1 and *Cf*PDIP1) was carried out by restriction digestion, and PCR using hygromycin gene (HPTII) and gene_UFR _DFR sequence specific primers. To study PTI/ETI mediated immune responses of *Cf*EPL1/*Cf*PDIP1 in sugarcane, a novel dexamethasone-based inducible vector, pC1302DEX was constructed and its chemical inducibility for GFP expression was assessed by agroinfiltration in *N. tabacum*.

Results of genomic variability of SCBV from germplasm samples revealed more than 85% identity to SCBV-BRU and SCBV-BO91 from India, SCBV-CHN2 from China, and SCBV-IM genome from Australia.

Two *Trichoderma* isolates viz., *T. harzianum* and *T. aureoviride* were selected for the extraction of intra-cellular and extra-cellular metabolites for biosynthesis of nano-particles, which will be used in the Biogenesis of nanomaterials for the management of red rot disease in sugarcane.

As part of the Virus indexing service, about 677 tissue culture raised plants from different tissue culture production units viz., M/s EID Parry, Pugalur, M/s RSCL, Theni and ICAR-SBI tissue culture lab were indexed for SCYLV, SCMV, SCSMV and grassy shoot phytoplasmas by following SOPs. A revenue of Rs 1,28,900/- was generated under virus indexing charges from the private tissue culture labs.

Yield loss assessment due to internode borer (INB) attack indicated that only three generations of borer attack cause significant loss.

Out of 20 red-fleshed *Saccharum robustum* clones screened under field conditions for resistance against INB, the genotypes GUK14-836 and GUK14-129 were found to be least susceptible.

Among eight *Erianthus arundinaceus* genotypes identified as resistant to shoot borer (SB) in field screening, lowest larval and pupal survival was recorded in the genotypes IJ 76 370, IK 76 78 and IJ 76 364 in the lab.

In an augmentative field trial with *Telenomus* sp. at a dosage equivalent of 4500/ha, INB incidence and intensity were considerably lower in release plot than in control plot 30 d after release.

For economizing mass culture 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%) comparable with 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.

Mass production techniques for *Aschersonia placenta,* an EPF on whitefly, were standardized and the growth and spore production on SBI medium at both concentrations (10 and 15%) were comparable with standard mediums available.

In pot culture experiments with various combinations of *B. brongniartii, B. bassiana, M. anispliae, Heterorhabditis indica*, *Steinermea glaseri* and six selected insecticides at field recommended dose, EPFs showed high mortality rates of white grub.

The full length sequence of two *cry* genes, *viz. cry1D* and *cry1E* isolated from the *Bacillus thuringiensis* isolate SBI-KK27 after cloning was found to be 3501 and 3531 bp respectively.

Analysis of the whole genome sequence of SBI-Bt41 revealed the presence of a novel *cry8* gene and SBI-Bt721 had the presence of a full length *cry3* gene. Similarly, another Bt isolate SBI-M6 was found to harbor a new holotype *cry 66* gene whose function is yet unknown.

DNA barcodes developed for *Chilo infuscatellus*, *Scirpophaga excerptalis*, *Sesamia inferens*, *Proutista moesta*, *Pyrilla perpusilla*, *Melanaphis sacchari*, *Tetraneura javensis, Neomaskellia bergii*, *Aleurolobus barodensis*, *Sturmiopsis inferens*, *Epiricania melanoleuca* and *Dipha aphidivora* were used to design primers for amplifying specific regions from the *COI* gene fragments. The target fragments were of 204 (*C. infuscatellus*) to 599 bp (*S. inferens*) in size.

Among fortified sugarcane juice with nitrogen supplements to enhance Bt62 spore production, maximum spores (6.12 x 10^{12} CFU/ml) was obtained in yeast extract followed by calcium chloride (3.50 x 10^{12} CFU/ml).

For standardizing large scale production of Bt 62, the bacterium was multiplied on the standard T3 media and molasses 3% in seed fermentor. T3 media produced higher bacterial population than molasses.

Mass production of four *Steinernema* spp. was attempted in monoxenic liquid culturing and successful nematode mass production was observed in the liquid media.

Shelf life studies of novel talc formulation of 15 EPN (seven *Heterorhabditis* spp. and eight *Steinernema* spp.) stored at 22-25 °C was evaluated against *Galleria* larvae All EPN caused 100% mortality of *Galleria* larvae at 8th month storage and at 10th month 10 EPN recorded 100 % mortality of *Galleria* larvae. At 12th month, three EPN recorded maximum shelf life of 100%.

Shelf life of novel talc formulation of fifteen EPN (seven *Heterorhabditis* spp and eight *Steinernema* spp) isolates stored at 22-25 °C was evaluated against 2nd instar white grub. All EPN caused 100% mortality of white grub at 6th month storage. *S. glaseri* caused 100% mortality till 12 months.

Survey was conducted in fall army worm (FAW) infested fields of maize and sugarcane from different districts of Tamil Nadu and fourteen numbers of EPN naturally occurring in maize fields were isolated.

Newly isolated EPN populations from FAW fields were subjected to the series of bioassays and it was found that isolate 5 (*Steinernema siam-kayai*), isolate 7 (*Heterorhabditis indica*), isolate 13 (*H. bacteriophora*) and *S. glaseri* were identified as superior in causing mortality of FAW.

The ICAR-SBI EPN Biopesticide formulation technology has been commercialized (Coordinated by AGRINNOVATE) with a license fee of Rs. 2,00,000/- to three biopesticide companies viz., M/s. T. Stanes & Company Ltd., Coimbatore; M/s.Varsha Agrotech, Vijayapura, Karnataka and M/s. Indigo Agro, Akola, Maharashtra.

ICAR-SBI Regional Centre, Karnal

Co 13035, a midlate maturing variety was gazette notified (No 3482 dt 07.10.2020) for commercial cultivation in NWZ (comprising central & western UP, Uttarakhand, Haryana, Punjab, Delhi and Rajasthan). Co 15023, an early maturing variety was identified in the 33rd biannual workshop of AICRP(S), held during 19-20 October 2020. The release proposal of the variety was approved in the 85th meeting of the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops held on 9 November 2020. Three Co canes viz., Co 20016 (early), Co 20017 (midlate), Co 20018 (midlate) for NWZ, whereas one i.e. Co 15023 (early), for NE & NC Zone were accepted for inclusion in ZVT trails in the 33rd biennial workshop of AICRP(S).

The seedling ground nursery comprising 4960 seedlings was winter ratooned during 3rd week of December 2020. Ninety (K18-01 to K18-90) ground nursery clones were selected and field transplanted for C1 evaluation along with four standards (Co 0238, CoJ 64, Co 05011 and CoS 767). Out of 494 first clonal selections (K16 series), 108 were advanced to preliminary trial. For sucrose% at 8 month crop stage entries K16-144 (19.65), K16-01 (18.34), K16-43 (17.91), K16-99 (17.86) and K16-475 (17.79) found promising over CoJ 64 (17.56), the best standard. In First clonal trial, the HR Brix of clones K17-001 (20.2%), K17-037 (19.7%) and K17-038 (19.4%) was comparatively higher than Co 0238 (19.1), the best standard. Considering cane yield, juice quality and red rot reaction, two early K14- 219 (Co 20015), K14-425 (Co 20016) and three midlate clones K14-352 (Co 20017), K14-410 (Co 20018) and K14-501 (Co 20019) were assigned Co number. In the factory trials Co 15023, wasthe best performing test entry for juice quality parameters at all the test locations *viz.,* Ajabapur, Rupapur, Hariyawan, Loni, Balrampur, Ramgarh, Yamunanagar and Daurala.

A total of 278 clones (C1, preliminary and PZVT clones) were evaluated for red rot resistance, 115 exhibited resistant/moderately resistant, 50 moderately susceptible and 113 susceptible/ highly susceptible reactions.

In the 'Co' canes evaluation trial, Co 15023 (21.37%), Co 17016 (21.21%), Co 14034 (20.84%), Co 0118 (20.44%), Co 0116 (20.22%) at 10th month, whereas Co 15023 (22.56%), Co 14034 (21.95%), Co 17015 (21.74%), Co 0116 (21.43%), Co 17016 (21.42%) at 12th month, were the top five performing entries for juice sucrose%.

The sugarcane germplasm tested under drought conditions, indicates 41% reduction for cane yield, but no significant reduction for cane quality. Entries Cavangerie, 14-50, 12 CBE and CL41-141 had least reduction (<10%) in cane yield under drought. In the 2020-21 experiment, (27 test entries), there was 22.39% reduction in the cane height under drought. The mean reduction in SPAD value for chlorophyll content was 11.36%. The normal conditions recorded more chlorophyll (43.21) than of the drought stress (37.84). The NMC population under normal and drought conditions was 1.07 lakhs/ ha and 0.91 lakhs/ha respectively. A reduction of 17.62% was observed for SCW under the drought. At 8th month, the HR Brix was higher under drought conditions (17.12%) compared to normal conditions (15.5%). Clones SA14-147, SA14-52, SA 14-49 produced higher number of millable canes (NMC) as well higher sucrose% under drought at 8th month.

Average plant population reduced up to 17.12, 34.98 and 47.94% under 4 dSm^{-1}, 8 dSm^{-1} and 10 dSm^{-1}, respectively. Minimum reduction was recorded in H49-104 (23.3%) followed by 14- 50 (24.4%), GU00-139 (25.8%) and Cavangerie (29.3%) while maximum reduction was recorded in Co 0238 (37.3%) and 51NG-163 (33.3%).

Co clones, Co 0238, Co 05011, Co 98014, Co 12029 and Co 15023 produced higher tillers and cane yield under water stress condition and showed lesser reduction in NMC, and SCW than the mean reduction for these traits. These clones exhibited the tolerance mechanism by maintaining better

Pn rate, RWC and chlorophyll content etc. or inherent capabilities to withstand water deficit at formative.

Among the 27 ISH clones evaluated, 16 found to be resistant /moderately resistant, six moderately susceptible and five susceptible/ highly susceptible reactions.

Identified 13 AVT genotypes and 26 ISH/IGH clones as least susceptible to black bug, early shoot borer, top borer and stalk borer.

In the 2019-20, AICRP experiments, combining cane yield and juice quality test entries Co 15025 (IVT IP), Co 15023 (AVT IP), Co 15027 (AVT IP), Co 14034 (AVT IIP & Ratoon) were the better entries under early, whereas CoS 16232 (IVT), Co 16030 (IVT) and CoS 16233 (IVT) were the better entries under midlate group.

Red rot pathotype CF11 found to be most virulent followed by CF01, CF02, CF08, CF07, CF09 and CF03, whereas, four new Cf 238 isolates were also expressed susceptibility on 8-10 host differentials. Red rot incidence was recorded up to 30.0% in the samples of variety Co 89003 of five sugar mills of Haryana and UP, whereas, smut, pokkah boeng and wilt diseases were prevalent in some of the popular sugarcane varieties grown in the zone.

Tetrasticus pyrillae identified as an egg parasitoid and *Epiricania melanoleuca* as nymph as well as adult parasitoid of *Pyrilla perpusilla. Isotima javensis* and *Stenobracon deesae* recorded as a larval parasitoids of top borer. *Cotesia flavipes* was found as larval cum pre pupal parasitoid of stalk borer. Severe incidence of top borer and blister mite was found during survey program.

Overnight soaking of sett with 200 and 500 ppm ethrel enhanced germination in cavity trays up to 30% and 19%, respectively as compared to un-treated control (5%) at 40 DAP during winter by modulating biochemical changes like increase in reducing sugar and acid invertase activities. However, exogenous application of different doses of ethrel *i.e.* 100, 200, 500 and 1000 ppm on stubble did not found effective for enhance-ment of winter sprouting in three varieties i.e. Co 0118, Co 0238 and Co 05011.

A total of 167 sub-tropical sugarcane reference varieties were field maintained, DUS descriptors of reference varieties were verified. The single budded setts of candidate variety Co 12029 along with reference varieties were raised in portray and 30 days old settling of candidate variety Co 12029 along with reference variety (Co 05011 and CoS 97264) were field transplanted in randomized block design.

A total of 34301.71 quintals seed cane of varieties Co 0118, Co 0238, and Co 12029 was supplied during the crop year 2019-20. From the sale of seed revenue worth Rs. 21,91,387/- was generated. A total of 180240 settlings of varieties Co 0118, Co 0238, Co 12029 were produced and sold to various stakeholders. During the autumn season (2020-21), a total of 10075.69 quintals breeder seed and 207395 numbers of settlings were produced and sold to various stakeholder. The licensing rights of Quatro Sugarcane Single Sett Cutter (QSSSC) machine was given to M/s Hanzra Engg Works, vill- Bansa, Karnal and royalty worth Rs 40,000/- was received from the firm. To promote STT, the entire area under sugarcane seed crop at ICAR-SBI, RC, Karnal was transplanted with the settlings using settling transplanter. For the production of quality seed material using STT, the MoU were signed between Director, ICAR- SBI, Coimbatore and ten sugar mills/groups. Nearly 10 farmer ICAR-SBI, RC, Karnal trained & motivated entrepreneurs produced around 8, 80,000 settlings and which were either self- utilized or supplied to other fellow farmers for planting in nearly 110 acres of area.

The farmers of the Karnal region were allowed to use implements purchased under RKVY *viz.*, Reverse rotary Rotavator, Sugarcane Trash Mulcher, Ratoon management device and two tyne reversible MB plough towards management of sugarcane trash, ratoon crop etc. Quatro Sugarcane Single Bud Cutters (10 Nos) were supplied to all the cooperative sugar mills of Haryana. Utilizing the plant growth chamber installed under RKVY seed project, nearly 70,000 settlings of variety Co 15023 were raised during peak winter. At 30 ^{0}C temperature and 90% relative humidity within 72 hrs germination started in the poly trays and the settlings attained ready to transplanting stage within 7-8 days. Sett roots showed negative geotropism growth

under darkness whereas positive geotropism growth under light condition in the plant growth chamber. The farmers of the region were advised to take various intercrops *viz.,* chickpea, carrot, garlic, radish, wheat, mustard, cabbage, potato etc. in autumn planted seed crop. The seed fields of village Kahangarh, Khudda Kalan, Kharkali, Barsalu, Budhanpur, Titavi, Santri, Rindal and Bal Pawana were monitored.

ICAR-SBI Research Centre, Kannur

The centre houses the world largest collection of sugarcane germplasm (3373 accession) which are maintained as field gene bank by annual replanting. The germplasm was monitored regularly for flowering, pests and diseases. 110 *Saccharum officinarum* clones are also maintained under *in vitro* condition to compliment fieldgene bank. 42 clones *S. barberi* and 30 clones of *S. sinense* were characterized for 31 morphological and yield and quality traits to understand the variability in the collection for different traits and to find duplicate collection if any by combining with molecular profiling. In a final clonal evaluation trial under waterlogged situation, 16 clones were evaluated and two clones WL16-457 and WL16-498 with significantly higher CCS yield coupled with red rot resistance were identified for PZVT.

Another 130 clones were evaluated in two replicated trials and the promising clones were advanced for further trials. 1270 progenies from 12 crosses were evaluated in ground nursery and 116 were selected for first clonal trial and 16 new crosses were attempted. Under the utilization of genetic resources for developing new genetic stocks, four clones (GUK 16-967 GUK 16-975, GUK 16-801 and GUK 16-917) with diverse genetic background were identified as genetic stock with higher or on par CCS yield compared to checks and GUK 16-967 was identified for PZVT. Another set of 82 clones were evaluated in two replicated trials and the promising clones were advanced to next trials. 556 seedlings form 5 crosses were evaluated in ground nursery 72 progenies were selected and 17 crosses including back crosses using diverse parental clones were attempted and fluff was harvested. In a study on harnessing antagonistic microbes for the management of wilt and rot diseases in sugarcane, sugarcane setts of Co86032 were treated with four PGPR cultures i.e. BC 23, PF 4, PF 60, BC 36 and bacterial consortia showed improved growth of sugarcane over control. Among the cultures and BC 36 followed by PF 60 improved the plant growth over other treatments.

On the study of evaluation of seasonal dynamics and biological control of sugarcane Pyrilla, the Pyrilla population abundance, comprisingnymphs and adults showed a resource concentration pattern with most abundant on *S. officinarum* and hybrids of Indian and foreign origin that are in high density crop patches, and least abundant on other crop assemblages *viz., S. robustum, S. sinense*, *S. barberi* that are in low density patches in the ecosystem. *P. perpusilla* has shown less host preference towards other wild sugarcane, *S. spontaneum* and sugarcane allied genera.

The attempt of isolating highly fastidious entomopathogenic fungus *Hirsutella sp.* infecting Pyrilla and culturing using SDAY media was successful. Production of mucilaginous colonies by *Hirsutella sp.* with numerous synnemata containing group of erect conidiophores was obtained.

ICAR-SBI Research Centre, Agali

Out of 1380 germplasm, 635 accessions (46.01%) came to flowering in 2020. The intensity of flowering was slightly higher than 2019 (44.28%). During 2020, nearly 65 clones of *S. officinarum,* six clones of *S. robustum,* six in each of *S. sinense* and *S. barberi* flowered. Flowers (opening of spikelets) began from 16th September 2020 and lasted up to 7th December 2020. 57 NG 174, Monget gayam, Naz, Otaheiti, LS 89-2064, Suphan-50, Sugar doctor, White transparent, are the early flowering clones (flowered during last week of Sept 2020). A total of 150 crosses were made during 2020 flowering season as per requests from Cuddalore, Locknow, Navsari, Pune, Padegeon, Pantnagr, Sankeshwar, and Shirohi centres.

A total of 233 reference varieties are being maintained clonally at Coimbatore and Agali centers respectively. DUS test for two farmers' varieties (FV) namely, Sugam Katari and Jeet Katari

and one new variety, Co 09004 was conducted during 2020-21 crop season.

Extension

The outreach programmes included eight state level training programs under National Food Security Mission, 12 one-day training programs, DSD sponsored one-day training program and National Science Day celebration.

The Institute participated in International Conference at Vasantdada Sugar Institute, Pune during 31 January to 2 February 2020 by putting up a stall depicting package of practices for sugarcane cultivation.

Entertained 2780 visitors to the Institute comprising students (2058), farmers (591) & cane development staff (131).

'Cane Adviser', an android mobile app on sugarcane containing information on state-wise sugarcane varieties, crop production technologies, crop protection technologies was made available in google playstore in three languages for free download. Total downloads were 11550 from 61 countries.

5. RESEARCH ACHIEVEMENTS

5.1 CROP IMPROVEMENT

5.1.1 BREEDING

New Varieties

Co 12009 [{(Co 7201 x (Co 62174 x SES 91) x Co 88037)}] x Co 62198, a midlate maturing variety has been notified in the 84th meeting of Central Sub-Committee on Crop Standards' Notification and release of varieties for cultivation in the States of Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, Kerala, Maharashtra, Madhya Pradesh, Tamil Nadu and Telengana of Peninsular Zone.

Co 11015 (Atulya) bred in this project was released and notified as a short duration sugarcane variety for commercial cultivation in Tamil Nadu. This variety is spreading in the state covering about 6200 acres and reported to yield better sugar recovery on an average of 1 unit.

Co 13013 (Akshaya) has been identified by the varietal Identification committee of AICRP (S) for release in Peninsular Zone for its improved cane and sugar yield over the ruling variety and standard Co 86032.

Genetic stocks

Co 13001 and Co 14016 have been registered with ICAR NBPGR as unique germplasm. Co 13001 is registered as a genetic stock of short duration nature with high sucrose at 240 days. Co 14016 is registered for its high cane population and ratoonability.

'Co' canes identified

Fourteen new Co cane from 2020 series have been identified and the performance of the selections is given in Table 4.

Table 4. Performance of 'Co' selections identified during 2020 at Coimbatore

'Co' Numbers	Parentage		CCS yield (t/ha)	Cane yield (t/ha)	Sucrose (%)		Red rot rating	
					360 days	300 days	Plug	Nodal
Co 20001	Co 86032 GC		21.85*	159.48*	19.45	17.75	R	R
Co 20002	Co 11019 x Co 06022		21.34	145.29	20.77	18.22	-	R
Co 20003	CP81-1384 x CoC 671		24.97*	167.98*	21.05	19.26	MR	R
Co 20004	Co 8371 x Co 94005		25.65*	182.76*	19.84	17.20	MR	R
Co 20005	ISH 100 x Co 8209		23.64*	160.52*	20.88	20.35	MS	R
Co 20006	Co 0320 x Co 99006		22.53*	162.47*	19.79	18.31	MR	R
Co 20007	Co 0240 x 2007-281		23.90*	161.52*	20.90	17.81	MS	R
Co 20008	Co 87044 x Co 06002		23.11*	162.87*	20.09	17.97	MR	R
Co 20009	Co 85002 x Co 8209		20.63	135.93	21.48	20.10	MR	R
Co 20010	Co 11015 GC		23.53*	167.68*	19.93	19.91	MR	R
Co 20011	Co 8353 x Co 94008		28.16*	191.46*	20.71	16.79	MS	R
Co 20012	98-210 x PIR 001057		28.57*	198.75*	20.59	18.82	MS	R
Genetic stocks								
Co 20013		Co 0240 x Co 12014	23.74	161.84	20.53	20.35	MS	S
Co 20014		Co 06022 GC	20.19	133.21	21.38	19.94	R	
Standards								
Co 86032			18.41	132.93	19.67	17.08		
CoC 671			14.15	94.73	21.08	20.04		

Co 99004		15.64	112.06	19.93	16.43		

'Co' Numbers	Parentage		CCS yield (t/ha)	Cane yield (t/ha)	Sucrose (%)		Red rot rating	
					360 days	300 days	Plug	Nodal
Co 09004			22.30	139.26	22.55	19.75		
CD			3.39	22.26	1.34	1.30		
CV			8.61	7.72	3.45	3.57		

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

Breeding sugarcane varieties for tropical region

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

Hybridization (2020 season)

Arrowing plot

A total of 291 parental clones comprising 161 Co canes, 65 Co allied canes, 19 foreign hybrids, 15 CYM clones, 9 ISH clones, 6 registered genetic stocks and 5 inbreds were planted in the arrowing plot for utilization during 2020. Flowering was observed during 3rd week of October 2020 in Co 13001 and Co 16001 and 88.54% clones flowered during 2020. At 10th month a total of 210 sugarcane parental clones were evaluated for cane traits including internode length and juice quality traits. Among the parental clones internode length ranged from 5.2 cm to 15.0 cm and sucrose content ranged from 13.1 % to 21.8%. A negative and non-significant correlation was observed between internode length and sucrose % (r= -0.041ns).

(K. Mohanraj and S. Sheelamary)

During the 2020 season, a total of 289 crosses were effected utilizing Co canes, Co allied canes, elite interspecific hybrids under ISH series, intergeneric hybrid derivatives, cytoplasmic diverse lines, genetic stocks with drought tolerant clones, red rot and smut resistant clones.

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

Ground nursery (2019 crosses)

Twenty five thousand seedlings from 125 crosses were transplanted in the ground nursery. Cross diversity index was estimated for 87 crosses having a minimum of 40 seedlings per cross. These crosses belonged to 17 diverse parental groups and resulted in a cross diversity index of 0.71 (Fig. 2). Eleven crosses *viz*., Co 11015 x Co

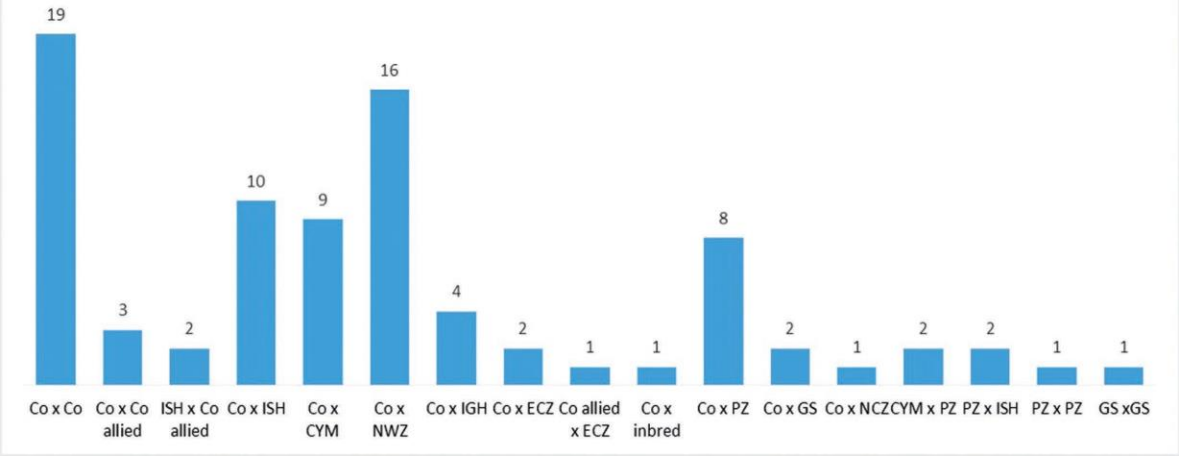


Fig. 2. Cross diversity index in ground nursry

12009, Co 06031 x Co 11015, Co 14002 x Co 97015, Co 98010 x Co 11015, Co 11015 x CoVc 14061, Co 11015 x CoH 119, Co 0240 x Co 0209, CoV 89101 x CoTl 14111, CoT 17366 x Co 12009 and CoV 89101 x Co 12009 had more than 500 seedlings in ground nursery. The ground nursery is ratooned to enable selection based on the performance of the seedlings in ratoon.

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

Ground nursery (2018 crosses)

Twenty thousand seedlings from 90 biparental crosses, four poly crosses and six GCs planted in the ground nursery was ratooned for studying the seedling performance in the ratoon stage for economic traits. Based on the performance in the plant crop, three crosses Co 16001 x Co 10033, Co 86032 x SP 80-185 and Co 86032 x Co 0238 were better for early high brix. Canes of crossCo 8371 x CoVc 14061 were thick types and the screening of the ground nursery was initiated for selection to I clonal trial.

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

I Clonal Trail

In all, 757 clones from 28 crosses were evaluated for NMC, cane thickness, cane height and HR Brix at 240 days. One hundred and seventy one clones had HR brix of >20.0 %, 96 clones were above 200 cm in cane height and 170 clones showed cane thickness more than 2.5 cm. Genotypes derived from crosses involving Co 11015, CoC 671, Co 86032, Co 08016 and CP 61-23 as one of the parents recorded early sucrose accumulation.

(A. Anna Durai and C. Appunu)

II Clonal Trial (Trial-1, 2019-20)

In this trial, 642 clones were evaluated for cane yield, juice quality and red rot reaction. Seventy superior clones were selected and promoted to PZVT. The crosses *viz*., Co 06010 x Co 11015 (5), Co 11015 x Co 0314 (4), Co 86032 x Co 85 R 186 (4), Co 8371 x Co 94005, Co 8371 x Co 11012, Co 0209 x ISH 69, CoM 0265 x Co 99006 (3), Co 86002 x Co 12014 (3) had more selections. Seven entries recorded more than 21% sucrose at 10th month and the clone 17-215 from the cross Co 87044 x Co 86011 recorded the highest sucrose of 21.60%. Out of 642 clones screened for red rot resistance in CCT, 32% of the clones were R and MR type.

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

II Clonal Trial (Trial-2)

In this trial, 822 entries were evaluated along with three standards in Augmented RCBD. At 240 days, 39 clones recorded juice sucrose above 18.0% and 19 clones recorded juice sucrose above 20.0 % in comparison with the quality standard CoC 671 (19.26 %). At 300 days, eight clones from the crosses Co 0403 x Co 99006, VSI 12021 x Co 11012, Co 0240 x Co 11012 and Co 11015 GC recorded more than 21.0 % sucrose. Maximum selections were obtained from 14 crosses mainly involving Co 11015, Co 0118, Co 8353, Co 8347 and CoC 671 as one of the parents. Two clones from the cross combination Co 0118 x Co 8353 and Co 10033 x Co Pant 97222 recorded > 22.0 % sucrose at 360 days. Among the entries, 315 were resistant/moderately resistant to red rot and 15 crosses produced more resistant progenies. A total of 81 clones with good field stand, yield and quality parameters were promoted to PZVT for further evaluation.

New planting

II Clonal Trial (Trial-1, 2020-21)

Five hundred and thirty one clones were planted in second clonal trial along with three standards. Maximum number of selections for the trial were obtained from the crosses *viz*., Co 11015 x Co 94008, Co 8371 and Co 12014, Co 86032 x Co 92008, Co 86011 x Co 97015 and Co - Se 93423, Co 99008 x Co 97015 and Co 0303, Co 98010 x SA 03-131, Co 8371 GC, BM 130110 x Co 0209, Co 86002 x AS 04-1689, Co 15002 x Co 97015, Co 10033 x Co - Pant 97222 and Co 86032 x CoN 10072.

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

II Clonal Trial (Trial-2, 2020-21)

Second clonal trial consisting of 624 clones along with three standards *viz*., Co 86032, Co 11015 and Co 0212 were planted in an augmented design. The test clones were selected based on juice quality and cane parameters at 12th month crop stage. The crosses Co 16018 PC (Co 0209,Co 0303, CoPant 97222) (37 selections), Co 86032 x Co 0238 (21), Co 15007 GC (21) and Co 86032 x Co 0209, Co 94008 (9) gave more selections. Based on the results obtained at 300 days, 24 clones have been identified to be promising with early high sucrose accumulation and superiority to the zonal standard Co 86032 (Table 5).

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

Pre-Zonal Varietal Trial (2019-20)

Sixty five test entries and four standards (Co 86032, Co 99004, Co 09004 and CoC 671) were evaluated in RBD with two replications. Fourteen Co canes (Co 20001 to 20014) were identified from the test entries. Among these, ten clones were significantly superior to Co 86032 for commercial sugar yield and cane yield. Co 20012 recorded the highest CCS yield of 28.57 t/ha followed by Co 20011 (28.16 t/ha), Co 20004

Table 5. Performance of clones in II Clonal Trial (Trial -2)

Clone No.	Parentage	Sucrose (%) (10m)	SCW (kg) (10m)	Reaction to red rot
2019-343	Co 11015 x Co 94008, Co 8371 and Co 12014	20.01	1.10	MS
2019-226	1148-13-11-2-251 x Co 62198	20.45	1.33	MR
17-437	(Co 740 x Co 2000 - 03) x Co 0209	20.38	1.12	MR
17-166	Co 11015 x Co 97015	20.51	1.20	MS
2018-22	CoC 671 x Co 775	20.60	1.32	MS
2018-34	CoC 671 x Co 775	20.00	0.92	MS
2018-69	2013-157GC	20.17	1.01	MS
2018-104	Co 11015 PC	20.56	1.02	MS
2018-131	Co 11015 PC	20.41	1.20	MR
2018-156	Co 08016	20.04	1.43	MS
2018-171	Co 15018GC	21.18	1.63	MR
2018-16	Co 0331x CoPant 97222	20.09	1.40	MS
2018-133	Co 86002 x Co 11012	20.32	1.01	MR
2018-84	Co 86032 x Co 0238	20.51	1.12	MS
2018-16	Co 86002 x Co 12014	20.13	1.55	MR
2018-117	Co 10033 x CoC 671	20.10	1.21	R
2018-248	Co 98010 x Co 0209	20.06	1.65	MR
2018-220	Co 12001 PC	21.12	1.14	MR
2018-61	CoM 0265GC	20.63	1.04	MR
2018-68	CoM 0265GC	20.55	1.52	MR
2018-125	Co 99006 x Co 06032	21.00	1.60	MS
2018-74	Co 14020 x Co 89003	20.65	1.06	MS

2018-9	2017-187 GC	21.09	1.10	MR

Clone No.	Parentage	Sucrose (%) (10m)	SCW (kg) (10m)	Reaction to red rot
2018-20	Co 11015 GC	20.00	0.86	MR
Agl2018-18	PZVT 2013-55 x PC	20.59	1.16	R
Agl2018-23	Co 14020 GC	20.71	1.38	MR
SDC2019-8	Co 16018 GC	21.33	1.51	MS
SDC2019-15	(Co 0118 x *S. spont*. SES 114) x Co 11015	21.48	1.50	MR

(25.64 t/ha), Co 20003 (24.97 t/ha) and Co 20007 (23.90 t/ha) than the better standard Co 86032 (18.41 t/ha). Co 20012 was the top yielder with the highest cane yield of 198.75 t/ha followed by Co 20011 with 191.46 t/ha, Co 20004 (182.76 t/ha) and Co 20003 (167.98 t/ha) in comparison to the best standard Co 86032 (132.93 t/ha).

At 300 days, CoC 671 was the best check with juice sucrose of 20.04 % followed by Co 09004 (19.75 %). Co 20005 recorded the highest sucrose of 20.35 % followed by Co 20009 (20.10 %) and Co 20010 (19.91 %). Two entries *viz*., Co 20009 and Co 20003 were significantly superior to Co 86032 with CCS and sucrose content of 13.85 % and 19.67% respectively at 360 days. Among the entries, 48 were R and 5 were S to red rot by nodal method of inoculation, while 29 entries were R/MR, 23 entries were MS and one was S by plug method. Two entries *viz*., Co 20013 and Co 20014 were identified as genetic stocks for utilization in breeding programmes. The identified Co canes involved parents *viz*., Co 0240, Co 11015, Co 11019, CP81-138, Co 06022, Co 8353 and ISH clones. Among the Co canes of 2020 series, Co 20001, Co 20002, Co 20003, Co 20005, Co 20006, Co 20007, Co 20009, Co 20010, Co 20010, Co 20011 and Co 20012 were promoted for AICRP testing in Peninsular zone.

(S. Alarmelu and A. Anna Durai)

Pre-Zonal Varietal Trial (2020-21)

The PZVT trial comprised of 43 test clones along with four standards (Co 86032, Co 0212, Co 09004 and Co 11015) in a randomised block design with two replications. The test clones were selected from the PZVT multiplication plot based on the yield and quality parameters at 10th month, red rot resistance and field stand. At 240 days, three entries were better than the best quality standard for sucrose content. At 360 days two entries recorded above 21% sucrose. The entries are being studied for growth parameters and flowering nature at different stages.

(G. Hemaprabha and V. Sreenivasa)

Multiplication of Pre-Zonal Varietal Trial (2020-21)

In the PZVT multiplication, 166 clones from Coimbatore and four clones from SBIRC, Kannur were planted in two rows with three checks (Co 86032, Co 09004, CoC 671). Hand refractometer brix and crop stand were recorded at 240 days and 49 entries combined better sucrose content, red rot resistance and good field stand.

(K. Mohanraj and H.K. Mahadevaswamy)

Screening for diseases

Forty five PZVT clones were evaluated for red rot resistance under field conditions by plug and nodal methods against CF06 inoculum. Among them 26 were identified as resistant in plug method and 43 as resistant in the nodal method.

(P. Malathi)

Smut

Totally, 45 PZVT entries were evaluated against sugarcane smut during the crop season 2020-21. Among the 45 entries, six entries *viz.,* 2019-5, 2019-44, 2019-69, 2019-85, 2019-106 and Co 15023 were identified as resistant, whereas three entries, *viz.,* 2019-25, 2019-50 and 2019-52 were identified as moderately resistant.

(A. Ramesh Sundar)

Botanical characterization and DNA Fingerprinting of elite selections and varieties

Botanical characterization of 14 'Co' canes developed during 2020 were described based on DUS guidelines.

DNA fingerprinting: DNA profiles of Co 13013 and Co 15023 which are identified as promising entries for release in peninsular zone and North Western zone through AICRP trails were generated. Fig. 3 shows the molecular profile

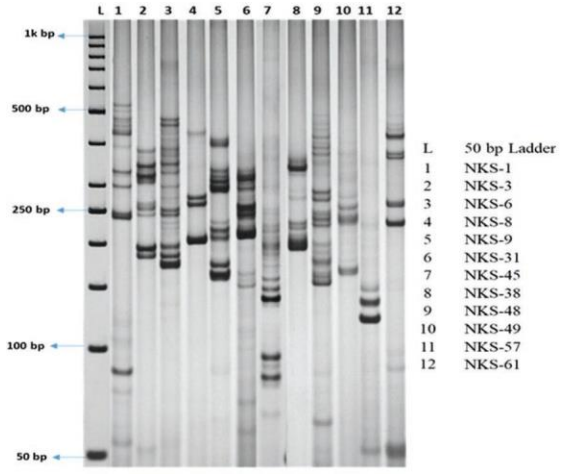


Fig. 3. Molecular profile of Co 13013 using STMS primers

of Co 13013. On payment basis DNA profiles of CoPb 14185, from PAU Regional Research Station, Faridkot and Si 6, Si 7 and Si 8 from TNAU Sugarcane Research Station, Sirugamani were generated during the current year.

(H.K. Mahadevaswamy and G. Hemaprabha)

Identification and testing of short duration sugarcane clones

To identify source of short duration high sugar clones a total of 350 clones including seven clones of *Saccharum robustum*, 19 *S. sinense*, 32 *S. barberi*, 38 *S. officinarum,* 152 parental clones maintained in arrowing plot and 102 selections maintained in clonal nurseries were evaluated for juice quality parameters at 8th month after planting. Among the species clones and parental clones, none qualified the criteria of short duration clones (>18% sucrose with >85% purity at 8th month). Two selections from clonal nursery (Agl 2018-4 and Agl 2018-35) showed 20.58% and 19.27% sucrose at 8th month. In addition, 56 perspective high sucrose clones identified by breeders of ICAR-SBI were multiplied during 2019-20 and a new trial was planted during Feb 2020.

(R. Karuppaiyan and G. Hemaprabha)

Evaluation of elite clones for identifying promising location specific sugarcane varieties

Maharashtra

Drought experiment: Fourteen drought tolerant clones and standard varieties (Co 86032 and CoM 0265) were evaluated in four sugar factory farms by imposing drought stress during formative phase. The pooled mean performance of two plant and one ratoon trials showed that 30.54 and 5.45 percent improvement in Co 85019 for cane over Co 86032 and CoM 0265 respectively. For sucrose content, Co 85019 recorded 7.81 and 1.46 percent improvement over CoM 0265 and Co 86032 respectively. Co 98017 recorded significantly superior cane yield of 118.34 t/ha and number of millable canes as compared to CoM 0265 under five-month long duration water stress at Kopargaon. Stay green of young leaves during stress period and dried tight clasping leaf sheaths during recovery was observed in Co 98017. BLUP based AMMI stability analysis showed that Co 85019 recorded the second lower values for genotypic selection index (GSI) for cane yield and sucrose content. BLUP based discriminativeness vs representativeness Biplots showed that Jalna centre for cane yield and, Kopargaon and Pune centres for sucrose contents were highly discriminative environments. Stability vs mean and Ranking of genotypes views GGE Biplots showed that superior of ranking for Co 85019 and Co 98017 for cane yield and, Co 0238 and Co 85019 for sucrose content. Therefore, Co 85019 and Co 98017 recorded significant improvement and stability for cane yield and sucrose content under formative phase drought stress over the better standards Co 86032 and CoM 0265 in Maharashtra (Fig. 4).

(C. Mahadevaiah and V. Sreenivasa)

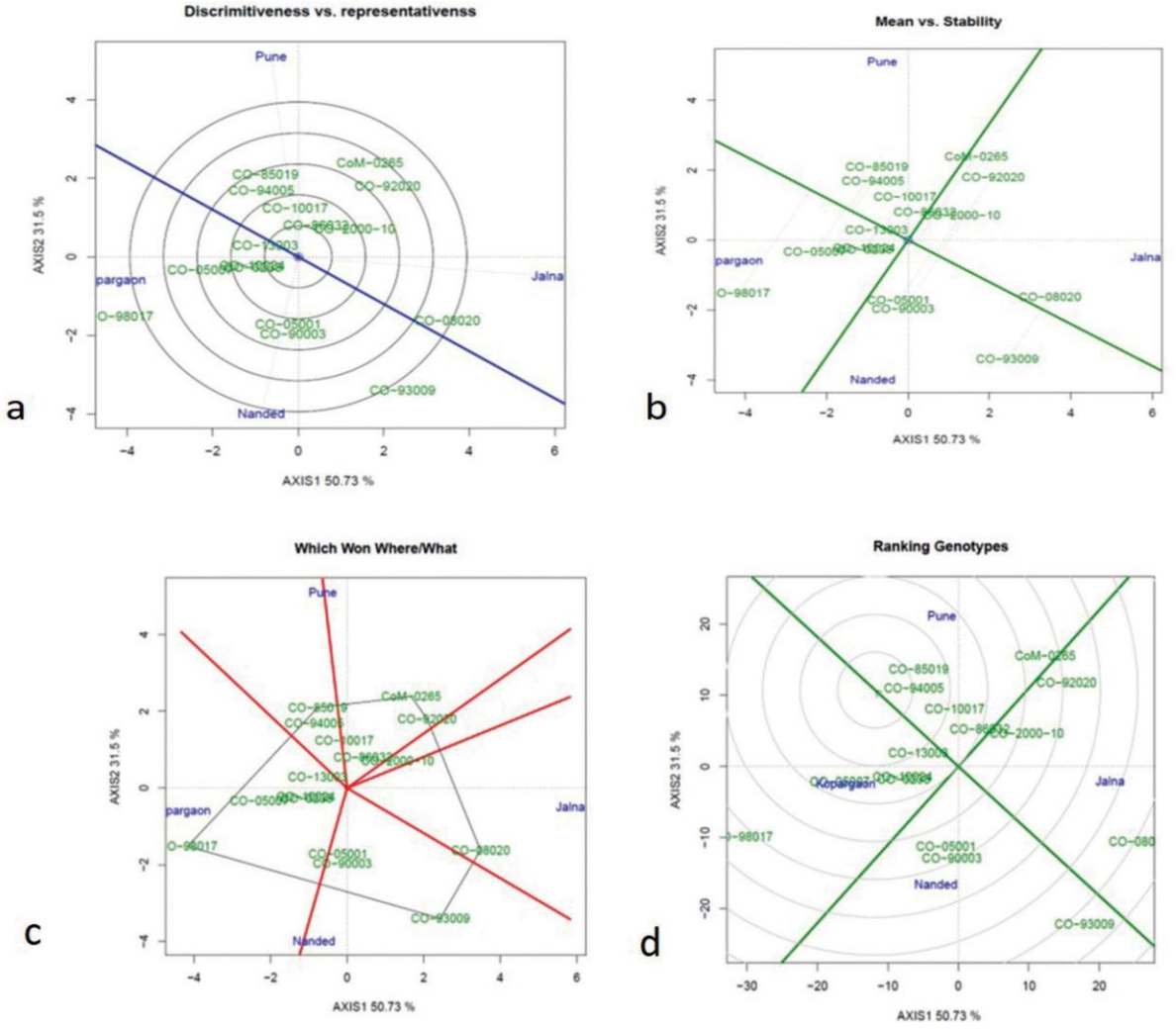


Fig. 4. GGE Biplot for G × E interactions of fourteen drought tolerant sugarcane varieties for cane yield under formative phase drought stress. a) Discriminativeness vs representativeness view of GGE Biplot; b) Average environment coordinate (AEC) visualization of biplots for Environmental focussed scaling for Mean vs stability; c) Polygonal view of GGE Biplot for visualization of 'which own where' for genotypes and environments and d) Average environment coordinate (AEC) view of biplots for genotype focussed scaling for ideal genotypes or ranking of genotypes

KCP Sugars, Vuyyuru, Andhra Pradesh

Thirteen Co canes along with the check CoV 09356 were evaluated for cane and juice quality traits at 10th and 12th month at KCP Sugars, Vuyyuru, Andhra Pradesh. Four entries *viz*., Co 09004, Co 11015, Co 14008 and Co 0238 had better field stand. Flowering was observed in Co 0238. The entry Co 09004 recorded the highest sucrose of 18.78% followed by Co 11015 (17.22 %) and Co 14002 (17.05 %) compared to the standard CoV 09356 (15.22%) at 10th month. At 12th month, four entries *viz*., Co 11015, Co 09004, Co 0238 and Co 15007 showed higher sucrose % than the local check CoV 09356 (18.94%). Highest single cane weight of 1.42 kg was recorded in the entry Co 11015 followed by Co 15021 (1.37 kg) compared to CoV 09356 (1.16 kgs). Co 15021 recorded the highest cane yield of 139. 27 t/ha followed by Co 14002 (131.97 t/ha compared to the standard CoV 09356 (109.04 t/ha). Co 11015 recorded the highest CCS of 14.91% followed by Co 09004 (13.23%) and Co 15007 (13.23%) compared to the standard (13.2%). From this trial, four Co canes *viz.* Co 11015, Co 09004, Co 14002 and Co 15021 were promoted for multi-location testing in the East coast zone through AICRP(S). A new trial

was laid out with Co 14016, Co 16009, Co 06030, Co 17003, Co 17004, Co 18009 and the check CoV 09356. Based on the performance of clones in the trial selected entries (Co 11015, Co 09004, Co 15007) were planted in 2.0 acres, 2.5 acres and 0.5 acres respectively.

(K. Mohanraj and T. Lakshmi Pathy)

SNSI, Belagavi, Karnataka

New varietal trial

Second plant trial: Twenty eight clones (Co canes and PZVT clones) were evaluated along with standard Co 86032 in RBD with two replications at SNSI, Belagavi. Juice analysis at 360 days revealed that the clones Co 14011, Co 15001, Co 15002, Co 15003, Co 15005, Co 15010, Co 15011, Co 15020, Co 13003, Co 13006, 2014-177, 2012-147, Co 18024 and 2012-92 were better with higher sucrose% as well as CCS% over trial standard Co 86032 (19.76% and 14.82%), but were inferior to the standard CoC 671 (22.62% & 16.41%). The clones *viz.* Co 15002, Co 15003, Co 15013, Co 18024, 2013-129, 2012-147, 2014-99 and 2012-44 recorded higher cane yield than trial standards Co 86032 (129.39 t/ha) and CoC 671 (93.91 t/ha) at harvest. For CCS t/ha, the clones *viz*., 2012-147, 2013-129, 2014-99, Co 15002, Co 15003 and Co 18024 recorded numerically higher sugar yield than the standards Co 86032 (17.90 t/ha) and CoC 671 (15.02 t/ha).

Ratoon Trial: Juice quality analysis at 360 days in ratoon trial showed that the entries Co 14011, Co 15002, Co 15005, Co 15020, Co 13006, 2014-177, 2012-147 and Co 18024 were better for sucrose % and CCS% over trial standard Co 86032 (20.98% and 16.11%), but were inferior to CoC 671 (22.40% and 16.80%). At harvest, entries *viz*., Co 18024, Co 13003, Co 14010 and Co 15007 were better for cane yield and entries *viz.* Co 13003, Co 15011, Co 15007 and Co 18024 were better for CCS (t/ha) than the standard Co 86032.

Pooled Analysis: Based on the pooled analysis data of two plant and one ratoon, the entries 2012-147, 2014-177, Co 13003, Co 13006, Co 14011, Co 15001, Co 15005, Co 15007, Co 15020 and Co 18024 were better for sucrose % and CCS % at harvest over the standard Co 86032 (19.90% and 13.94%), but all were inferior to CoC 671 (22.51% and 15.90%). The clones 2012-147, 2014-99 and Co 18024 recorded numerically higher cane yield and CCS yield than standards Co 86032 (123.25 t/ha and 17.11 t/ha) and CoC 671 (79.01 t/ha and 12.56 t/ha) respectively.

Drought Trial: Twenty one clones along with two standards (CoC 671 and Co 86032) were evaluated in both normal (regular irrigation) and drought conditions (withholding of irrigation from 60 DAP to 150 DAP). In the ratoon, drought was imposed at 60 days after ratooning. In ratoon trial, the test entries Co 98017 (118.37 t/ha) and Co 85019 (112.44 t/ha) recorded higher cane yield than the better standard Co 86032 (111.86 t/ha). The highest CCS yield (t/ha) was recorded by Co 86032 (16.58 t/ha), followed by Co 09004 (15.90 t/ha), Co 85019 (15.77 t/ha), Co 92002 (15.28 t/ha), Co 13006 (15.07 t/ha), Co 98017 (14.66 t/ha), Co 92020 (14.58 t/ha) and CoC 671 (14.05 t/ha). CoC 671 was the best entry for sucrose (21.89 %) at harvest and the entries Co 12007, Co 95020, Co 13006, Co 06015, Co 09004 and Co 14011 recorded numerically better sucrose than Co 86032 (20.93%).

Under normal conditions, in II plant crop Co 85019 (143.99 t/ha) recorded highest yield followed by the entries Co 09004, CoC 671, Co 86032, Co 10033, Co 13003, Co 12007 and Co 13006. Whereas CoC 671 was the best entry for sucrose (22.46%) at harvest, the entries Co 85019, Co 92020, Co 09004, Co 07015, Co 12007, Co 93009, Co 14011, Co 0303 and Co 13003 were better than Co 86032 (20.94%). The entry Co 85019 (125.84 t/ha) was again the highest cane yielder and the entries Co 10033, Co 12007, Co 09004 and Co 13003 were superior to Co 86032 (113.17 t/ha). Co 85019 was superior under drought for CCS yield (19.87 t/ha) and the entries Co 12007, Co 10033, Co 09004 Co 13003 were superior to Co 86032 (16.63 t/ha). CoC 671 was the best for sucrose at harvest under drought as well (22.48 %). Based on the percent yield reduction under drought, the entries Co 12007, Co 10033 and Co 85019 were found best, followed by Co 13003, Co 86032 and Co 09004.

(V. Sreenivasa and H.K. Mahadevaswamy)

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

Energy cane bagasse as a raw material for new product development such as crude oil,pulp for paper industries and texture fibre for garment industries was attempted. Bio- crude oil production potential was estimated through batch Hydrothermal Liquefaction (HTL) reactor. An average of 45g bio-crude oil was obtained from 100g energy cane bagasse compared to the 37.5g bio-crude oil produced from 100g sugarcane bagasse. The results were encouraging and energycane bagasse can be a good feedstock for bio-crude oil production.

Bagasse was sent to ICAR-Central Institute for Research on Cotton Technology, Mumbai for analyzing the textile fibre properties and Central Pulp and Paper Research Institute, Shaharanpur, Haryana for paper pulp properties. Energy cane bagasse was also sent to M/s. Seshasayee Paper and Boards Limited, Erode for the lab analysis. The result indicated higher pulp yield, higher water soluble and low pith content in the energy cane bagasse. Pulp yield in energy cane bagasse was higher (51.4 %) compared to the sugarcane bagasse (48.00 %). The pith % in energy cane bagasse was lower (11.00 %) compared to the sugarcane bagasse (28.00 %). The chemical requirement of energy cane bagasse was higher than that of sugarcane bagasse to achieve same kappa number of 10-12. Pulp strength properties are slightly lower than that of sugarcane bagasse pulp. Fibre pith ratio was higher in energycane bagasse (7.1:1) compared to the sugarcane bagasse (2.25:1). Energycane bagasse had all good pulping qualities and found to be a better alternative for sugarcane bagasse.

(P. Govindaraj and M.R. Meena)

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

In August 2019, 72 fodder type clones were supplied to ICAR-IGFRI, Jhansi for analyzing the nutritional qualities and palatability. The supplied fodder type clones were putative hybrids derived from the crosses involving (sugarcane x *S. halepense*) x (sugarcane, maize, bajra, *Erianthus arundinaceus*). A set of these clones were evaluated at ICAR-SBI Coimbatore during 2019-20 in a microplot (90 cm row spacing x 0.80 m spacing between clumps x 3 clumps per entry) for green fodder (biomass) yield. First cutting was made at 150 days after planting. The fresh biomass yield (without root) at an average moisture content of 58.9% ranged from 0.16 to 2.90 kg per clump. Five clones *viz*., Agl 2019-56 (5.81 kg/plot), Agl 2019-82 (6.50 kg/plot), Agl 2019-51 (6.19 kg/plot) and Agl 2019-14 (6.04 kg/plot) recorded > 5.0 kg green biomass yield per plot.

(P. Govindaraj and R. Karuppaiyan)

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

Adaptive Research Trial (ART, 2019-20)

Pilot study on juice quality characters of 14 test entries was carried out at 10th month of crop maturity along with four standards (Co 86032, CoC 24, TNAU Si 8 and Co 09004) at three ART locations of Coimbatore region. At Sakthi Sugars, Appakudal, Co 15007 (17.80%), Co 11015 (17.71%) and Co 13003 (17.71%) were superior to the best standard Co 09004 (16.97%) for sucrose content at 300 days. Other entries superior to Co 86032 (14.96%) were Si 10-27 (16.72%), C 30010 (16.54%) and G 08028 (16.34%). Co 86032 was the best standard for cane characters with single cane weight of 2.16 kg and four entries (Si 10-27, Si 10-02, Co 06031 and SI 10-12) were better than Co 86032. Similarly at Bannarimman Sugars, Sathyamangalam, Co 11015 recorded the highest juice sucrose content (19.08%) at 10th month. Other entries superior to Co 86032 (17.73%) were Co 15007 (18.05%), Co 09004 (17.99%) and G 08019 (17.91%). At Ponni Sugars, Erode, Co 11015 registered the highest sucrose content of 16.96 % at 240 days followed by C 30010 (16.56%), Co 09004 (16.25%), Co 06031 (15.64%) and Si 10-27 (15.56%) which were superior to Co 86032 (15.27 %).

Adaptive Research Trial (ART, 2020-21)

Adaptive Research Trial which was planned with 14 test entries was modified with limitednumber of entries along with Co 86032 and recent releases from different sugarcane research institutions located in Tamil Nadu *viz*., Co 11015 (ICAR-SBI), CoC 25 (SRS, Cuddalore), TNAU Si 8 (SRS, Sirugamani) and CoG 6 (SRS, Gudiyatham). Four entries selected for this trial are Co 14016, Co 15007, C 30010 and Si 10-12. Planting of the new trial was taken up during January- February 2020 at six locations *viz*., Sathyamangalam, Appakudal, Odapalley, Udumalpet, Theni and Pugalur which were allotted to ICAR- SBI, Coimbatore.

Multi-location Trial (MLT, 2020-21)

Six entries *viz*., Co 14004, Co 14012 and Co 18023 from ICAR-SBI, C 14516 and C 14436 from SRS, Cuddalore and G 10045 from SRS, Gudiyatham were planted in MLT at ICAR-SBI, Coimbatore. The seed materials of the three nominations from ICAR- SBI for MLT-2020-21 were supplied to the other centres during the first fortnight of February 2020.

Multi-location Trial (MLT, 2021-22)

Co 15020 was nominated for the forthcoming MLT 2021-22 and its seed material will be supplied during January 2021 to Sugarcane Research Stations of TNAU.

(A. Anna Durai, C. Mahadevaiah and K. Mohanraj)

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

This activity was initiated during July, 2020. A set of drought tolerant and sensitive clones were identified for evaluation for drought during 2021-2022 season. Thirty two drought specific candidate gene markers (ABF2, ABF3, Cipk14, CDPK18, LEA3, MYB2, RD28, RGS1, SNRK2.5, TPS2, DREB1A, DRF1, HRD, Hep2, NAC2, NIT1, Kgm, Pin1, Pin3, SHN1, SIZ1, Snac1, WRKY38, Apx1, GPX2, OCP3, DHN1, SAPK4, SPDS, ASN, HVA 22, PYL5) available were chosen for genotyping. Presently genotyping is under progress.

(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 initiated to study the effect of extended photoperiod on growth in sugarcane. Two sugarcane clones with regular flowering habit *viz*., Co 0238 and Co 16001 were used in this study. The single bud setts were planted in pots and one month after the establishment, the settlings were subjected to an extended photoperiod of 16hrs with 50000 luxfor 90 days. The results showed that the clone Co 0238 produced mean tiller of 5 under treatment and it was 2.5 under control indicating 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/plant under control whereas the dry root weight was 88.5g/ plant under treatment compared to 56.0g/plant under control.

(K. Mohanraj and R. Arun Kumar)

Enhancement of sugarcane germplasm and development of prebreeding material

Development of Multiparent Advanced Generation Inter-Cross (MAGIC) Population for Drought Tolerance in Sugarcane

Registration of genetic stock: CYM 08-922, a backcross derivative with *Erianthus* cytoplasm has been registered with ICAR-NBPGR, New Delhi as a potential pre-bred material for drought tolerance with higher relative water content and lower malondialdehyde content under drought.

Evaluation of four way intercross population for drought tolerance

Forty clones of fourway intercross populations, six drought tolerant clones from twoway cross population along with checks Co 86032, Co 06022 and Co 775 were evaluated for cane and juice quality traits under both drought and irrigated condition. Visual scoring of clones

under drought showed that the clones *viz*., FWC-25, FWC-28, FWC-31, FWC-10, FWC-42, FWC-43 and FWC-26 were drought tolerant. The fourway cross population was compared with twoway cross and commercial variety Co 86032 for their drought tolerant potential. In commercial variety Co 86032, 23.75% reduction was observed for cane height compared to 17.05% in twoway cross and 13.16% in fourway intercross population. For single cane weight, the lowest reduction was recorded in fourway intercross (12.98%). For juice sucrose, the highest reduction was recorded in twoway cross population (11.89%) and lowest in fourway intercross population (2.69%).

Screening for red rot

Forty fourway intercross clones were screened for red rot resistance in CCT and the clones FWC-31, FWC-29, FWC-15, FWC-33, FWC- 14, FWC-32, FWC-6, FWC-8, FWC-42, FWC-4, FWC-34, FWC-16, FWC-26, FWC-43 and FWC-30 were identified as red rot resistant.

Planting of Eight way/Second intercross population

A final population of 1550 seedlings from fifty five eight way/intercrosses were planted in the field for further evaluation.

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

Collection, Maintenance, Evaluation and Cataloguing of Sugarcane Germplasm at Coimbatore

Maintenance at Coimbatore and Wellington

Two thousand one hundred and thirty sugarcane germplasm accessions of *Saccharum spontaneum* (1620), *Erianthus arundinaceous* (215), *Erianthus* spp. (172), (*Erianthus* spp. total = 387 Nos.), Allied Genera (59), Improved *Erianthus* for fibre (48) and *Saccharum* canes (16) were maintained at Coimbatore and forty seven accessions from Arunachal Pradesh were maintained at IARI Regional Station, Wellington. Fifty four sugarcane germplasm collections of *Saccharum spontaneum* (39), *Erianthus arundinaceous* (11), *Erianthus* spp. (2) and *Saccharum officinarum* types (2) collected from Western Ghat regions were maintained in glasshouse and subjected to quarantine for pests and diseases.

(S. Karthigeyan and S. Sheelamary)

Maintenance of commercial hybrids and genetic stocks

A total of 1998 clones which includes 'Co' canes, foreign hybrids and other genetic stocks are maintained under the maintenance of commercial hybrids and genetic stocks. The details of the clones are as follows:

Categories of clones	No. of clones
'Co' canes	1346
'Co' allied	18
Foreign hybrids	52
ISH	284
PL	58
CD	86
IGH	38
IA	13
GU	1
CYM	96
IND	6
Total	1998

(H.K. Mahadevaswamy and V. Vinu)

National Active Germplasm maintenance

The seed materials received from different centres were submitted to quarantine process and periodical monitoring was done for their growth. A total of 271 notified and registered genetic stocks were maintained in the field (2020- 21). Index number was assigned to 16 clones (CoN 13072/ 256A, Co 13001/ 257, Co 14016/ 258, CYM 08-922/ 259, AS04-2097/260, CoM 12085 /261, SBIEC14006/262, BM1010-168/263, Co 14034/ 264, Co 15023/ 265, GU 07-2276/ 266 and Co 13013/ 267).

(C. Jayabose and S. Alarmelu)

Characterization, Evaluation and Cataloguing

Out of the 1620 *Saccharum spontaneum* planted during 2019 in the field at Coimbatore, nine hundred and twenty eight accessions flowered during 25th of April, 2019 to 31st of Dec., 2019

(S. Karthigeyan and S. Sheelamary)

Characterization of germplasm: The well-established, healthy and pest and disease free twenty four clones collected from Assam and West Bengal states were taken for the germplasm characterization and completed. All the thirty-nine morphomertic traits were observed and recorded. Among the clones characterized, IND 18-1939 showed the highest HR brix of 15.2% while the lowest of 5.0% was observed in IND 18-1980 and IND 18-1986. Ligule hair was present in all clones except IND18 - 1984 and IND 18-1986. The cross section of internodes was recorded 1 and 5 clones found to be possessing hallow, IND 18 - 1990, IND 18 - 1989, IND 18 - 1987, IND 18 - 1986 and IND 18 - 1985 having pithy internodes and clones like IND 18 - 1994 and IND 18 1993 exhibited solid internodes. Observations on intermodal shapes classified the clones into 11 clones as Conoidal, 8 as bobbin shaped four as cylindrical internodes (IND18-1940,1948,1958 and 1962) and one as rambhoid type (IND 18 - 1989).

Flowering behaviour of Allied Genera: Studies on the flowering behavior of allied seven genera indicated that a total of 58 clones were flowered till 2nd week of December and short blade stage was noticed in some clones. Among 172 *Erianthus* species clones 145 flowered till December 2nd week. *Imperata* (5), *Narenga* (5), *Neyrudia* (5), *Sclerostachya* (7), *Pragmites* (5), *Veteveria* (18) and *Pennisetum* (13) flowered during 2019.

Cryopreservation

Protocols were optimized to enhance the regeneration efficiency of nodal buds for cryopreservation studies. Previous experiments took longer time and percentage of germination was less. In order to accelerate this process, nodal bud (dormant buds) samples were treated in different combination of hormones

The nodal buds treated with 100ppm NAA hormone alone showed 85% germination within 10 days while the nodal buds treated with 100ppm GA3 showed 90% germination within 8 days. Hundred percent germination was observed in buds treated in combination of 100 ppm NAA +GA3 along with ½ MS media within a week.

(C. Jayabose)

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

Somatic chromosome number (2n) was determined in 80 clones of *S. spontaneum* collected from Punjab and Haryana (IND 16 collection-28 Nos.), Jharkhand (IND 17 collection- 52 Nos.) states. From IND 16 collections different cytotypes like 2n= 52, 54, 56, 64, 72 and 76 were identified. In IND 17 collection cytotypes like 2n= 54, 56, 60, 62, 64, 70, 72 and 74 were identified. The lowest cytotype with 2n=40 (IND 17-1852) was also found in this collection.

So far, a total of 88 clones from Punjab and Haryana (IND 16) were cytologically analyzed. Analysis on the evolutionary origin of different cytotypes revealed independent as well as multiple origins. Somatic chromosome number of 18 clones collected from Arunachal Pradesh (IND 90) has been determined. Different cytotypes like 2n=54, 56, 62, 64 and 90 were identified.

Clone	2n
IND 90- 782	54
IND 90- 802	56
IND 90- 788, IND 90- 795A	58
IND 90- 822	62
IND 90- 797, IND 90- 803, IND 90-804, IND 90- 807, IND 90- 796, IND 90- 797, IND 90- 811, IND 90- 813, IND 90- 815, IND 90- 796, IND 90-844, IND 90- 787, IND 90- 769, IND 90- 780	64
IND 90- 755	90

The diversity and distribution of different cytotypes of *S. spontaneum* in India has been studied with so far reported chromosome numbers. Twenty six cytotypes ranging from 2n=40 (8x) to 2n=112 (14x) has been identified in this species from India. Gangetic valley of Sub Himalayan region and deltaic region of South-east zone can be considered as regions of cytogeographic interest with the largest concentration of different chromosome numbers. In North and North-East India the evolutionary

mechanism are highly active in this species and it is found that its cyto-morphological variability favor the accumulation of adaptability characters, especially to biotic and abiotic stresses.

(V.P. Sobhakumari)

Floral biological and cytological characterization of *E. arundinaceus*

Identification key for *Erianthus* clones using the DELTA (DEscription Language for TAxonomy) software was developed and 52 clones were characterized. Chromosome number of six clones *viz*., IND 04-1335, IND 10-1591, IND 10-1594, IND 15-1715, IND 15-1701 and IND 16-1770 indicated 2n=40, 2n=40, 2n=40, 2n=60, 2n=20 and 2n=40 respectively (Fig. 5). Twenty selfs were made to assess seed set and fluffs were sown.

(A. Suganya)

the clones was 0.015 (mg/cm^2) with a range of 0.009-0.034 (mg/cm2). The clones *viz*., G16-90, H 60-4-5 and SH 217 had higher chlorophyll content (>0.030) while the standards Irrity -2 and Pampa recorded 0.009 and 0.011 respectively. The clones SES 49, SES 297A, SES 162B, SES 45, Glagah and H 60-4-5 recorded comparatively higher biomass (> 3 kg) under drought stress. During 2020-21 crop season 170 *S. spontaneum* genotypes were planted in augmented design in two sets, control and treatment, for water deficit stress tolerance evaluation and stress was imposed by withholding irrigation at the tillering phase. The mean growth rate for plant height during stress period in treatment plot was 0.32 compared to 0.85 in control plot. Similarly for number of tillers per clump the mean growth rate was 0.10 in treatment plot compared to 0.27 in control plot. Significant difference

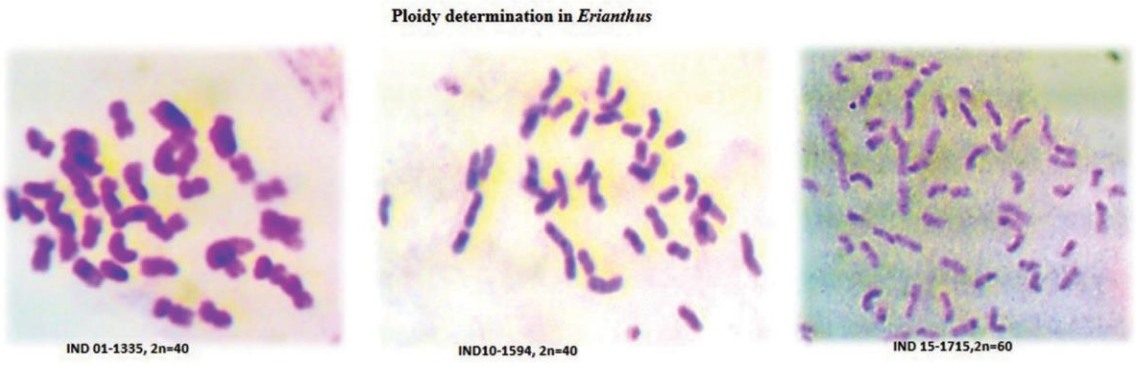


Fig. 5. Ploidy determination in Erianthus

Evaluation of sugarcane germplasm for biotic and abiotic stresses at Coimbatore

Saccharum spontaneum: Sixty *S. spontaneum* accessions were evaluated for drought tolerance under field condition along with two standards (Irrity -2 and Pampa) in augmented design during the crop season 2019-20. The clones were exposed to drought at the tillering phase by withholding irrigation. Phenotypic observations like plant height and tiller count and physiological observations *viz*., relative water content, SPAD index and chlorophyll content were recorded periodically. The SPAD index ranged from 15.83 to 37.13. Three clones *viz*., G16-90, H 60-4-5 and SH 217 were observed with more SPAD index (>30). The mean chlorophyll content of

was observed between control and treatment experiments for chlorophyll a, chlorophyll b and total chlorophyll contents during stress period.

Erianthus arundinaceus: Second year field evaluation of drought tolerance related traits among 208 *Erianthus arundinaceus* accessions were carried out along with four standards (SES 288, SES 293, IS 76 215 and IS 76 218) in

normal (well irrigated) and drought (with holding of irrigation from 60- 150 days) conditions. During 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. Per cent biomass reduction in drought varied from < 10% (SES 347, SES 293, IND 10- 1594, IS 76- 158, SES 75, IND 99- 886, IS 76- 205, IK 76-62 and SES 149) to > 85 % (IS 76- 215, IJ 76- 511, SES 89, IM 76-257, IK 76- 101, IK 76- 55, IND 99- 957, IK 76- 76, Dr.Rakki 2, IK 76- 105 and E.a Lyalpur). Similarly percent reduction in stalk number at harvest in drought varied from no reduction (SES 149, SES 27, IND 99- 871) to > 90 % reduction (IJ 76- 332, IND 99- 895, IS 76- 193, IJ 76- 513, IND 99- 957, IND 99- 888, IS 76- 134, Dr. Rakki 3, IM 76- 257, Dr. Rakki 2 and IK 76- 88).

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

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

Genomic DNA has been isolated from *S. officinarum* (28 NG 210), *S. spontaneum* (SES 275 and Coimbatore) and *Erianthus* (IK 76-62 and IK 76-91). After checking the quality and quantity of the DNA it was fragmented to 500-1000bp size by sonication. The fragmented DNA has been labeled 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. Four back cross progenies of Co 15015 (Co 15015 is having four *Erianthus* chromosomes) developed from the cross Co 15015 x Co 11012 were subjected to GISH analysis and in one progeny two chromosomes of *Erianthus* was observed. In order to differentiate the different species genomes of *Saccharum*, two interspecific hybrids (ISH 288 and Co 285) were analyzed by *in situ* hybridization. ISH 288 (*S. officinarum*, Oramboo 2n=80 x *S. spontaneum*, SES 275, 2n=64) was showing 2n=84. GISH analysis with biotin labeled SES 275 genomic DNA revealed that this hybrid genome contained 44 *S. spontaneum* chromosomes and three recombinant chromosomes between *S. spontaneum* and *S. officinarum*. Somatic chromosome number of Co 285 (*S. officinarum*, Green sport 2n=80 x *S. spontaneum* Coimbatore, 2n=64) has been determined as 2n=112 (2n+n). GISH analysis with labeled probe of *S. spontaneum*, Coimbatore showed 32 *S. spontaneum* chromosomes and 7 recombinant chromosomes of *S. spontaneum* and *S. officinarum* in the Co 285 genome. GISH analysis of an intergeneric hybrid [GU 04(72) COE-1] between CoC 671 x IK 76-91 has been done with labeled probe of IK 76-91. In this hybrid 30 chromosomes of *Erianthus* has been observed and found to be a product of 2n+n chromosome segregation. Introgression pattern of *Erianthus* in the following back cross progenies of *Erianthus* x *S. spontaneum* has been analyzed by using labeled probe of IK 76-62. In Cym 07-971 (BC1) 2n+n segregation was observed with more than 20 chromosomes of IK 76-62. In Cym 08- 922 (BC2) twelve *Erianthus* chromosomes were observed and in TWC 82 (BC3) seven *Erianthus* chromosomes were observed.

(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

Preliminary studies: One hundred clones were evaluated for yield and quality parameters at 240 and 300 days for their utilization in breeding. Forty five clones were high tillering types in comparison with the checks Co 86032 and CoC 671. At 240 days 28 clones recorded HR brix in the range of 17.50% to 18.50%. Cane weight and height was appreciable in the genetic stocks identified for further studies. Sixty five clones recorded more NMC and estimated cane yield was above 70.00 kg/ row. Preliminary physiological observations recorded in the improved species derived interspecific clones (174) indicated wide variations for relative water content (RWC), SPAD index and chlorophyll content. RWC ranged from 54.5% (PIO 88-79) to a highest of 85.2% (PIO 14-100) with a mean of 73.3%. SPAD index ranged from 19.5 (PIO99- 141) to 38.7 (PIR 07-776) while chlorophyll content varied from 0.013 mg/cm^2 (PIO99-141) to 0.036mg/cm^2 (PIR 07-776) with a mean of 0.028mg/cm^2.

Evaluation of hybrids for drought tolerance: During 2019-20 planting season, 97 interspecific hybrids from four different mating groups were planted along with three standards (Co 85019, Co 10026 and CoM 0265). Germination and tillering in entries were good. Twenty eight vigorous and high tillering types were observed. Drought stress was induced during formative phase of the crop by withholding irrigation. Crop has developed drought symptoms and three entries expressed severe drought symptom. Pre- stress observations *viz*., SPAD, Fluorescence, leaf temperature, shoot population, number of leaves, leaf length and leaf width were recorded.

Germplasm maintenance: A total of 293 clones consisting of 96 *Saccharum officinarum*, 28 *S. barberi*, 9 *S.sinense*, 28 *S. robustum* and 132 IS hybrids and their derivatives were obtained from SBIRC, Kannur and SBIRC, Agali and planted in the field at Coimbatore for further utilization.

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

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

Red rot

At ICAR-SBI, Coimbatore: Ninety one *Saccharum* species clones were evaluated for their reaction against CF06 pathotype of red rot pathogen *Colletotrichum falcatum*. Majority of the accessions (52) showed susceptible (S) reaction while two accessions *viz.*, NG 77-94 and 57 NG 203 were exhibiting highly susceptible reaction. Equal number of accessions showed moderately resistance (15) and moderately susceptible reaction (14). Eight accessions *viz*., Nargori, Mangasic, Maneria IMP 1552, Daur Kinara, Chin, Mungo 254, Kheli and Reha showed resistant reaction. Similarly 120 inter-specific hybrids developed at SBIRC, Kannur which were found flowering were raised at Coimbatore and evaluated for resistance against red rot pathogen (CF 06). Most of the hybrids were MR (72) while three hybrids were exhibiting R reactions. Other reactions observed in these hybrids were S (29), MS (11) and HS (5).

One thousand two hundred and seventy six seedlings of the crosses *viz*., 51NG 036 x Co 88025, 51NG 159 x CP 62-23, Uba White x Co 88028, Awela Green sport x CoSe 92423, Manjuria X Co 13007, Uba white x SP 80-1848, S.O hybrid x Co 12009, Laukana15 x Co 0233, Norgori x Pathri, Dhaur Kalig x Pathri and IJ 76470 x IJ 76436 effected during 2018 flowering season were planted to raise a ground nursery in order to study these crosses for red rot resistance. Ten crosses involving four *Saccharum officinarum* clones *viz*., Mongetgayam, Naz, IJ 76-274, and Otaheite and seven new collections of *S. spontaneum viz*., 04-1351, 17-1920, 07-1457, 04-1369, 04-1327, 05-1416, 04-1374, and 04-1381 and eight crosses involving red rot resistant interspecific hybrids were hybridized with high quality Co and Co allied canes during 2019 flowering season for further improvement.

At ICAR-SBIRC, Kannur: A total of 22 seedlings from two crosses involving Pathri were evaluated in ground nursery at ICAR-SBIRC, Kannur. The HR brix ranged from 13.20 (GUK 18-527) to 18.60 % (GUK 18-520) in the cross Daur Kalig x Pathri and 9.0 (GUK 18-532) to 19.20% (GUK 18-538 in the cross Pathri x Co 62175).

Drought Trial: A total of 39 interspecific and intergeneric clones developed from a new genetic background were planted for drought evaluation. Twenty six crosses were effected between co-canes and ISH, IGH and early generation hybrids derived from *S. officinarum*, *S. barberi*, *S. sinense* and *S. robustum* and fluff was sown.

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

Developing trait specific genetic stocks with *Erianthus* genetic base

Hybridization: Thirty five backcrosses were made using BC1 progenies involving *E. procerus viz.*, GU 12-16, GU 12-17, GU 12-19, GU 12-25, GU 12-37, GU 12-41, GU 12-50, and GU 12-51 as parents during the crossing season 2019. From 2018 crosses, 178 BC2 seedlings were transplanted in the field.

Maintenance of distant hybrids: 580 distant hybrids and their derivatives developed over the

years are planted for maintenance and further utilization

Clonal evaluation: Forty elite clones with diverse genetic base were evaluated for cane and juice quality traits. The clone GU 15-1586 recorded the highest sucrose of 21.10% and twenty six clones recorded higher sucrose than the standard Co 86032 (18.10%) at 10th month.Four clones *viz.,* GU 15-96, GU 15-100, GU 15-1697 and GU13-84 recorded single cane weight of more than 2.0 kgs. Fifteen superior clones were promoted to PZVT. Maximum selections were from the cross Co 85002 x GU 13-138 and CoC 671 x IG 91-1100.

(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)

Genetic stocks registered

AS 04-2097 (20112; IC0635053 INGR20070) for drought tolerance: AS 04-2097 is a hybrid of Co 8371 x SH 216 (2n=72). The clone distinguished in semi erect habit with curved canes, moderately thick internodes, prominent node swelling and lanceolate auricle. In AICRP trial, AS 04- 2097 showed less reduction for cane thickness, single cane weight and cane yield at 360 days atharvest under drought condition. Cane diameter showed 9.13% reduction with the mean value of 2.19 cm. Less reduction in single cane weight (3.0 %) was observed with mean cane weight of 1.0 kg/cane and 0.93 kg/cane under normal and drought conditions respectively. The complex character cane yield (90.48 t/a) had 13.08% of reduction under drought while the checks exhibited 17.21% reduction.

AS 04-1687 (20177; IC0636675 INGR20110) for drought tolerance and water logging tolerance: AS 04-1687 is a derivative of BO 102 x IND 84-337 (2n=56). It has erect canes, purple coloured cylindrical internode and leaf sheath which istight and glabrous with brown coloured dewlop and deltoid auricle. AS 04-1687 exhibited the best performance with less than 20% reduction for cane yield t/ha (18.5%), CCS t/ha (10.08%) and NMC ('000/ha) (13.01%) under drought condition while in the checks, reductions were 29.77%, 29.73% and 17.57% respectively for these three characters. The traits *viz.,* cane diameter and relative water content after drought had shown least impact due to drought condition with 1.01% and 2.11% reductions respectively.In the checks 3.58% reduction for cane diameter and 4.31% reduction for relative water content after drought were observed. Tillers mortality % was less in AS 04-1687% with 30.09% while it was higher with 39.84 in the checks. In addition, AS 04-1687 exhibited low percent reduction for many traits after the waterlogging period. The clone showed 2.01%, 8.26 % and 5.20% reduction for CCS t/ha, single cane weight (kg) and NMC (000'/ha) respectively while the checks showed 19.79%, 20.04% and 10.05% reduction respectively for these traits. Cane yield also exhibited less reduction (16.42%). Sucrose % was unaffected in AS 04-1687 while the checks recorded 5.24 % reduction.

RT-PCR analysis revealed differential expression of key genes implicated in drought and salinity tolerance in AS 04-1687 for the genes *viz.,* MYB transcription factor, Cis binding factor, Sorghum-SNAC1, Sugarcane-Invertase, Sugarcane-SPS, RAB, Calcium dependent protein kinase, Late embryogenesis abundance and Dehydrin. Candidate genes were used for the amplification of the hybrid AS 04-1687 along with drought and salinity tolerant clones of *S. spontaneum*. The gene products/alleles amplified in AS 04-1687 had 93.33 similarity with IND 00-1039 (*S. spontaneum*) and both of are tolerant to drought and salinity.

Hybridisation: Thirty back crosses were effected utilising 10 typical clones of *S. officinarum* (28 NG 288, Chapina, Shamsera, Keong, Aweola green sport, NC 94, 57 NG 078 sport, IJ 76-564, IJ 76-567 and IJ 76- 364) and two atypical clones (Baragua and Seleri). Higher cytotype (2n=72 and 80) derived progenies were used as male. The genetic stock which are tolerant to drought and waterlogging were also crossed with *S. officinarum* clones. The clone 57 NG 078 sport was crossed with the elite hybrids (female). Twenty backcrosses were made with elite hybrids and Co varieties.

Meristem tip culture: About 762 meristem tips from 20 clones of *S. officinarum* clones with 2n=80 and Indian clones were inoculated and subcultured. Regeneration was obtained in IND 01-1084, IND 01-1116, IND 03-1261, IND 04-1377, Ogles selection, NG 77-137, NG 77-154, 28 NG 210 and NG 77-142 in MS media supplemented with GA3 (0.5 mg/L) and BAP (0.25 mg/L). Among these the clones IND 04-1377, IND 01-1084, Ogles selection and 28 NG 210 showed faster elongation rate (Fig. 6). Plantlets of IND 04-1377 were planted in polybags for hardening.

Fig. 6. In vitro regeneration in 28 NG 210

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

Targeted Prebreeding with different cytotypes of *Saccharum spontaneum* L. characterized for abiotic stress tolerance

Confirmation of somatic chromosome number of S. spontaneum: The *S. spontaneum* clones with different cytotypes along with abiotic stress tolerance were selected for developing interspecific crosses. The grouping of the clones available in the field bank was done based on different chromosome number and the clones were selected representing each group. The chromosome number of selected clones (50) were confirmed and presented in table 6.

Hybridization: During the crossing season 2020, 46 interspecific crosses were made involving *Saccharum spontaneum* used as a female parents and elite clones. The female parents were selected based on different cytotypes (2n= 48, 54, 64,72,80,88 and 96) with abiotic stress tolerance, and the male parents were chosen on their merit, abundance of pollen, synchrony of flowering and also based on economically important traits including cane yield, high sucrose content and disease resistance. About 40 female parents and 15 male parents were used to generate crosses. Before crossing the chromosome number of the selected parents were reconfirmed cytologically.

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

Sugarcane genomics and molecular markers

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

miRNA co-net work analysis: The co-expressed stress responsive miRNAs in the wild and cultivated sugarcane cultivars were clustered into nine clusters. Cluster1 shows the highest number of co-expressed miRNAs (149) and cluster 2 showed 105 co-expressed miRNAs. In starch and sucrose metabolism, differentially

Table 6. Somatic chromosome number (2n) of *S. spontaneum* clones

Clone	(2n)	Clone	(2n)	Clone	(2n=)	Clone	(2n=)
IND 99-986	70	IND 90-813	60+2F	IND 81-144	64	IND 00- 1036	64
IND 99-984	66	IND 81-146	54	IND 81-80	70	IND 00-1037	70
IND 99-851	64	IND 81-165	56	IND 16-1762	54	IND 01- 1072	54+2F
IND 07- 1465	80	IND 08- 1500	64	SES 248	64	S.SPONT 11	80
IND 07- 1470	80	IND 07- 1471	80	SES 106 B	64	SES 84 B	64

IND 01-1133	64	IND 02- 1209	58+2F	IND 07- 1462	80		

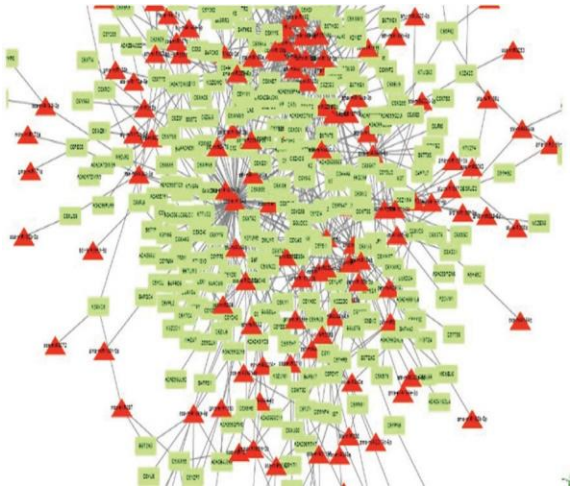


Fig. 7. Co expressed network of differentially expressing miRNA families under oxidative stress conditions

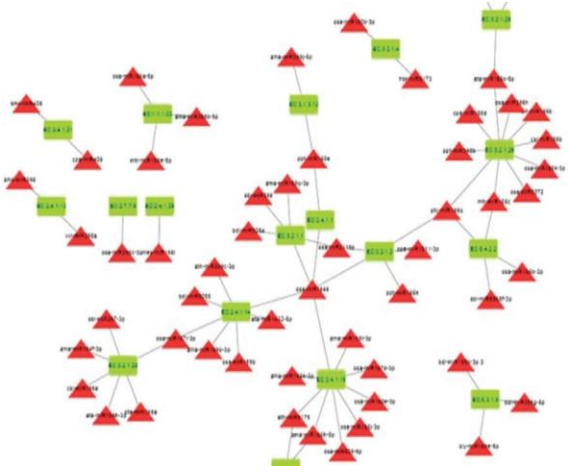


Fig . 8. Co expressed network of miRNAs influencing sucrose metabolism, miRNAs influencing sugar metabolism (osa-miR396c-3p, mes-miR166i, smo-miR408, cpa-miR408, smo-miR396 and vvi-miR396a).

expressed miRNAs were zma-miR164f-3p, ata-miR1432-5p, osa-miR5072, osa-miR156b- 3p, zma-miR398b-5p, ata-miR166b-5p, osa-miR1848, bdi-miR159b-3p.3 (up-regulated) and ath-miR399c-3p, ppt-miR160e, osa-miR396h, osa-miR2118p (down-regulated) in *Erianthus arundinaceus* (Fig.7). The analysis of miRNA related to sucrose metabolism showed that osa-miR1848 targeted sucrose-phosphate synthase and beta-fructo furanosidase and ppt-miR160e targeted the trehalose 6-phosphate synthase (Fig.8). Three miRNA families involved in sucrose metabolism were indentified in *Saccharum spontaneum* (zma-miR169o-3p, vvi-miR396a, Smo-miR396) and Co 86032 (miR167i-3p, miR1848, and miR159b).

Validation of differentially expressed miRNA: The expression values of seven miRNAs were validated using qRT PCR (miR444, miR166, miR166, miR390, miR398_2, miR397 and miR169e) using stem loop primers. The expression profiles obtained using RT-PCR showed similar expression profiles with that of the NGS except for miR169e (Fig. 9).

NAC genes expression profiles: The NAC genes ScNAC36, ScNAC69 and ScNAC80 showed neutral regulation in Co 86032. But in *E. arundinaceus and S. spontaneum* these genes showed upregulation. The ScNAC65 gene showed upregulation in Co 86032 whereas ScNAC81 showed upregulation only in *E. arundinaceus* and possibly the low copy of transcripts (very low read count in NGS data) could not reveal the difference relative

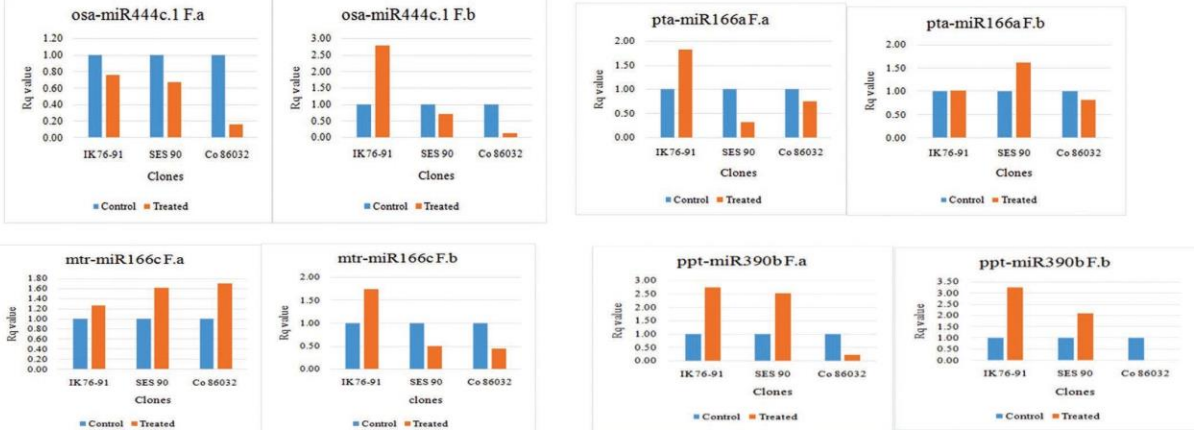


Fig. 9. Validation of Differentially expressed miRNAs

expression between control and stresses samples. Out of the 9 down regulated genes, 8 NAC genes except ScNAC59 correlated with the NGS data in *S. spontaneum*. ScNAC34 shows down regulation in all the samples same as in NGS data. ScNAC78 and ScNAC70 also showed down regulation in both *S. spontaneum* and Co 86032.

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

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

Isolation and expression of miRNA genes: Total RNA was isolated from flowering and non flowering clone. MiRNAs expression analysis at flower initiation stage showed differential expression between flowering and non flowering clones. Lower expression of miR397-3p in non flowering clones and a higher expression of miR169e-5P in flowering clones were observed (Fig. 10). Oligos were synthesized for the 20 bp region in the flowering gene. The constriction of CRISPR – CAS vector is in progress.

Endogenous hormone levels in flowering and non flowering clones: Endogenous gibberellins were high in flowering clones as compared to non-flowering clones during pre induction period. The content ranged from 46.2 µg/g to 271.4 µg/g, while in non flowering clones it ranged from trace amount to 243 µg/g. ABA, an endogenous growth inhibitor was detected in both flowering and non flowering clones.

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

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

Transcript levels of differentially expressed genes among all stages: The expression levels of significant DEGs among all stages of drought and recovery in the tolerant and susceptible cultivar was identified. Under 10 days of stress, the expression profile of *cytochrome p450* was up-regulated in tolerant (Co 06022) genotype while it was down-regulated in susceptible (Co 8021) genotype. The expression profile of *cytochrome p450* gene was similar at 2, 6 days of stress and rehydration stages of both genotypes. *Microtubule associated protein futsch* was highly up-regulated at recovery stage of susceptible genotype while it was down-regulated in tolerant genotype. The stress responsible genes like heat stress transcription factor c-1b, late embryogenesis abundant protein and heat shock 70kDa protein were up-regulated in tolerant genotype at recovery stage, while these were down-regulated in susceptible genotype upon rehydration. The drought responsive gene *HSP20 family protein* was highly upregulated in Co 06022 during

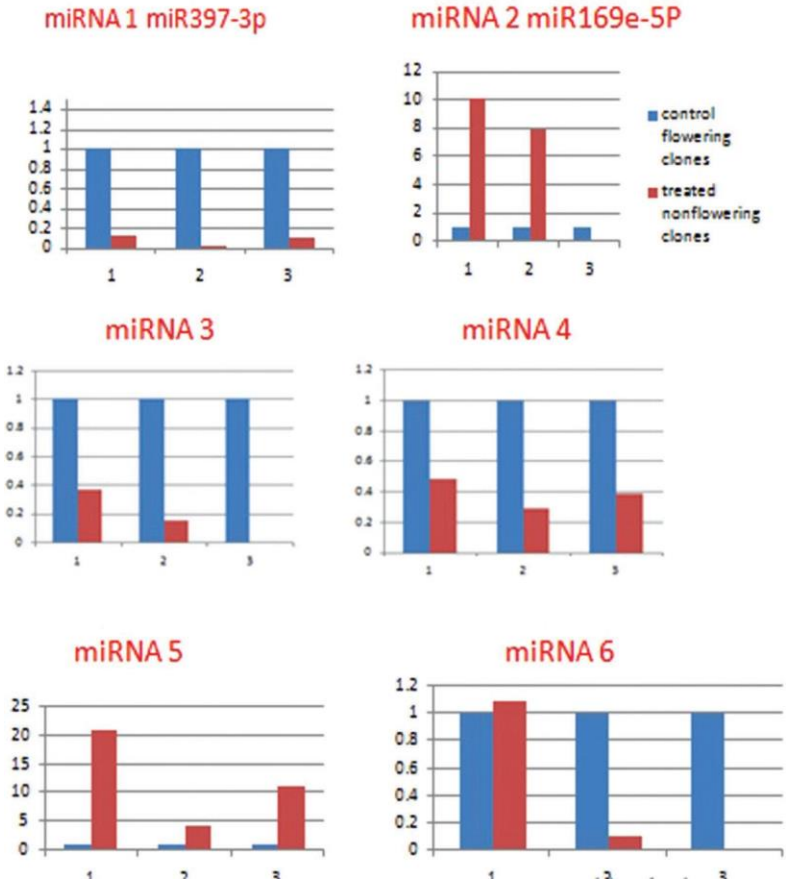


Fig. 10. miRNAs regulation during flowering phase in flowering and non flowering clones

2 and 6 days of stress whereas the up regulation was highest in 10 days stress in Co 8021 and it was highly down regulated in Co 8021 after rehydration. The expression of *peroxidase* was down-regulated in susceptible genotype at two days stress, however it was up-regulated in tolerant genotype. Some of the genes that showed an immediate up-regulation at 2 days stress in tolerant cultivar as compared to the susceptible cultivar were *HSP 20* family protein, heat stress transcription factor c-1b, heat shock 70kDa protein, disease resistance protein RPM1, soluble inorganic pyrophosphatase like isoform X2, peroxidase and glutathione S- transferase. At rehydration genes such as jasmonate- induced protein homolog, probable protein phosphatase 2c- 32 and katE: catalase were highly up-regulated in susceptible genotype however *ZIM motif family protein, WRKY- transcription factor40* and *protein app 1 precursor* were highly up-regulated in tolerant genotype. Both *peroxidase* and *carboxypeptidase* were up-regulated at recovery stages in Co 06022 whereas in Co 8021 they remained down-regulated.

Identification of miRNA and their targets for water stress: miRNAs that are abundantly expressed on the tolerant and susceptible cultivars were identified (Fig. 11). We identified 145 miRNAs that were differentially expressed in susceptible variety (V1-31) and 143 miRNAs differentially expressed in the tolerant variety (V2-31). Target prediction revealed 10312 and 11357 targets for the differentially expressed miRNAs ofsusceptible and tolerant cultivars. Target genes mainly encoded transcription factors, proteins, phosphatase and kinases involved in signal transduction pathways, integral components of membrane and inorganic ion transport metabolism, enzymes involved in carbohydrate transport and metabolism and drought- stress related proteins involved in defence mechanisms. "General function prediction only"

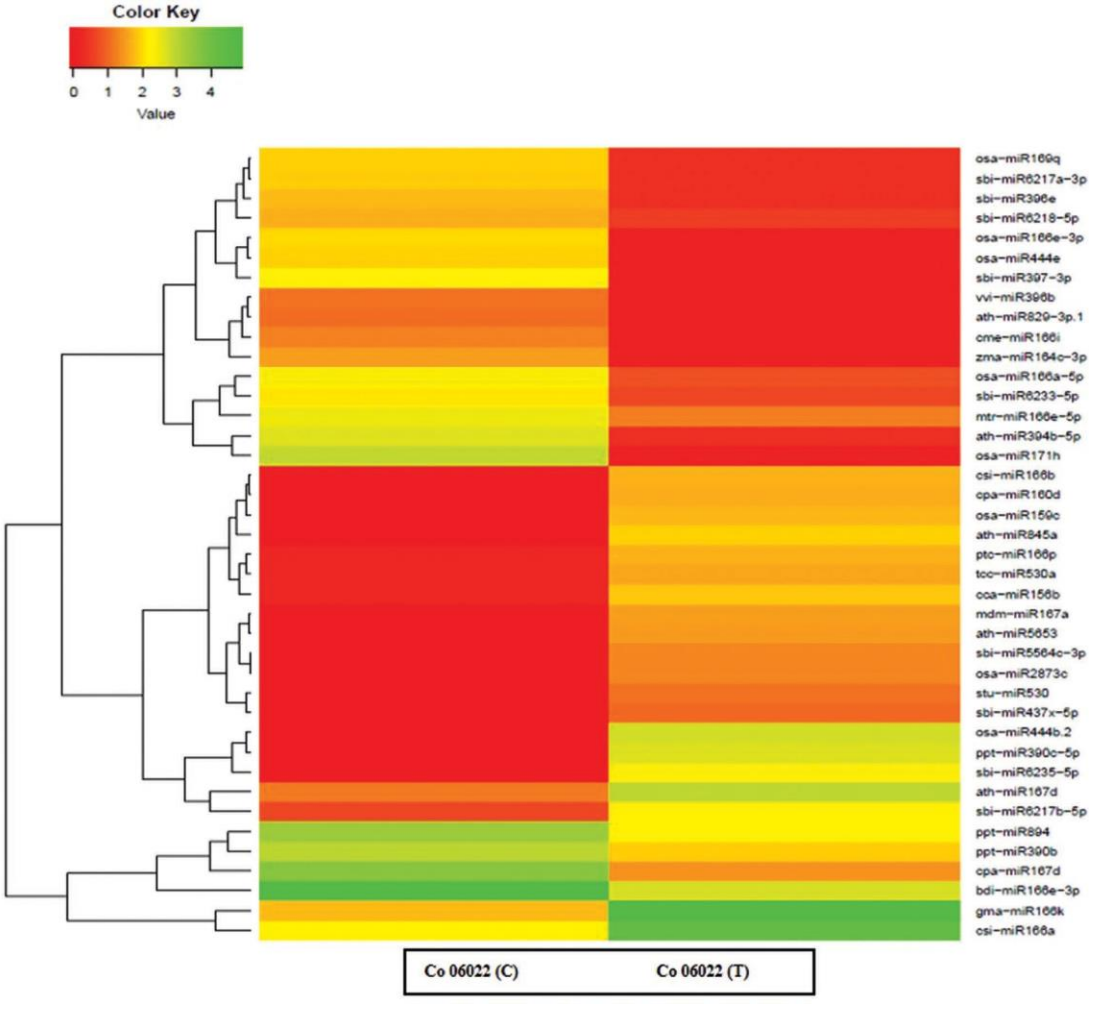


Fig. 11. Heat map of abundant miRNAs in the tolerant variety Co 06022

was the most significant pathway observed in both tolerant and susceptible genotypes with 1212 and 1271 genes respectively followed by signal transduction mechanisms with 615 and 714 genes respectively. qRT- PCR was used to verify the expression levels of miRNAs and their potential targets obtained from RNA sequencing results.

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

Sucrose regulating genes in sugarcane: identification of isoforms and transcript variants

The samples for RNA isolation were collected at regular intervals and juice analyses were performed at 240, 300 and 360 days after planting. Juice analysis was conducted in 19 sugarcane clones, comprising of Co canes, genetic stocks along with standards. The clones Co 09004, Co 11015 and the standard CoC 671 consistently recorded higher sucrose levelsacross the maturity durations, while clones TWC-28, TWC-88, TWC-71 had lowest sucrose levels. All the evaluated clones showed increase in their sucrose levels from 240 to 360 days, with Co 11015, Co 09004 and CoC 671 having highest increase, while TWC-88 had the lowest increase. Brix was recorded regularly after 6 months of planting. A time lapse of changes occurring over the study period in the genotypes for the sugar traits studied are shown in Bi- Plot (Fig. 12). Expression studies were carried out for sucrose transporters, one of the major regulators of sucrose accumulation in high and low sugar genotypes, as revealed by a previous study. Sweet sorghum was compared with sugarcane for the expression studies until they were harvested at the end of 3 months. RNA for Iso-seq sequencing was collected at 6, 9 and 12 months after planting and stored at -80C for further processing.

(P.T.Prathima and T. Lakshmi Pathy)

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

Forty two water use efficiency related genes were retrieved from the Sugarcane monoploid genome and it's closely related model crops such as Sorghum and Maize. The promotor and gene structure analysis of these genes were carried out. The phylogenetic analysis of the WUE related genes between sugarcane, sorghum and maize was carried out and it was found that many of these genes have high similiarity and have a common ancestral lineage. More than 20 primers were designed based on the sorghum WUE related and tested for amplification in sugarcane. No amplification was found. Primers were also designed to amplify the domain region of the WUE related protein for the genes GTL1A, GTL1B, SLAC, SLAC 100, SDD1, WIN1 and ERECTA. These primers were tested in 20 sugarcane genotypes that are field evaluated for WUE. An expected size range of 500 bp PCR

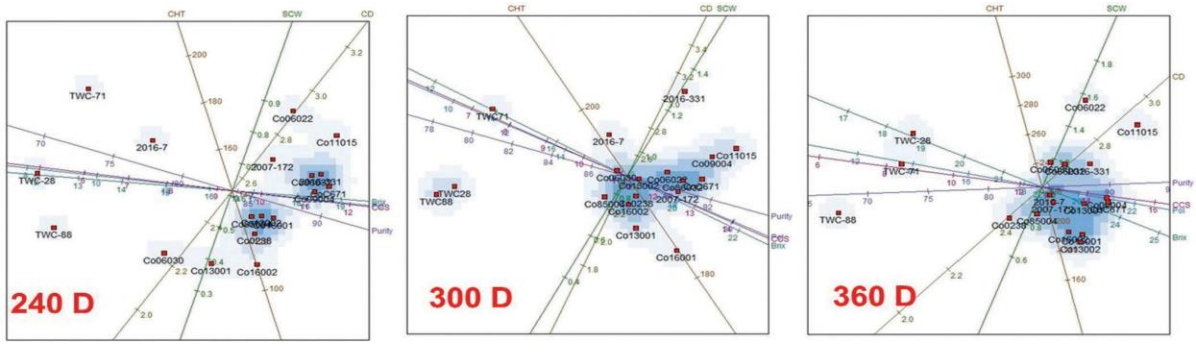


Fig. 12. Bi-plot showing the time lapse of changes occurring over the study period in the genotypes for the sugar traits studied. Juice analyses were performed for 240, 300 and 360 days(D). The recorded values for brix, polarity, commercial cane sugar(CCS), cane height (CHT), cane diameter (CD), and single cane weight (SCW) for the genotypes Co 0238, Co 06022, Co 06030, Co 09004, Co 11015, Co 13001, Co 13002, Co 16001, Co 16002, Co 85004, Co 86032, CoC 671, TWC-28, TWC-71, TWC-75, TWC-

88, 2007-172, 2016-331 and 2016-7 were used for the analysis.

product was amplified in all the 20 sugarcane genotypes for the GTL1A gene and sequenced. PCR conditions were standardized to amplify the 1.2 kb fragment of the SLAC gene, 1.7 kb SDD1 gene and 1 kb of SLAC 100 gene. The DNA sequence results of the GTL 1A genes are being analyzed for any changes in the nucleotide sequences and its effect on the alteration in the transcription factor functional domain. RNA isolation was also carried out for five of the low and high WUE sugarcane genotypes and expression analysis didn't show any WUE gene expression. The twenty sugarcane genotypes are being regularly maintained in field for further studies.

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

Gene discovery and genetic transformation in sugarcane

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

Upstream region (1102 bp) of phosphate transporter (*Pht*) gene was cloned and found promoter motifs (Fig. 13). 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 deletions (D1 to D5) construct were generated with different root specific motifs (Table 7). 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 T_1 were harvested from putative transgenic plants, and were sown to get T_2 seedlings.

(C. Appunu and H. K. Mahadevaswamy)

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

Based on the physiological analysis the genotype IND-16-1762 was chosen for molecular profiling of salinity stress responsive genes. This genotype was exposed to salinity stress at 8 ds/m and samples were collected after four days of stress for total RNA isolation. Twenty one

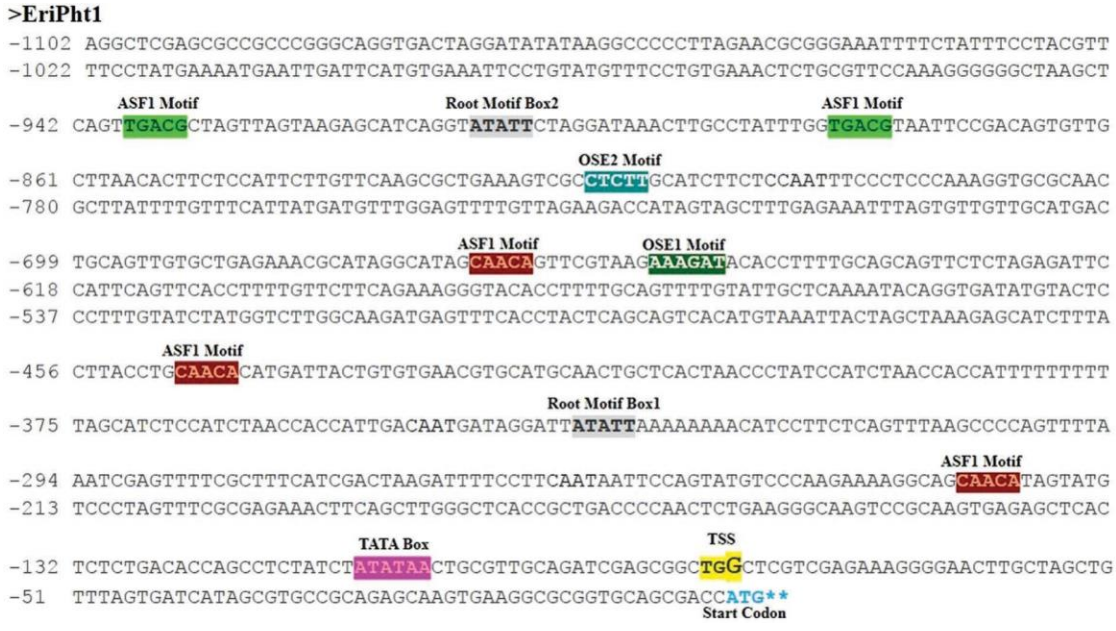


Fig. 13. Upstream region of Phosphate transporter gene with promoter motifs

Table 7. Putative tissue specific motifs found in EriPht1

Root motif	Sequence	Base No
RootmotiftapoxTAPOX1	ATATT or AATAT	(+) –275 to –271
ASF1 MOTIF CAMV	TGACG	(+) –275 to –271
ARFAT	TGTCTC	(–) –474 to –469
OSE1	AAAGAT	(+) –75 to –70
OSE2	CTCTT	(–) –175 to –171
RAV1AAT	CAACA	(+) –49 to –45
SURE core	GAGAC	(+) –474 to –470

genes/ transcription factors representing three gene families such as (a) salinity responsive gene (Glyoxalase I, II and lll; DREB, antiporter genes NHX and HYT1; salinity related protein and ABA inducer) (b) cell wall related genes (Laccase, Caffeic acid 3-O-methyltransferase, Cellulose synthase, pectin esterase, Peroxidase) and other abiotic stress signaling genes (Glutathione transferase, Aquaporin synthesis, nitric oxide synthase, genes encoding NAC domain and Photosystem II protein). Glyoxalase I involved in the glyoxalase pathway along with glyoxalase II (gly II) required for glutathione-based detoxification of methylglyoxal synthesized during salinity stress, had a 2.8 fold increase in gene expression. Antiporter gene NHX also had increased expression of 1.7 fold change during stress, which is involved in vacuole compartmentation (Fig. 14a). Among the cell wall related genes Laccase, Caffeic acid 0 methyl transferase showed an 1.7 and 1.8 fold change, while Cellulose synthase, Pectinesterase and Peroxidase showed 1.3, 1.1 and 1.3 fold change indicating that salinity stress is involved in response to the gene transcription regulating plant cell wall synthesis and hydrolysis (Fig. 14b). Lignification of the secondary cell wall was induced along with the increased expression of Laccase and peroxidase which are major player in Lignin polymerization. Among the signaling genes/ transcription factors Glutathione

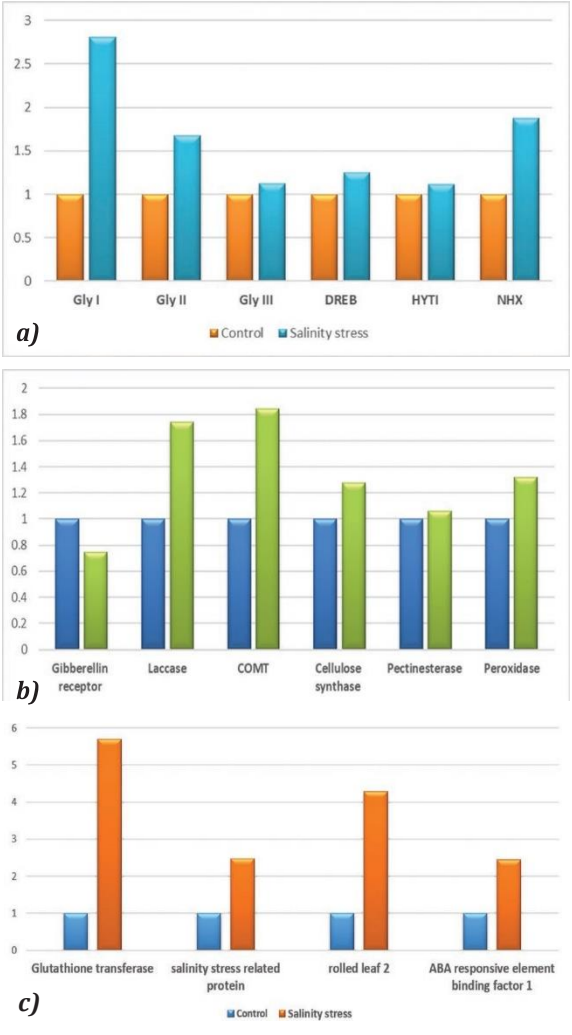


Fig. 14. Real Time Expression analysis of (a) Salinity responsive gene (b) Cell wall related genes (c) Abiotic stress signaling genes

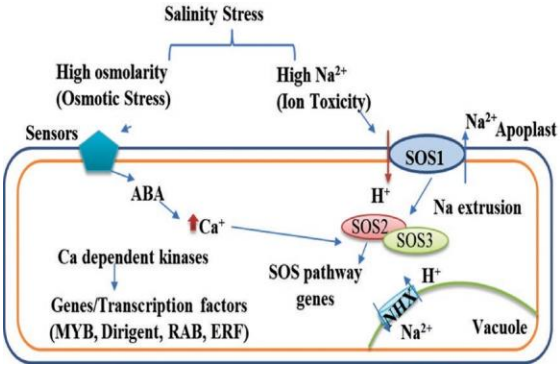


Fig. 15. The predicted gene network induced during salinity stress in S. spontaneum clones

transferase showed an increased expression of 5.4 fold change which was also as that of the expression of Glyoxlase I. Other genes were rolled leaf, salinity stress protein and ABA responsive protein which showed 4.1 and 2.2 increased fold change during salinity stress (Fig. 14c). Totally the glutathione pathway along with the SOS pathway were the prominent pathway induced with key gene player (SOS, Gly 1, RAB and NHX) induced during salinity stress in *S. spontaneum* (Fig. 15).

To perform SSH, total RNA was isolated from control (driver) and salinity stress exposed at 8ds/m (tester) plant material. The integrity and purity were analyzed through Nanodrop. Hence to develop a mRNA population it was converted to first strand and subsequently to second strand. Later these samples are subjected to *Rsa*I restriction and ethanol precipitation. A part of the restricted samples has been analyzed for the yield. The tester cDNA alone was ligated to two different adapters (1 and 2R) to perform forward subtraction. Presently the driver and the tester samples are analyzed for first hybridization. As we observed a poor yield (600 ng/µL) recovery after restriction and ethanol precipitation the experiment is repeated with higher yield of total RNA (~2 µg/µL). Standardization of first hybridization of stressed mRNA population against control mRNA population is being performed.

(K. Lakshmi and S. Vasantha)

CRISPR/Cas9-mediated targeted mutagenesis in sugarcane

Sugarcane, a tropical C4 grass in the genus *Saccharum* (Poaceae), accounts for nearly 80% of sugar produced worldwide and is alsoa prime feedstock for commercial biofuel production. Sugarcane is an interspecific hybrid with a complex, highly polyploidy genome, making crop improvement by breeding and genetic transformation challenging. In order to enhance the productivity, improve the quality and resistance to diseases and pests wild and exotic germplasm are being used in sugarcane improvement programmes. During introgression of various traits from wild and exotic germplasm into parents of hybrids, breeders have encountered issues of genetic drag/ donor's genome content (DGC). This bottleneck has compelled to find alternative technologies that make precise alterations inthe genome of the varieties or hybrids and, this may help to address regulatory hurdles to some extent. GE (Gene Edited) crops hold promise, as monoploid genome of sugarcane has been sequenced. So far, no study has been performed using CRISPR/Cas9-mediated targeted mutagenesis in sugarcane. In order to validate the genome editing in sugarcane through CRISPR/ Cas9 mediated gene editing by targeting *Phytoene Desaturase* (PDS) gene. PDS gene size of 1713bp was cloned from commercial sugarcane variety Co 86032 and *Erianthus arundinaceus*. Four guide RNA constructs were prepared and genetic transformation is in progress.

(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. Seven sugarcane genotypes (Co 14016, Co 86032, CoC 671, Co 17008, Co 0238, Co 12009, Co 0118) contrasting for tillering behaviour was selected and screened for both tiller bud initiation and bud outgrowth. The genotypes showed difference in both duration of tillering and the number of tillers developed during initial stages of settling development. After 40 days of planting the microscopic sections of first internode showed bud formation in high tillering varieties such as Co 14016, Co 86032 and Co 0238. The early bud formation also reflected in tiller developed after 60 days of planting. Genotypes Co 14016, Co 86032 and Co 0238 showed tiller developed after 60 DAPand after 90 days of planting high tillering genotypes Co 86032, Co 14016 showed well established primary and emerging secondary tillers. The relative expression of strigolactone branching inhibitor gene (MAX) was studiedin a set of seven genotypes contrasting for tillering behavior. The study showed significant

variation in expression profiles of strigolactone branching inhibitor gene (MAX) among high tillering and low tillering genotypes. Branching inhibitor MAX gene were less expressed in high tillering genotypes compared to the high transcript abundance in low tillering genotypes.

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

MULTI- DISCIPLINARY PROJECTS

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

(Bakshi Ram and G. Hemaprabha)

Inbreeding

Screening of inbreds for economic traits: Inbreds numbering 155 inbreds belonging to different stages of selfIng (S1 to S7) were studied for flowering behaviour, early sucrose accumulation potential at 240 days and red rot resistance for choosing the inbreds in crossing programme. H.R. Brix at 240 days was above 22% in nine inbreds, the highest being in the sixth generation inbred of Co 1148 *viz.* 1148-13-11-2-237-2- 360 (25.2%) and 17 inbreds combined red rot resistance and early high Brix (>20% at 240 days). Red rot evaluation of 143 inbreds revealed that two inbreds *viz.,* 1148-13-11-2-242-1-69 and ms 68/47-39 were resistant, while majority were either MR (59) or MS (47) or S types (34).

At 300 days, 224 inbreds were screened for juice quality traits along with CoC 671 and Co 86032. Among the inbreds, 1148-13-11-2-150 (20.19% sucrose) was on par with CoC 671 (20.45% sucrose) and ten inbreds viz.,1148-13-11-2-252-33-361 (19.84), 1148-13-11-2-252-180 (19.99), 1148-13-11-2-242-3-80 (19.71), 1148-13-11-2-242-1-56 (19.58), 1148-13-11-2-242-5-249 (19.44), 1148-13-11-2-1-42 (19.35), 86032 – 127 (19.21), 1148-13-11-2-242-5-263 (18.95), 775-5-102 (18.79 and 775-12-35 (18.51) were better than Co 86032 (18.40% sucrose).

Marker assisted selection among the selected inbreds to be used as parental lines for developing hybrid population was carried out to select inbreds with minimum heterozygosity. More homozygous lines identified were 775-21, 775-12-18, 775-148, 775-12-23, 99008-106, 99008-107, 99008 -108, 99008-340-343, 1148-13-11-2-237-2-6, 1148-13-11-2-237-2-69, 1148-13-11-2-237-2-81, 7201-153-1, 7201 -138, 7201 -135, among which 1148-13-11-2-237-2-61 exhibited maximum homozygosity (Fig. 16) and was used in selfing as well as crossing with other promising inbreds.

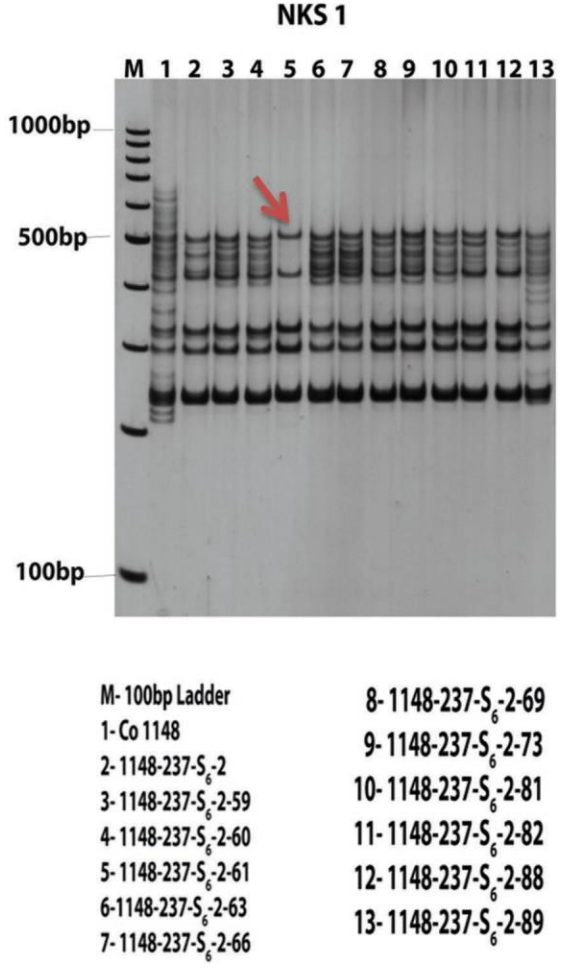


Fig. 16. Molecular profiling of Co 1148 and S6selfs based on the primer NKS 1

Inbreeding depression and hybrid vigour: Progenies of two crosses involving the 1148-13-11-2-237-2- 61 and its selfs were studied for cane characters. Least segregation in cane characteristics was observed in the crossed population with over 90
% of the clones were of yellow purple / purple yellow colour range and with tall medium thick vigorous canes. In contrast its selfs (S7) exhibited high inbreeding depression. The magnitude of vigour in hybrids in relation to the selfs for early growth parameters is shown in Fig. 17.

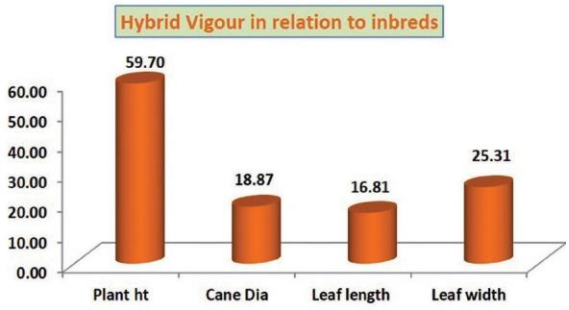


Fig. 17. Improvement of hybrids (S6 x S6) over S7 inbreds of the S6 parent 1148-13-11-2-237-2-61

Category wise and generation wise evaluation of the inbreds from ten commercial hybrids belonging to S1 to S7 generations were carried out. CV of the selfed population revealed less variability in the inbred groups of Co 95012, Co 99008, Co 86032 and Co 7201. Within the inbred groups, the S_2 inbreds derived from 775-27, S_5 population derived from 1148-13-11-2-242 and 1148-13-11-2-251 and sixth generation progeny from 1148-13-11-2-242-1 exhibited high uniformity for ten traits as well as for cane stand. Results of the STRUCTURE analysis identified groups with less gene flow and less heterozygosoty index for further selfing. Based on flowering synchrony, 20 selected inbreds were intercrossed to effect 12 crosses for progeny evaluation. Fifteen Co canes and 25 inbreds of early and advanced generations were also utilized in order to attempt development of near homozygous populations.

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

Anther culture

Among the 27 calli, the plants derived from two calli are phenotypically distinct from Co 86032, reduced vigour, thin canes and reduced bud size, bud groove enlarging upto next node and smaller leaf canopy. Cytological and molecular characterizations are in progress. During 2019-20, 200 and 20 calli were generated from anther derived microspores of Co 86032 and Co 16001 respectively by manipulating different media composition and plantlets are presently under hardening stage. Co 86032, Co 0238, Co 11012, were cultured in the flowering season 2020-21. The callus induction was observed in Co 86032 and other genotypes did not respond. Co 775 developed phenolic and both anthers and media turned brown/blackish. Other genotypes such as Co 11012, CoVc 14061, Co 12009 and Co 0212 showing early sign of androgenesis like bulging of anther.

(C. Mahadevaiah, Sanghamitra Samataray and H.K. Mahadevaswamy)

Chromosome elimination

In order to identify the CENH3 mutation and polymorphisms in heteroduplex DNA of the EMS treated mutants of Co 775, a mismatch-specific DNA endonuclease from surveyor mutation kit has been used. The DNA fragments at mismatched sites were analyzed by PAGE. In three pools (4x3) additional bands were observed as a result of formation of cleaved products due to the presence of one or more mismatches. These three DNA pools (Sample ID I, II, III with individual E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11 and E12), which showed cleaved bands on PAGE analysis were selected for individual analysis and subjected for second screening (individual mutant screening). The genomic DNA from these 12 samples were amplified with advantage PCR kit with gene specific primers and examined for a the presence of the

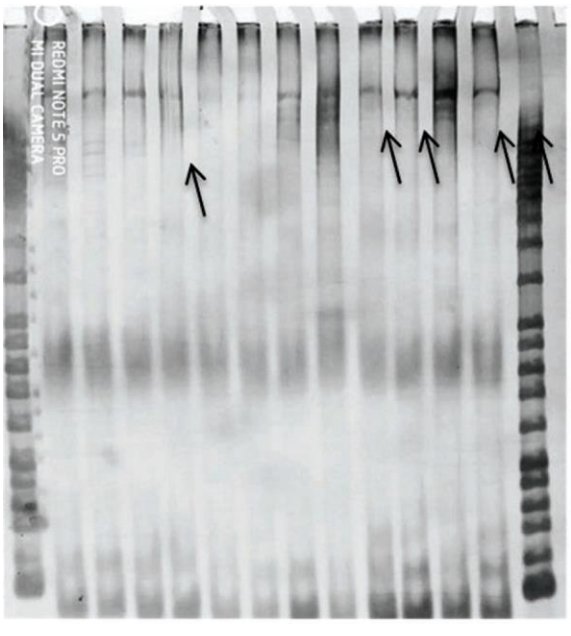


Fig. 18. PAGE profile showing five samples with cleaved bands

single band (CENH3 600 bp). The protocol for mutation detection in individual samples was repeated through IDT surveyor kit with PCR amplicons from 12 individual mutant (test) and wild type DNA (reference-Co775). Mixed equal amounts of test and reference DNA, hybridize them by heating and cooling the mixture to form hetero and homo duplexes. The annealed heteroduplex/homoduplex mixture was treated with Surveyor Nuclease. The reference DNA alone treated similarly, serves as a negative control. Out of the 12 individual samples we were able to observe cleaved bands in five individual samples (E2, E5, E6, E10, E11) (Fig. 18). These five samples have been amplified and submitted for sequence analysis. Identified these clones from mutant population and planted them in the field.

(V. P. Sobhakumari and K. Lakshmi)

Wide hybridization

A total of 69 inter-generic crosses were made during 2019 between sugarcane (as female & male) and sweet corn, sweet sorghum, bajra, *Narenga*, *Erianthus*, Fodder type *Sorghum halepense* to generate haploid. Chromosome numbers of 73 putative inter-generic hybrids were determined. It ranged from 2n=14 to 2n=100. A hybrid with 2n=60 from the cross of *S. officinarum* x maize was found. In the cross between sugarcane cv. CoJ 64 x sweet sorghum, four hybrids with 2n=70-75 were identified. Haploid seedling could not be found.

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

Apomixis

Apomixis regulating genes from sorghum and maize were used as references for retrieving sequences from published sugarcane genome data and primers were designed. Genes for which sequence information were not available from sugarcane, sequences from sorghum and maize were used as such. *Baby boom* 1, *somatic embryogenesis receptor-like kinase (SERK)* 1, *ameiotic* 1, *DMT102 methyltransferases* and *suppressor of gene silencing* 3 were some of the important genes that are identified, cloned and are being studied currently. The full-length sequence of *SERK* gene of 1200 bp cloned and sequenced from sugarcane showed 96% sequence similarity to *Zea mays SERK* gene. This gene is responsible for the processes of cell-signalling and transport events in sporogenesis, embryogenesis and gametogenesis. Gene editing will be taken up as and when the full-length gene sequences from sugarcane are obtained from the study.

(P.T. Prathima and C. Appunu)

Evaluation of hybrids

Extent of variability in the intermated inbred progenies: Variability was assessed in nine combinations of intermated inbreds for caneyield and juice quality traits. The combination S6x S6 (1148-13-11-2-242-2-61x 1148-13-11-2-242-3-272) registered the least variability (Table 8) for cane diameter (7.88%), cane height (14.15%), single cane weight (19.72%), number of millable canes per clump (35.61%) and HR brix (13.11%). This cross displayed two color groups i.e. purple waxy (72.50%) and purple green (27.50%). Comparative performance of progenies from inbreds at different stages indicated a gradual reduction in the magnitude of variability across intermatings involving clones from S1 to S6. Among the traits, cane diameter was found to be the most stable trait that recorded the maximum reduction in variability of 46.94 % (Fig. 19) followed by single cane weight (23.71%), HR brix (22.15%), cane height (20.59%) and NMC/clump (18.54%).

Assessing variability in biparental crosses: Nine hundred and fifty three seedling progenies from ten biparental crosses were evaluated for cane yield parameters, HR brix and cane

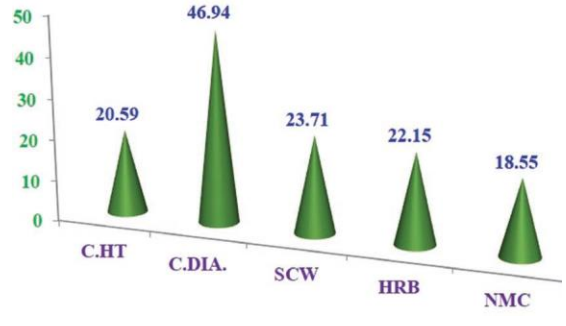


Fig. 19. Percent reduction in variability (S1-S6) in intermated inbred progenies

Table 8. Extent of variability in S6xS6 intermated inbreds for cane yield and juice quality

S6xS6	CANE		SCW	HRB	NMC
	HEIGHT	DIAMETER			
Mean	244.65	2.70	1.08	18.98	5.27
MIN	165.00	2.06	0.63	12.00	2.00
MAX	350.00	3.14	1.65	24.40	14.00
SD	34.62	0.21	0.21	2.49	1.88
CV	14.15	7.88	19.72	13.11	35.61

color. Percent variability for number of millable stalks ranged from 30.68% (Co 99008 x CoPant 97222) to 63.68% (CoVc 14061 x Co 94008). For cane diameter, the cross Co 86032 x SP- 80-185 recorded the least variability of 9.62 % while the cross CoVc 14061x CoC 671 recorded a maximum variability of 17.15%. Percent variability for cane height ranged from 15.06 % (Co 99008 x CoPant 97222) to 25.30% (CoVc 14061 x CoC 671). The cross Co 86032 x SP 80-185 recorded the minimum variability of 11.15 % for H.R. brix while the cross Co 85002 x Co 1148 recorded the maximum (16.42%). Number of groups with regard to stalk color varied from three to four and yellow green was the most predominant one among the crosses screened. The seedling progenies from two crosses *viz*., Co 99008 x CoPant 97222, Co 8371 x CoVc 14061 had more than eighty percent individuals exhibiting yellow green stalk color (Table 8).

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

Evaluation for diseases

Assessing phytotoxic effect of fungicide on germination of true seed: The fungicide captan + hexaconazole (Taqat 0.1%) was treated on fuzzed and defuzzed seeds of BO 130 and Co 1331, stored at -20°C and assessed for germination at monthly interval for 5 months. The seeds stored without fungicide treatment served as control. In BO 130 the germination of fungicide treated defuzzed seeds varied from 35 to 41.5%, while in control the germination ranged from 31.5 to 40%. In Co 1331 the germination of fungicide treated defuzzed seeds varied from 38.5 to 45%, while in control the germination ranged from 28.5 to 38.5%. When compared to control no germination loss was found in fungicide treated fuzzed and defuzzed seeds of both the varieties.

Assessing diseases of true seed: The inflorescence of sugarcane crop in National Hybridization Garden and other experimental fields of SBI, Coimbatore were observed in this flowering season for diseases on true seed. The visual observations and microscopic examination showed no disease development in any of the inflorescence.

(V. Jayakumar and K. Nithya)

Seed processing, packaging and storage

A prototype model of a brush-operated sugarcane seed defuzzing machine was fabricated in collaboration with ICAR - CIAE Regional Centre, Coimbatore. Rotating, circular nylon brushes were deployed for defuzzing and oscillating sieves for seed cleaning. Power transmission effected through 1HP electric motor. The seed fluff fed between the rotating brushes will get defuzzed and cleaned. The machine has been tested for its efficacy by feeding seed fluff of GCs. The seed recovery ranged from 50-70% and No reduction in seed germination has been noticed as compared to seed fluff. (Fig. 20)

(N. Rajendra Prasad)

All India Coordinated Research Project (Sugarcane)

(Bakshi Ram and P.G ovindaraj)

Peninsular Zone

Initial Varietal Trial

Among the fifteen test entries evaluated Co 11015 recorded the maximum CCS yield of 23.19 t/ha

Fig. 20. Brush-Operated Defuzzing Machine developed by (ICAR-SBI and ICAR-CIAE)

followed by Co 16009 (19.35 t/ha) and Co 16006 (18.97 t/ha). Among the standards, Co 09004 recorded the highest CCS yield of 20.50 t/ha followed by CoC 671 (17.63 t/ha) and Co 86032 (16.54 t/ha). The standard Co 09004 (129.90 t/ha) recorded the highest cane yield followed by Co 86032 (118.87 t/ha), while the entries CoM 16082 recorded the highest cane yield of 147.67 t/ha followed by Co 11015 (144.57 t/ha) and Co 16009 (137.91 t/ha). The highest sucrose content at 12th month was recorded by the standard Co 09004 (22.29%) followed by CoC 671 (21.01%) and at 10th month, Co 09004 recorded the highest sucrose content of 19.52% followed CoC 671 (19.32%). Among the test entries, Co 11015 recorded the highest sucrose content of 22.58% at 12th month and 19.41% of sucrose at 10th month (Table 9).

(C. Mahadevaiah and S. Sheelamary)

Advanced Varietal Trial (II Plant)

Seventeen entries along with three standards were evaluated for cane yield and juice quality traits at 240, 300 and 360 days. At harvest (360 days) the entry Co 13003 recorded the highest sugar yield (19.2 t ha^{-1}) followed by Co 13014, Co 13020, Co 13009, Co 13008, Co 13002, Co

Table 9. Performance of entries in Initial Varietal Trial

Clone	CCS (t/ha)	Cane yield (t/ha)	CCS (%) (12m)	Sucrose (%) (12m)	CCS (%) (10m)	Sucrose (%) (10m)
Co 11015	23.19	144.57	16.04	22.58	13.68	19.41
Co 16006	18.97	136.30	13.94	19.73	13.54	19.13
Co 16009	19.35	137.91	14.07	19.98	11.82	17.06
Co 16010	18.46	131.53	14.02	19.89	13.10	18.60
Co 16017	16.24	119.30	13.60	19.39	12.15	17.42
Co 16018	14.00	129.30	10.83	16.01	11.50	16.47
CoVc 16061	7.95	62.00	12.82	18.57	12.17	17.59
CoVc 16062	13.16	108.30	12.19	18.02	11.83	17.03
CoN 16071	14.92	108.89	13.70	19.43	11.84	16.91
CoM 16081	14.53	121.17	11.99	17.29	10.40	15.17
CoM 16082	19.56	147.67	13.25	18.91	12.04	17.29
CoVSI 16121	11.97	76.20	15.70	22.10	14.14	19.94
PI 16131	10.58	80.82	13.04	18.67	13.16	18.81

CoR 16141	14.28	122.74	11.57	17.36	9.97	14.66

Clone	CCS (t/ha)	Cane yield (t/ha)	CCS (%) (12m)	Sucrose (%) (12m)	CCS (%) (10m)	Sucrose (%) (10m)
CoR 16142	14.54	122.03	11.86	17.50	11.99	17.05
Standards						
Co 86032	16.54	118.87	13.90	19.73	12.22	17.44
CoC 671	17.63	118.81	14.89	21.01	13.58	19.32
Co 09004	20.50	129.90	15.79	22.29	13.79	19.52
C.D.	3.67	23.08	1.24	1.324	1.07	1.39
C.V.	13.85	11.78	5.49	4.104	5.18	4.70

13018, Co 13013, PI 13132 and CoSnk 13103, and were significantly superior to the best standard Co 86032 (13.76 t ha^{-1}). The highest cane yield at harvest was recorded by Co 13014 (145.8 t ha^{-1}) followed by Co 13009, Co 13013, Co 13020, Co 13008, Co 13002, PI 13132, Co 13003, Co 13018 and CoSnk 13103 and their cane yield were significantly superior over the best standard CoSnk 05106 (103.48 t ha^{-1}). At harvest only Co 13003 recorded the highest juice sucrose (21.44 %) than the best standard CoC 671 (20.47 %). At 300 days Co 13002 recorded numerically superior juice sucrose (19.30 %) than the best standard CoC 671 (18.17 %).

(S. Karthigeyan and H.K. Mahadevaswamy)

Advanced Varietal Trial (Ratoon)

Seventeen entries along with three standards were evaluated for yield and quality traits at 9th and 11th month during 2019-20. Three entries *viz*., Co 13003 (17.41 t/ha), Co 13014 (17.81 t/ha) and PI 13132 (17.16 t/ha) recorded significantly higher sugar yield than the best check Co 86032 (13.85 t/ha). None of the entries was superior for sucrose content compared to CoC 671, however seven entries recorded significantly superior sucrose than Co 86032 (19.55%).

(K. Mohanraj and K. Elayaraja)

Advanced Varietal Trial (Mean performance of two plant and one ratoon crop)

The trials were conducted during the years 2018-19 and 2019-20 and the mean of two plant crops and one ratoon showed that the highest sugar yield was recorded by the entry Co 13014 (18.05 t/ha) followed by Co 13003 (17.90 t/ha) compared to the best standard Co 86032 (14.49 t/ha). The entry Co 13014 also recorded the highest cane yield of 138.78 t/ha followed by PI 13132 (138.26 t/ha). For juice quality, none of the entries was superior compared to the best standard CoC 671 (21.40%). However, nine entries showed comparatively higher sucrose content than the standard Co 86032 (19.51%). Among the entries Co 13003 recorded the highest sucrose of 20.84% followed by Co 13020 (20.36%) (Table 10).

(K. Mohanraj, V. Sreenivasa, H.K. Mahadevaswamy, S. Karthigeyan and K. Elayaraja)

Table 10. Mean of two plant and one ratoon in AVT at Coimbatore

Clone	CCS yield (t/ha)	Cane yield (t/ha)	CCS (%)	Sucrose (%)
Co 13002	15.70	111.99	14.03	19.86
Co 13003	17.90	121.42	14.71	20.84
Co 13004	15.26	107.35	14.21	20.08
CoN 13072	11.62	93.65	13.32	18.04
CoSnk 13101	11.86	83.79	13.60	20.00
MS 13081	16.30	120.45	13.43	19.09

Co 13006	14.86	106.97	13.69	19.61

Clone	CCS yield (t/ha)	Cane yield (t/ha)	CCS (%)	Sucrose (%)
Co 13008	15.09	108.69	13.90	19.70
Co 13009	14.48	112.83	13.02	19.06
Co 13013	16.07	124.44	12.91	18.46
Co 13014	18.05	138.78	13.06	18.58
Co 13018	16.07	114.97	13.95	19.75
Co 13020	15.56	108.75	14.32	20.36
CoN 13073	10.43	85.18	12.14	17.43
CoSnk 13103	13.91	98.50	14.13	20.00
CoSnk 13106	12.53	93.05	13.42	19.02
PI 13132	17.87	138.26	12.99	18.46
Standards				
Co 86032	14.49	105.50	13.69	19.51
CoC 671	13.71	91.97	14.91	21.40
CoSnk 05103	13.49	105.63	12.77	18.18

Advanced Varietal Trial (I Plant)

Thirteen entries were evaluated for yield and juice quality and the entry Co 14016 recorded the highest cane yield of 150.42 t/ha followed by MS 14082 (145.47 t/ha). Seven entries recorded significantly higher cane yield than the check Co 86032 (121.97 t/ha). Five entries recorded significantly higher sugar yield than the best check CoC 671 (17.30 t/ha). For juice quality, only one entry Co 14032 (21.22%) recorded higher sucrose than the best check CoC 671 (21.14%) and four entries recorded higher sucrose than the standard Co 86032 (19.10%). The entries Co 14004 and Co 14027 were significantly superior for both yield and quality traits.

(K. Mohanraj and A. Anna Durai)

Multiplication and exchange of seed material

Seed materials of 65 ZVT entries were multiplied during 2019-20. Supplied 14 IVT entries to seven AICRP(S) Centres in Peninsular Zone namely, Rudrur, Perumalapalle, Mandya, Thiruvalla, Sameerwadi, Pugalur and Powerkheda.

(R. Karuppaiyan and C. Appunu)

Evaluation and identification of climate resilient ISH and IGH genetic stocks

Multiplication of climate resilient trial: Forty nine climate resilient clones comprising of eighteen water logging tolerant, eight drought tolerant, twenty 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

Supply of fluff (National Hybridization programme -2019): Fluff weighing 29.29 kg from crosses made at NHG during 2019 flowering season along with the particulars on germination was supplied to the 24 participating centers of fluff supply programme. Fluff of 27 general collections was sent to Bathuadahari center based on special request. Fluff (864.2 g) of 42 bi-parental crosses effected at National Distant Hybridization Facility (NDHF), ICAR-SBI, Research Centre, Agali were also sent to the nine participating centres attending crossing progarmme at Agali. Altogether 30.15kg of fluff was supplied to the 24 participating centres of fluff supply programme. Quantity of fluff supplied to the participating centers during February 2020 is given in the Table 11.

Hybridization (National Hybridization programme 2020): This year, since the COVID-19 pandemic has restricted travel, ICAR-Sugarcane Breeding Institute has taken up the responsibility of making the crosses for the entire country. The centres were asked to send the list of crosses of their choice. Among 24 participating centres, 22 centres have sent

Table 11. Details of crosses made and fluff supplied

Centre	Bi-parental crosses		General collections		Polycrosses		Total fluff weight (g)
	No.	Fluff weight (g)	No.	Fluff weight (g)	No.	Fluff weight (g)	
Peninsular Zone							
Mandya	21	544.0	20	299.0	13	193.0	1036.0
Navsari	22	580.0	30	525.0	13	184.0	1289.0
Padegaon	21	513.4	12	231.5	13	281.0	1025.9
Perumalapalle	26	556.0	21	572.0	13	183.0	1311.0
Powarhkheda	15	274.0	23	430.0	12	151.0	855.0
Pune	23	577.0	14	259.5	13	197.0	1033.5
Rudrur	31	732.0	22	351.0	13	201.0	1284.0
Sankeshwar	26	289.6	18	421.0	13	198.0	908.6
Thiruvalla	21	432.0	29	745.0	13	181.0	1358.0
Subtotal	206	4498.0	189*	3834.0	13*	1769.0	10101.0
East Coast Zone							
Anakapalle	30	727.7	29	502.0	13	208.0	1437.7
Cuddalore	26	666.0	21	449.0	13	192.0	1307.0
Nayagarh	22	539.0	20	560.4	13	194.0	1293.4
Vuyyuru	21	510.0	16	329.0	13	225.0	1064.0
Subtotal	99	2442.7	86*	1840.4	13*	819.0	5102.1
North West Zone							
Faridkot	19	293.9	47	844.7	5	137.8	1276.4
Kapurthala	34	730.3	30	647.9	5	136.9	1515.1
Lucknow	34	852.1	45	794.1	5	144.8	1791.0
Pantnagar	15	299.0	32	624.5	5	125.0	1048.5
Shahjahanpur	33	759.0	56	1140.0	5	123.0	2022.0
Uchani	24	477.5	27	465.9	5	117.6	1061.0
Subtotal	159	3411.8	237*	4517.1	5*	785.1	8714.0
North Central and North East Zone							
Bathudahari	-	-	27	343.0	-	-	343.0
Buralikson	16	395.0	25	550.8	5	110.3	
Motipur	20	432.0	21	472.0	5	125.0	1029.0
Pusa	36	802.0	28	677.5	5	102.0	1581.5
Seorahi	26	854.0	10	372.0	5	139.4	1365.4
Subtotal	98	2483	84	2415.3	5*	476.5	5375.0
Total	562	12835.5	245**	12606.8	18**	3849.8	29292.1

*including duplicates; ** excluding duplicates

the details of crosses. Hybridization work was initiated on 27th October 2020 and concluded on 5th December 2020. Out of 424 parents, 411 flowered with flowering intensity of 96.93 % and totally 426 crosses were effected for 21 centres.

Maintenance of parents (National Hybridization programme 2021): National Hybridization Garden 2021 was planted with 431 parents which included 7 introductions *viz*., 2014 A 340, CoA 16321, CoPant 12221, CoPant 12226, CoPb 18211, CoS 14231 and S 301/ 87.

(A. *Anna Durai, V. Sreenivasa*

and N. Rajendra Prasad)

Agronomic performance of elite sugarcane genotypes

A new experiment entitled "Agronomic performance of elite sugarcane genotypes" was laid out in split plot design with two replications. In all 8 elite sugarcane genotypes Co 13006, Co 13008, Co 13009, Co 13018, Co 13020, Co 86032, CoC 671 and Co 09004 with two fertilizer levels (100% RDF and 125% RDF) were planted in wide row spacing (150 cm). Sugarcane cane yield was influenced significantly due to different elite genotypes wherein, elite sugarcane genotype Co 13008 recorded significantly higher cane yield (134.00 t/ha) than two standard check varieties Co 86032 (122.65 t/ha) and CoC 671 (118.39 t/ha). Data were recorded on growth, juice quality, cane yield and yield attributes. Cane yield and juice quality were not influenced significantly due to fertilizer levels.

Juice quality (Brix, sucrose, purity and CCS percent) was studied by collecting cane samples at harvest. Juice Brix, Sucrose%, Purity % and CCS % at harvest showed significant varietal differences. Among different entries, Co 13020 recorded significantly higher mean sucrose % of 20.57 than Co 86032. Amongst the 8 elite sugarcane genotypes Co 13020 was found more promising and recorded significantly higher CCS yield of 19.70 t/ha than the check entries Co 86032 (16.86 t/ha) and CoC 67 (18.40 t/ha).

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

Identification of pathotypes / races of red rot pathogen

Three new isolates (Cf86032- NKM, CfM0265-Palapatti and Cf86027-Amaravathi) along with five old isolates and two standard pathotypes (CF06 and CF12) were inoculated on 19 sugarcane differentials and disease intensity was rated. The standard isolate CF12 was more virulent followed by an old isolate Cf86027-Vellalapalayam. Among new isolates Cf86032 NKM and CfM0265-Palapatti exhibited moderate level of virulence, while Cf86027-Amaravathi exhibited least virulence among all the tested isolates. Among the old isolates CfC24-Thandavarayanpatti showed distinct differential reaction from standard isolates on five varieties and the isolates CfM0265-RK Pet and CfC24-Mandagapattu also showed differential reaction from standard pathotypes on few host differentials. The new isolates exhibited more or less similar reactions of standard pathotypes on all the host differentials.

(V. Jayakumar and R. Selvakumar)

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

About 12 AVT entries were evaluated for red rot resistance under field conditions and among them 5 were found to be R/MR by plug method and 11 were resistant under nodal method against CF06 pathotype. Among the 18 IVT entries evaluated for red rot resistance under field conditions, 14 were found to be R/MR by plug method and 16 were resistant under nodal method against CF06 pathotype. Totally, 30 IVT and AVT entries were evaluated against sugarcane smut reactions under field conditions following standard dip inoculation method. Among them six entries Co 15009, Co 15017, Co 17002, Co 17004, MS 17081 and MS 17082 were identified as resistant, whereas four entries, Co 15006, Co 15010, CoN 15071 and Co 17012 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, of the 18 entries 7 (38.8%) were identified as R, 44.44% as MS, and only one entry was HS and S *viz.* Co 17013 and Co 17006, respectively. In AVT I plant, out of 12 entries, 7 entries were identified as R (58.33%), 3 MR (25%), and one exhibited MS (Co 15010) and one was HS (Co 15006). In AVT II plant, 93.33% entries were identified as R and only one, Co 14027 was identified as MS to YLD whereas, the same 15 entries in ratoon (AVT I plant) exhibited different reactions *viz.,* R was observed only at 20% in the entries *viz.,* CoT 14367, Co 14030, and CoSnk 14102, 26.66% were MR, 33% were MS and 13.33% were S (Co 14012, Co 14027).

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

Assessment of elite ISH clones for resistance to red rot

About 30 ISH and IGH clones were evaluated for red rot resistance by plug and nodal methods under field conditions against the pathotypes CF06 and CF12. About 20 of them were identified as resistant to the pathotypes by plug method and 25 resistant under nodal method.

(R. Viswanathan)

Survey and surveillance of sugarcane insect pests

In sugarcane farms around Coimbatore, internode borer incidence was low (13.0-16.9%) during February-March 2020. The incidence was slightly higher (17.9%) in August 2020 with considerable plot-to-plot variation. Stray incidence of mealybug and woolly aphid was also observed in growers' farms. In Satyamangalam area, endemic for white grub, variable incidence was observed in growers' farms with a mean grub number of 6 per sq m.

Monitoring: Internode borer incidence in monitoring plot was generally low during October-December 2020 with a range of 0.9-4.9%, the highest being in November. Besides internode borer, stray incidence of whitefly, mealybug, leaf mite and woolly aphid was noticed in the crop.

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

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

In order to economize the media for mass production of EPF, jaggery based media were assessed for spore production and virulence. Sabouraud' Dextrose Broth or Emerson's YPSS media were the standards. The YPSS medium was amended by replacing the soluble starch with jaggery at 0.5 - 1.5% concentration, to economize. Spore yield of *B. bassiana* was 12.2, 10.4, 9.2 x 10^7/ml in Jaggery 0.5, 1 and 1.5% jaggery based media respectively in comparison to 2.27 and 15 x10^7/ml in the standards, SD and YPSS. Production of 4.3, 3.75, 4.03 x 10^8/ml of *B. brongniartii* spores was observed in 0.5-1.5% jaggery media while very low production of 3.4 and 12.2 x 10^7/ml were produced in the standards SD and YPSS respectively. The jaggery media produced the highest number of *M. anisopliae* (14.2 x 10^7/ml) at 1.5% concentration while it was 10.3 and 13 x 10^7/ml at 0.5 and 1.5% jaggery concentration. SD media produced low number of spores (0.09 x 10^7/ml) but YPSS yielded 11.8 x 10^7/ml of *M. anisopliae* spores. The virulence of *B. bassiana* against *G. mellonella* was maximum (93.33 when produced in jaggery 1.0 and 1.5%) but was the lowest from the spores produced in SD at 56.67%. Similar pattern of higher efficacy with jaggery medium-derived spores was observed in *B. brongniartii* with more than 90% mortality at 1.0 and 1.5% concentration and lower than 60% efficacy with spores derived from SD medium. However , with reference to *M. anisopliae* spores, it was seen that the virulence of YPSS –derived spores was 93.33% which was the highest while that harvested from jaggery was 83.3% or lesser. That *M. anisopliae* needs more carbon to produce colony and subsequent spores than either of *Beauveria* spp. is proven.

Impact of pH of culture media on the virulence of EPF was assessed with relevance to molasses media at varied concentrations. Of the two sets of experiments conducted, in the first set, molasses at the concentration of 0.3 to 1.5% whereas in the second set, molasses of 2.0 to 5.0% without any supplements were used with or without pH adjustments for production of *B. bassiana* , *B. brongniartii* and *M. anisopliae* whose virulence of spores were subsequently checked. Both SD and Potato Dextrose broths served as the standards. Highest virulence in molasses medium with pH adjustment was observed at the concentration of 1.2% in the first set and at 4.5% in the second set (94.44%) followed by 2.0 % and 4.0% (88.89 %). The standard medium SD produced more virulent spores (94.44%) than PD (61.11%). The molasses media without pH produced variable results with the highest virulence recorded by *B. bassiana* spores harvested from 3.5% molasses (58.33%) while virulence as low as 5.56% was recorded in treatment with *B. bassiana* derived from 5.0% molasses without pH adjustment. Spore production of *B. bassiana* in molasses-based media with or without pH adjustment

showed that PD (12.27 x 10^7/ml) as standard was better than SD (0.36 x 10^7/ml) and the spore harvest ranged from 0.92- 1.36 x10^7/ml mostly in response to increase in concentration. The production of *B. bassiana* ranged as 11.6, 12.67, 15.33, 18.00, 19.07, 20.10, 20.27 x10^7/ml at 2, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0 % concentration of molasses respectively when amended with pH but when, not adjusted for the pH 5.7 the *B. bassiana* spore harvest was affected tremendously with 2.4, 3.2, 2.4, 3.2, 2.4, 1.2, 1.2 and 1.07 x10^7/ml at the corresponding concentrations, respectively.

In case of *B. brongniartii* production of spores below 1.5% concentration of molasses with or without pH adjustment was not economical. The maximum production was 0.47 x10^7/ml while in the standard PD it was 25.33 x10^7/ml. When the concentrations were increased gradually from 2.0 to 5.0%, the maximum production of spores was at 3.0% (12.0 x10^7/ml) , the rest resulting in lower production. However, the mortality was highest when the spores were harvested from 0.3% medium (97.23%) while that from SD and PD showed 44.4 and 86.1% mortality. However, when the concentrations tested ranged from 2.0-5.0% the mortality observed was more than 90% with cannibalism pooled in. Without the amendment of pH, the production of spores ranged from 5.47 to 18.27 x10^7/ml at 3% and 5% concentration respectively. Virulence of *B. brongniartii* was highest when derived from media of 2% concentration (22.2%) and lowest at 0.3% concentration (88.89%).

When the same studies were repeated with Jaggery medium at the same concentrations, *B. brongniartii* produced highest number of spores at 2% concentration (2.0 x10^7/ml) which was comparable with SD but not YPSS (15.47 x10^7/ml) and the mortality ranged between 6.67% and 80.0% at various concentrations of jaggery medium amended with pH. Without the amendment of pH spore production was very scanty though the virulence of *B. brongniartii* was more than 80% when concentration exceeded 3.0%. Similar variability was observed with both jaggery and molasses medium with reference to amendment with pH affecting the spore production and efficacy of *M. anisopliae*.

An improved medium with increased concentrations (10 and 15%) of jaggery and amended with supplements was assessed for culturing the EPF and compared with jaggery media without supplements. Oats medium and YPSS were standards. Termed SBI-I and II, they yielded encouraging results. However, the response was species-specific. For example, the spore production of *M. anisopliae* was 8.27 and 9.6 x10^7/ml in jaggery 10% and SBI-I respectively while at 15% jaggery concentration it was 11.87 but ,10.93 in SBI-II. While being much higher than what was produced in oats medium (5.07 x10^7/ml) they were lower than that in YPSS (17.33 x10^7/ml). Efficacy data showed that highest mortality was seen with SBI-I(94.44%) comparable with 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 which was again species-specific.

Mass production techniques for *Aschersonia placenta* an EPF on whitefly were standardized and the growth on SBI medium at both concentrations (10 and 15%) was comparable with standard mediums available.

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

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

Maintenance breeding: A total of 233 tropical sugarcane reference varieties (RV) were maintained in field through clonal propagation and in disease free condition.

Re-characterization of Reference varieties: Reference varieties maintained at Coimbatore Centre (30 varieties) were re-characterized.

Conduct of DUS test for FV: DUS test was completed in three farmer's varieties *viz*., Desi 1, Desi 2 and Meitei Chu Angangba. Desi 1 was distinct from both the reference varieties IJ 76-317 and Tahiti 3 for leaf sheath adherence, ligule shape, shape of inner auricle, dewlap colour and bud groove. Desi II was distinct from NG 77-137 and 57 NG 192 for ligule shape, internode colour

(not exposed to sun), zigzag alignment, bud groove and number of millable canes. Meiti Chu Angangba was distinct from NG 77-015, HM black and Red sport for internode colour (not exposed to sun), internode shape and waxiness. All the three varieties were distinct from their respective reference varieties.

DUS test (2020-21): Two farmer's varieties Jeet Katari (RV:Tahiii-3 and NG 77-015) and Sugam Katari (RV: IJ 76-317, NG 77-137 and 57 NG 192) were planted during February, 2020. Variety Co 09004 from ICAR-SBI Coimbatore was planted along with reference varieties *viz.*, CoV 89101, CoN 95132, Co 7717 and zonal standards of Peninsular zone *viz.*, Co 86032 and CoC 671 for conducting DUS test. The candidate variety Co 09004 was distinct from all the reference varieties. Both the farmer's varieties were also distinct from their reference varieties.

(S. Alarmelu and C. Jayabose)

Sugarcane seed production: ICARmega seed project: Seed production in agricultural crops and fisheries- sugarcane

Breeder seed production

The crop period was most favourable to undertake quality seed production by the seed unit both at the Institute and the seed villages. The indents received in advance from farmers and sugar factories for both breeder seed cane and tissue culture plants were supplied to the maximum extent possible. The efforts initiated during previous years had strengthened the seed programme so as to deliver large quantity of seeds with high genetic purity and adequate quality to the indenters.

Maintenance Breeding: Maintenance breeding and multiplication of nucleus clones of all released varieties in seed chain from the Institute *viz.,* Co 86032, Co 0212, Co 09004 and Co 11015 were continued and the newly released sugarcane variety Co 11015 has been included in the micropropagation. The nucleus clones are being maintained under the direct supervision of the breeders as a continuous activity and selected canes from each variety were micropropagted to supply disease free plantlets for further multiplication as breeder seed.

Breeder Seed production: Breeder seed multiplication was taken up using the initial source of the tissue culture plants produced from the nucleus clones 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 2021-1 had also been taken up. About 124.534 tons of breeder seed thus produced have been supplied to the selected farmers to undertake the quality seed production during July 2020 under the guidance from ICAR-SBI in addition to the seed indents from various sugar factories.

Farmers' participatory quality seed production: Due to the awareness on the need for quality seed material created by this programme the demand for quality planting material has increased manyfold in recent times. The need to produce a large quantity of quality seed cane coupled with the limited availablity of resources in the Institute provided an opportunity to explore the farmers' participatory mode under ICAR Seed Project. Based on the seed requests received from farmers and different sugar factories about 1200 tons of quality seed has been finalised as target for 2019-20 seed season to be supplied in February 2020. About 29 ac of seed crop has been raised with the help of progressive seed farmers under farmers' participatory seed production mode at Seyur, Mathampalayam, Vellamadai and Neelambur. About 1196.530 tons of quality seed has been supplied during February 2020 to both cooperative and private sugar factories as per allotments received from Directorate of Sugar, Govt of Tamil Nadu.

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 during 2020-21. As in previous years, progressive seed farmers have been selected to undertake farmers' participatory seed production from Seyur, Pasur, Vellamadai, Podhanur and Neelambur and seed production was undertaken in about 38 ac. The seed crops are being strictly monitored and the supply is planned during February 2021 to both cooperative and private sugar factories as per

Fig. 21. Seed Village Day at Seyur

allotments received from Directorate of Sugar, Govt of Tamil Nadu.

Training and Extension: A Field day on the new variety Co 11015 followed by Seed Village day were conducted at Killakulam village near Seyur, Tiruppur dt on January 29, 2020. Co 11015 Field day held on Jan 29, 2020 at Seyur (Fig. 21).

Tribal Sub Plan under ICAR seed project: An amount of Rs.2,00,000 has been utilized for providing four no. of motor pumpsets,seeds of Gingelly (100Kg), Jowar (300 Kg), Bajra (400Kg), Fox tail millet (Thinai), Kodo Millet (Varagu), Little Millet (Saamai) besides about 2000 no. of tissue culture plants of Banana var. Grandnaine were provided to tribal farmers at Chembukarai, Dhoomanoor, Aravukadai, Senguttai, Panapalli, Kandivazhi, Kondanur, Kondanur pudur, Poothamalli in Anaikatti area of Coimbatore District.

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

Production of tissue culture plants

Through apical meristem tip culture, the varieties Co 86032, Co 11015, Co 09004 and Co 0212 were multiplied. In vitro cultures of varieties Co 86032, Co 11015, Co 09004 and Co 0212 were virus indexed and found to be free from SCYLV, SCMV, SCSMV and GSD. A total of 1,62,275 tissue culture plants were supplied to private and co-operative sugar factories of Tamil Nadu, sugar factories from other states, breeder seed production and progressive farmers. An amount of Rs.16, 22,750 has been generated through supply of tissue culture seedlings. Seventy mother culture flasks were supplied to various sugar factories and an additional amount of Rs.1,75000/ revenue was generated.

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

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

Variety released from first set evaluation (2017-2019): Evaluation of first set of clones was carried out during 2017-2019. Pooled data analysis for yield and quality traits was performed based on data of two plants and one ratoon crop. Overall, Co 13014, Co 11015, Co 13018, Co 14016 and Co 06031 performed better than Co 86032 for cane yield and sugar yield at harvest. Of these, Co 11015 recorded 10.23%, 20.13% and 9.66% improvement over Co 86032 for cane yield, sugar yield and sucrose content across Tamil Nadu. Hence, it was identified as best performing variety combining yield and quality. ICAR-SBI Institute Research Committee and SISMA TN committee members recommended Co 11015 for release in Tamil Nadu for the benefit of sugar factories and farming community. Based on the recommendation Co 11015 (Atulya) was proposed and released as short duration sugarcane variety for commercial cultivation in Tamil Nadu and subsequently this variety was notified by Central Variety Release Committee (CVRC) during January 2020.

Identification of location specific variety (second set of clones)

Co varieties: A total of seventeen promising genotypes (Co 12008, Co 12009, Co 14002, Co 14005, Co 14025, Co 15015, Co 15018, Co 16009, Co 16010, Co 16018, Co 17001, Co 17003, Co 17004, Co 17012, Co 17013, Co 18009 and Co 18024) were evaluated in following nine locations during 2019-20.

Performance of varieties: Seventeen varieties were evaluated along with Co 86032 and local standards in a replicated trial during 2019-20. Harvesting was completed in all factory locations before end of March 2020. Data was compiled and analyzed. Varieties were classified based on sucrose accumulation and cane yield at harvest. Overall, Co 17003 and Co 14027 were better than Co 86032 for quality whereas Co 12009, Co 14027, Co 17001 and Co 18009 performed better than Co 86032 for yield at harvest (12 months). Location specific varieties suitable for different crushing time factory wise are given in Table 12. Varieties that recorded higher sucrose % than Co 86032 were considered for classification.

Action taken by factories (after first year of trial – second set of clones): Varieties found performing better than Co 86032 and local standards in respective factory locations were planted for further multiplication.

Identification of location specific variety (2019-2020): Second plant crop trial was laid out in all sugar factory locations for further evaluation. First

Table 12. Factory wise location specific varieties suitable for different crushing time

Sugar Factory	Varieties with high sucrose at		
	8 months	10 months	12 months
Bannari Amman Sugars	Co 12009, Co 14005, Co 14027, Co 16010, Co 16018, Co 17003	Co 12008, Co 14002, Co 14027, Co 16009, Co 16010, Co 17003, Co 17004	Co 14002, Co 14005, Co 14027, Co 17003, Co 17004, Co 18009
Dharani Sugars	Co 12008	Nil	Co 17003
EID Parry (India)	Co 12008, Co 16010, Co 17003	Co 16010, Co 17003	Co 17003
Kothari Sugars	Nil	Nil	Co 12008, Co 12009, Co 16010, Co 17003
Ponni Sugars	Co 16010, Co 17003	Co 12008, Co 16010, Co 17003	Co 12008, Co 14002, Co 14005, Co 14027, Co 17001, Co 17003, Co 18009
Rajshree Sugars	Co 17003	Co 12008, Co 14005, Co 14027, Co 16009, Co 17001, Co 17003	Co 12008, Co 12009, Co 14002, Co 14005, Co 14027, Co 16009, Co 16010, Co 17001, Co 17003, Co 18009, Co 18024
Sakthi Sugars	Co 17003	Co 17003	Co 17001, Co 17003
V.V. Sugars	Co 12008, Co 12009, Co 14002, Co 14005, Co 14027, Co 16009, Co 16010, Co 17001, Co 17003, Co 18024	Co 14002, Co 14005, Co 17001, Co 17003	Co 12008, Co 14027, Co 17001, Co 17003

ICAR-SBI	Co 12008, Co 14005, Co 16010, Co 16018, Co 17001, Co 17003	Co 12008, Co 12009, Co 14002, Co 14005, Co 14027, Co 16010, Co 16018, Co 17001, Co 17003, Co 17012, Co 17013	Co 12009, Co 14002, Co 14005, Co 14027, Co 16010, Co 17001, Co 17003

plant crop was harvested and field was ratooned to evaluate the potential of Co varieties. Based on the first plant crop, the entry Co 17003 with high quality was found suitable for harvesting, starting from 8 months onwards in six factory locations and thus considered as a short duration variety, while Co 12008 and Co 16010 were found suitable for harvesting starting from 8 months onwards at four locations each. Varieties Co 12008, Co 14002, Co 14005, Co 14027, Co 16010, Co 17001 and Co 18009 recoded higher sucrose % than standard Co 86032 atleast three factory locations at harvest (12 months). Varieties Co 12009, Co 14002, Co 16009, Co 16018, Co 17001 and Co 18009 recorded more than 10 tonnes higher cane yield than Co 86032 at harvest (12 months).

(Bakshi Ram, G. Hemaprabha, A.J. Prabakaran, R.M. Shanthi, S. Alarmelu, P. Govindaraj, D. Neelamathi, S. Karthigeyan, A. Anna Durai, R. Karuppaiyyan, K. Mohanraj, C. Appunu, C. Mahadevaiah, V. Sreenivasa, S. Sheelamary, H.K. Mahadevaswamy, T. Lakshmi Pathy, V. Vinu and K. Elayaraja)

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 during 2019-20 in six locations *viz.*, Kallakurichi-I Cooperative Sugar Mill, Moongilthuraipattu, Amaravathy Cooperative Sugar Mills Ltd., Krishnapuram, Udumalpet, Subramaniya Siva Cooperative Sugar Mills Ltd., Harur, Salem Cooperative Sugar Mills Ltd., Mohanur, Arignar Anna Sugar Mills, Kurungulam, Thanjavur and Tiruttani Coop. Sugar Mills Ltd., Tiruvalangadu, Thiruvallur.

First plant harvesting was completed and data were compiled and analyzed. The entries were classified based on sucrose accumulation and cane yield at harvest. Overall, Co 09004, Co 11015 and Co 17003 recorded better sucrose % than Co 86032 from 8 months onwards. Co 11015 and Co 17003 topped for quality at three

Table 13. Location specific varieties with higher sucrose suitable for different crushing times in Tamil Nadu

Sugar Factory	Varieties with high sucrose content		
	8 months	10 months	12 months
KI Coop. sugar	Nil	Co 11015, Co 17003	Co 09004, Co 11015, Co 12008, Co 12009, Co 14002, Co 14005, Co 15007, Co 17003
Subramaniya Siva Coop. sugar	Co 09004, Co 11015, Co 17003	Co 09004, Co 11015, Co 12008, Co 14027, Co 15007, Co 17003, Co 18009	Co 09004, Co 11015, Co 12008, Co 14027, Co 15007, Co 17003
Arignar Anna Coop. sugar	Co 09004, Co 11015, Co 12008, Co 14002, Co 14005, Co 14027, Co 16009, Co 16010, Co 17001, Co 17003, Co 17013	Co 14002, Co 14005, Co 17003	Co 09004, Co 11015, Co 14005, Co 14027, Co 16010, Co 17001, Co 17003, Co 17004, Co 17012, Co 18024
Tiruttani Coop. sugar	Co 12009, Co 17013	Co 09004, Co 11015, Co 12008, Co 12009, Co 14027, Co 15007	Co 09004, Co 11015, Co 12008, Co 12009, Co 14027, Co 15007, Co 16009, Co 16010, Co 17003

and four locations respectively at 10 months. Clones Co 09004, Co 11015 and Co 17003 topped for quality in four locations at 12 months. The entries Co 11015, Co 12009, Co 15007, Co 15018, Co 16009, Co 16010, Co 16018, Co 17004, Co 17012, Co 18009 and Co 18024 recorded more than 10 tonnes higher cane yield than Co 86032 (151.3 t/ha) at harvest (12 months). Location specific varieties with higher sucrose than Co 86032 and suitable for different crushing times are given factory wise in Table 13. Trials at Amaravathy Cooperative Sugar Mills Ltd and Salem Cooperative Sugar Mills Ltd were abandoned due to acute drought conditions.

(Bakshi Ram, G. Hemaprabha, S. Alarmelu, S. Karthigeyan, A. Anna Durai, R. Karuppaiyyan, K. Mohanraj, C. Appunu, C. Mahadevaiah, V. Sreenivasa, S. Sheelamary, H.K. Mahadevaswamy, T. Lakshmi Pathy and K. Elayaraja)

Genetic control and genomic selectionfor important traits in sugarcane and comparison of elite Indian and Australian germplasm.

Phenotyping of clones: The populations, BO 91xCo 775 scored for red rot response (plug method), Co canes, Co 86002 x BO 91, CoM 0265 x Co 775 (CCT method) (Fig. 22). More number of clones fall under MR category. Recorded the number of tillers, plant height, Number of millable canes and Brix for the above poulation. 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% (> 17), clones such as 303, 293, 229 and 260 had higher CCS (t/ha). Eighteen clones were selected from the other populations, CoM 0265 x Co 775 and Co 86002 x BO 91 for validation. Broad Sense Heritability was calculated for all the traits. The heritability %for the red rot trait from the 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 was 45 – 51 % (Table 14).

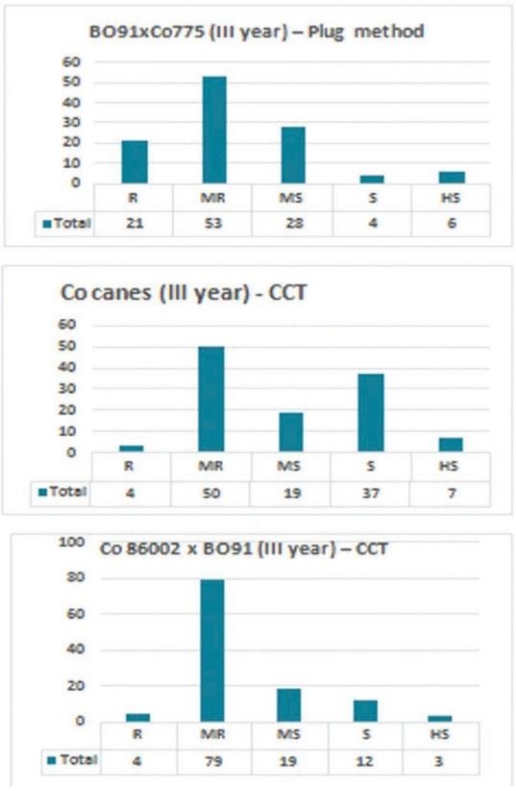


Fig. 22. Reaction of clones to red rot

Table 14. Heritability values for the population

Heritability - population

Population	Year	Crop	trait	h2	Condition
BO 91 X Co 775	2yr	p	CCS	0.7012	Control
BO 91 X Co 775	2yr	p	CCS	0.6909	Drought
BO 91 X Co 775	2yr	p	Yield	0.521	Control
BO 91 X Co 775	2yr	p	Yield	0.6068	Drought
BO 91 X Co 775	2yr	1R	CCS	0.7382	Control
BO 91 X Co 775	2yr	1R	CCS	0.6894	Drought
BO 91 X Co 775	2yr	1R	Yield	0.5424	Control

BO 91 X Co 775	2yr	1R	Yield	0.5412	Drought

Population	Year	Crop	trait	h2	Condition
Co 86002 X BO 91	2yr	P	CCS	0.7831	
Co 86002 X BO 91	2yr	P	Yield	0.8303	
Co 86002 X BO 91	2yr	P	CCS	0.9086	
Co 86002 X BO 91	2yr	P	Yield	0.8363	
CoM 0265 X Co 775	2yr	P	CCS	0.3073	
CoM 0265 X Co 775	2yr	P	Yield	0.5146	

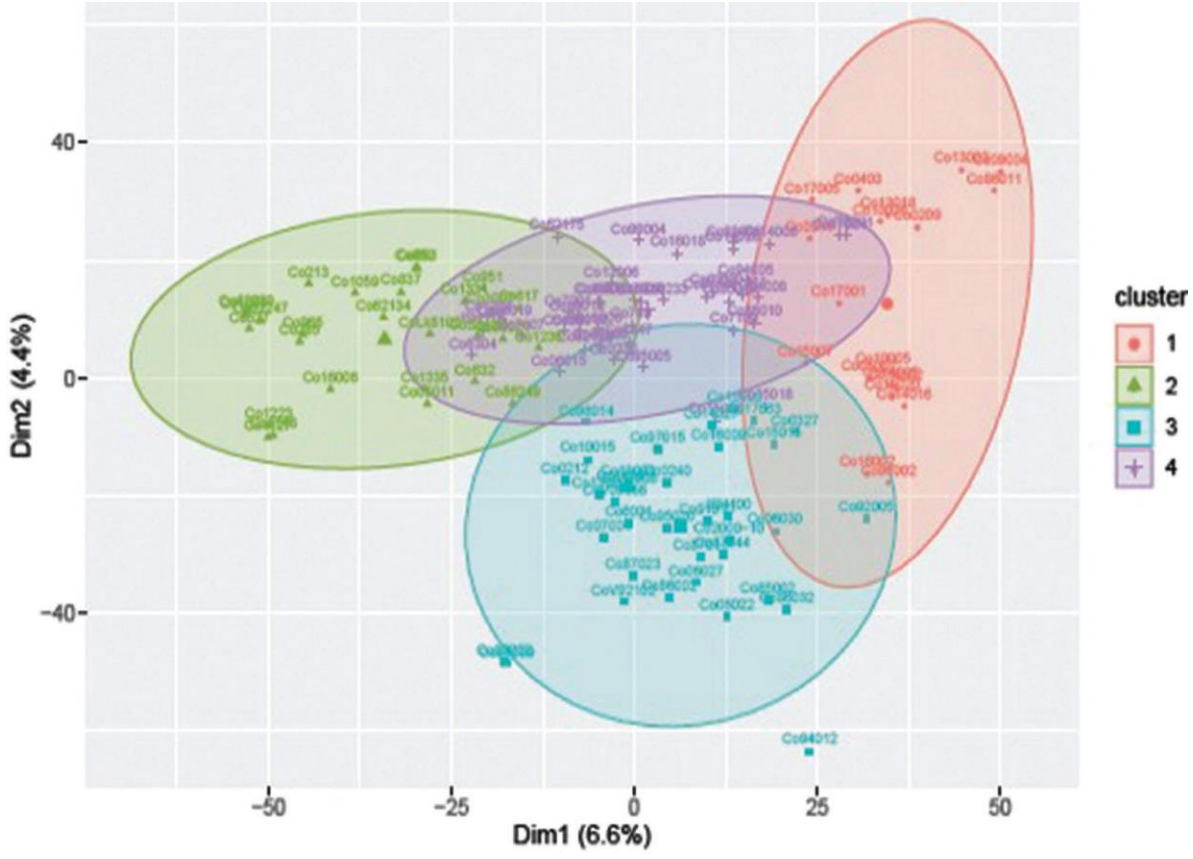


Fig. 23. Principal co ordinate analysis of Co canes with SNP markers

Genotyping of clones: The genotyping of 640 clones yielded 15, 040 SNPs as single dose markers. These markers were considered for further genetic analysis for each population. Filtered 9,149 SNPs from 15,040 SNPs for Principal coordinate analysis for Co canes for the sucrose trait (Fig. 23) and the cluster average of Pol % is presented in Table 15.

Table 15. Pol % of 'Co' Canes in respective clusters in Principal coordinate plot

Cluser/ Pol %	Min	Max	Average
Cluster 1	15.33	21.48	19.41
Cluster 2	9.6	18.94	15.43
Cluster 3	15.31	21.24	18.34
Cluster 4	13.55	20.22	17.33

Genomic prediction models: All the genotyped clones subjected to develop genomic selection / prediction models. Bayes A and Bayes B models showed significant SNPs for the sucrose and red rot traits. The correlation between prediction models for the sucrose trait with training and testing population was high (> 0.9) (Fig. 24) and the prediction accuracy was high for testing population (>0.65). Most significant SNPs (Top 100 SNPs calls) were used to plot 545 clones using principal coordinate analysis. The cluster 4 comprising most of the clones of CoM 0265 x BO 91 and other high sucrose clones of remaining population had high average Pol % (Table 16) (Fig. 25).

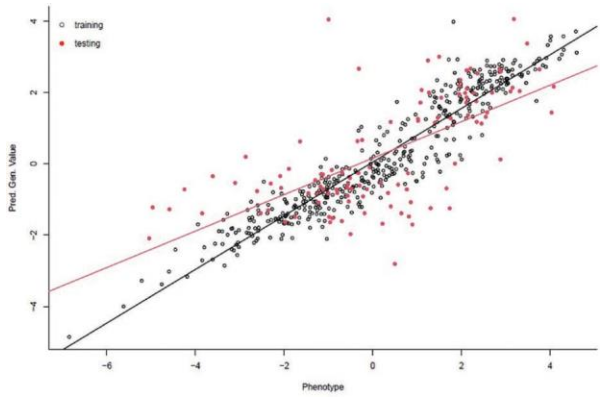


Fig. 24. Graph showing Genomic selection model based on Training and testing sets having high correlation

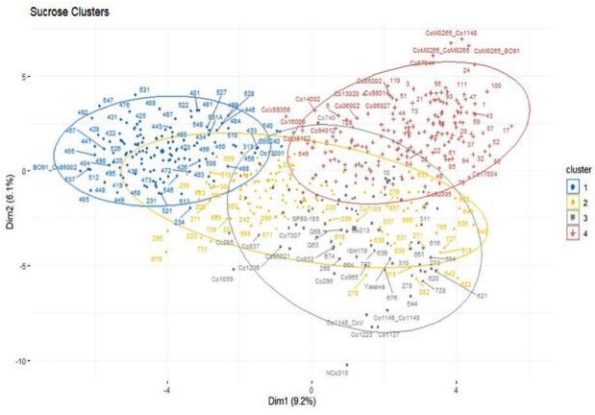


Fig. 25. PCA plot of clones based on significant SNPs derived from Bayes A model

Table 16. Pol % of Clones of various population based on Principal coordinate analysis with Top 100 SNPs

Cluster	No of Individuals in Cluster	POL % (Min)	POL % (Max)	POL % (Average)
Cluster 1	132	10.2	20.9	15.9
Cluster 2	148	10.3	19.7	15.3
Cluster 3	88	8.5	20.9	15.7
Cluster 4	177	14.2	21.2	18.6

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

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

A Genotype by Sequencing (GBS) panel of 96 *Erianthus* germplasm was constructed based on the data obtained from *Erianthus* genetic diversity and the drought phenotyping data. The panel comprising of drought sensitive, intermediate and tolerant clones were sequenced by Genotype By Sequencing method. Totally 5.143 Gb clean raw data was generated after filtering low-quality data. The raw data for each sample ranged from 354.548 Mb to 522.165 Mb, indicating the sufficient amount of data production. And the raw data obtained were analysed for quality using the software FASTQC, which showed the presence of 150k tags with 43% GC content and about seven to eight lakh sequences with more than 40 Phred

score in each sample. The effective sequencing data was aligned with the reference sequence through BWA software (parameters: mem -t 4 -k 32 -M), and the mapping rate and coverage was counted according to the alignment results. The BAM files were handled by SAMTOOLS. After mapping the SNP variations were analysed in the sequence and about 50,000 to 1, 60, 000 SNPs were detected in each sample. Further analyses of GBS data is ongoing.

Experiments were carried out to understand the metabolic changes in roots of a drought tolerant wild relative of sugarcane *Erianthus arundinaceus* clone (IND 04 1335) and compared with that of a commercial sugarcane cultivar Co 99004. Further a candidate gene RTCS (Rootless concerning Crown and Seminal roots) a member of the LOB domain transcription factors, which is a as a key regulator of shoot borne root initiation was characterized from a wild related genera of sugarcane *E. arundinaceus* and compared to the sequences of commercial sugarcane genotypes.

(R.Valarmathi and H.K. Mahadevaswamy)

Identification of salt responsive genes and micro RNA targets from salt tolerant *Erianthus arundinaceus* through transcriptome analysis

The comparative salinity stress transcriptome and small RNA sequencing in stressed and unstressed root samples of salt sensitive cultivated sugarcane variety Co 97010 and salt tolerant *Erianthus arundinaceus* IND99-907 was carried out. Total of 305, 244, 264, and 263 million raw reads were obtained from the stressed and control samples/libraries of IND 99-907 and Co 97010 respectively. The pre-processing of raw reads lead to a total of 226, 182, 196 and 198 million cleaned (Q30) reads in the stressed and control libraries of IND 99-907 and Co 97010 respectively. Clustered assembly resulted in 209612, 179304, 225911 and 242390 unigenes from stressed and control samples/libraries of IND 99-907 and Co 97010. The differential gene expression with stringent FDR<0.01 resulted in identification of 649 DEGs in IND 99-907 with 425 upregulated and 197 downregulated genes and 501 DEGs in Co 97010 DEG library with 283 upregulated and 213 downregulated genes. The KEGG annotations and Enzyme Code (EC) mapping were performed using Blast2GO showed 79 different KEGG pathways in IND 99-907 and 67 pathways in Co 97010. Further KEGG enrichment resulted in identification of 24 upregulated pathways in IND99-907 and three statistically significant downregulated pathways in Co 97010 respectively. In brief about salt responsive pathways in IND88-907, Oxidative phosphorylation is significantly enriched with FDR=0.002507 in IND 99-907 with 8 upregulated transcripts. The protein ATP synthase associated with formation of ATP was upregulated by log_2FC of 2.66. Several ATPase hits were observed in the pathway like calcium-transporting, plasma membrane, V-type proton ATPases with the highest upregulated one being ATPase subunit 6 (log_2FC=21.09). Contrastingly, the same pathway was significantly downregulated with FDR=0.000922 in Co 97010 with a total

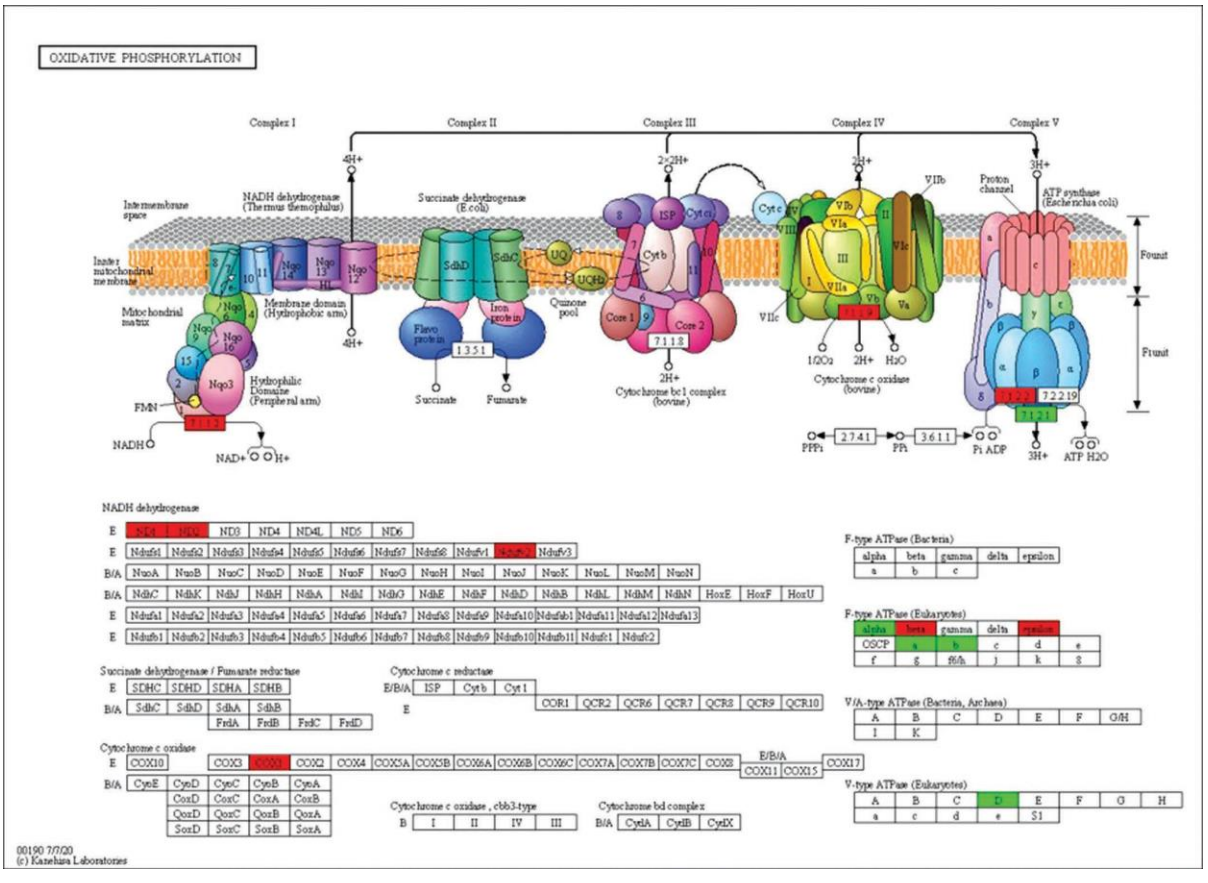


Fig. 26. The effect of salinity stress on plant oxidative phosphorylation pathway (ko00190), upregulated genes in IND 99-907 are marked in green and downregulated genes in

Co 97010 are marked in red

of 6 transcripts involving in the pathway including dehydrogenase, cytochrome c oxidase, and ATP synthase. The highest downregulation was observed in cytochrome c oxidase (COX) (log2FC=-26.86) followed by ATP synthase CF1 beta subunit (log2FC=-25.00). The putative salt responsive pathways described in Fig. 26. The MAPK signalling pathway significant (FDR < 0.00266) in KEGG Enrichment process and two genes viz., MAP3K1 and PP2C were highly upregulated in E. arundinaceus. Mitogen-activated protein kinase kinase kinase 1 (MAPKKK1)MAP3K (was upregulated by 8.04 log2FC) and five transcripts of PP2C (logFC value of 7.54) were upregulated under salinity stress in *E. arundinaceus.* Both MAP3K and PP2C are associated with ABA signalling pathways. Genes involved in signal transduction and transcriptional factor G-box binding factor 4 highly upregulated (log2FC=20.960) in IND99-907.

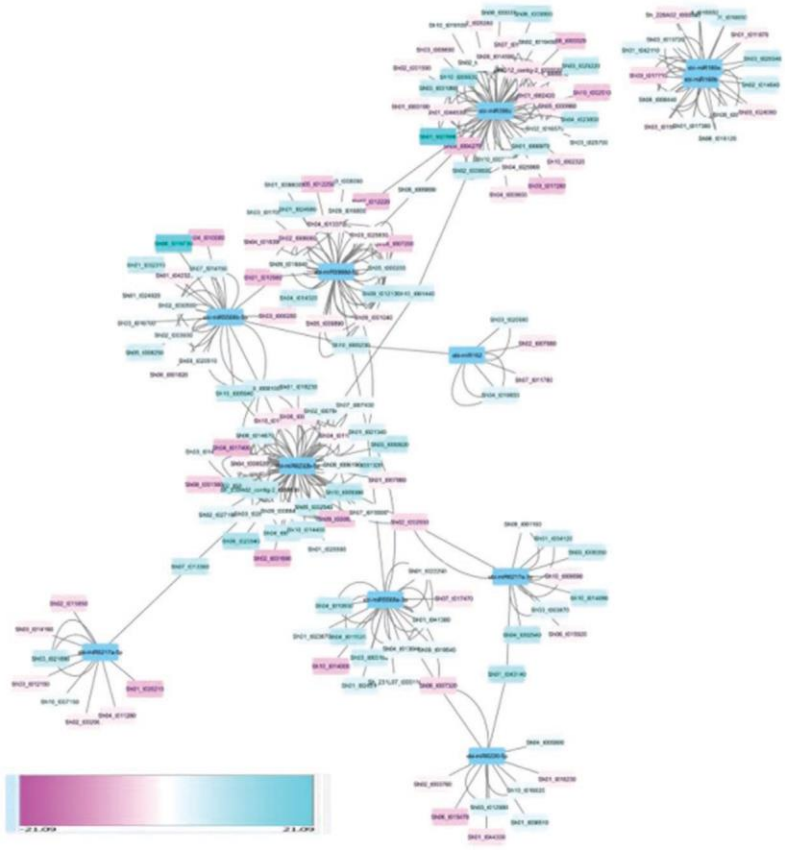


Fig. 27. Correlation network of top highly expressed miRNAs and their differentially expressed gene targets. Colours of expression of genes are shown from pink (downregulation) to blue (upregulation)

For identification of salt responsive miRNA, total of 210, 214, 197 and 242 million raw reads were generated from the stressed and control libraries of IND 99-907 and Co 97010 respectively. The pre-processing of raw reads resulted in total of 58, 86, 57 and 66 million cleaned reads (18-30 nucleotides). Total of 362 known miRNAs identified, which are belonging to 62 miRNA families and 353 miRNAs belonging to 63 families in IND 99-907 and Co 97010 respectively. Among them, 221 and 130 differentially expressed miRNAs in IND 99-907 and Co 97010 respectively. To identify the target genes of miRNAs, differentially expressed miRNA sequences from IND 99-907 and Co 97010 ($p<0.05$) were targeted against the i) whole Sugarcane monoploid genome, ii) our whole salt transcriptome assembly and iii) differentially expressed genes (DEGs) ($p<0.05$)

of the salt transcriptome. Gene annotation for the DEGs were obtained by performing a blastn search against the annotated cDNA sequences of the sugarcane monoploid genome. Targeting against sugarcane monoploid genome identified a total 12,693 gene targets for 221 DE miRNAs and 7,982 gene targets for 130 DE miRNAs. In the case of the salt transcriptome assembly, 15,031 and 12,152 gene targets were acquired for DE miRNAs of IND 99-907 and Co 97010 respectively. Further, in order to study miRNA-mRNA correlation based on their expression profiles, DE miRNAs were specifically targeted against 7731 and 6159 DEGs of IND 99-907 and Co 97010, which identified 4378 and 2744 gene targets in IND 99-907 and Co 97010 respectively. Total of 102 miRNA-mRNA correlation having the same target genes between IND 99-907 and Co 97010. Correlation network showing highly expressed miRNAs and their corresponding differentially expressed gene targets (Fig. 27).

(C. Mahadevaiah)

Isolation, functional characterizationand evaluation of water deficit stresstolerance responsive genes from high drought tolerant *Erianthus arundinaceus* by comparative drought transcriptome analysis

Around 6.0 gigabase pairs (Gb) of comparative raw data were obtained for each of stressed and nonstressed samples of leaves and roots from ninety days grown plants of *E. arundinaceus* and sugarcane commercial variety Co 86032. Detailed analysis is in progress. Based on preliminary analysis of data, plant nuclear factor (NF-Y), a transcription activating factor, consisting of three subunits, which plays a key regulatory role in many stress-responsive mechanisms including drought and salinity stresses was identified.

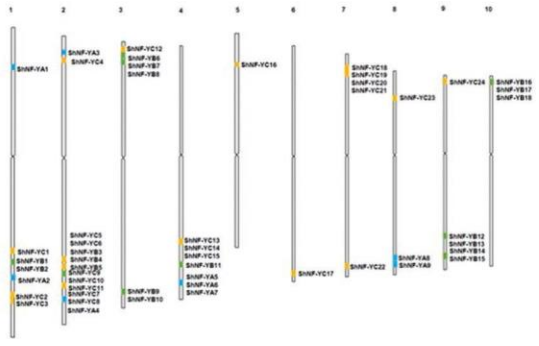


Fig. 28. Location of NF-Y genes on chromosomes of sugarcane genome

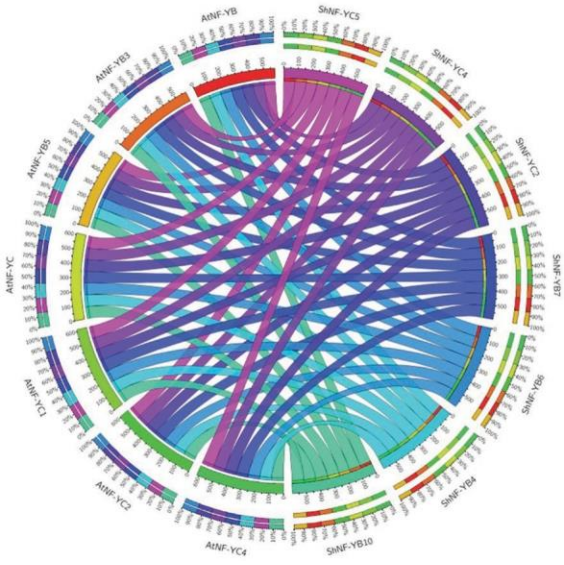


***Fig. 29. Synteny of NF-Y genes between Sugarcane* (Saccharum *hybrid), Sorghum* (Sorghum bicolor) *and Arabidopsis* (Arabidopsis thaliana)**

Hence, this gene member was characterised at genome level of *Saccharum* spp. In general, NF-Ys function both as complex and as individual subunits. NF-Y is a heterotrimeric CCAAT box binding plant transcription factor comprising of three subunits *viz*., NF-YA (CBF-B), NF-YB (CBF-A) and NF-YC (CBF-C). In animals, NF-Ys are encoded by a single gene whereas in plants NF-Ys are encoded by multiple gene members. NF-Ys play crucial role in many vegetative, developmental and reproductive processes in plants. Genome wide search of NF-Ys in mosaic monoploid reference sugarcane genome revealed the presence of 9 NF-YA, 18 NF-YB and 24 NF-YC genes. These identified NF-Y gene members were located on different chromosomes of sugarcane genome (Fig. 28). *In silico* analysis predicted the physio chemical properties and functionally important domains in NF-Y genes. Multiple sequence alignment of NF-Y proteins showed high conservation of functional domains. Phylogenetic analysis of NF-Y genes predicted orthologies which would assist in determining functional conservation and translation between species. Synteny analysis of ShNFY genes with *Arabidopsis thaliana* genome showed collinearity of NFY genes in sugarcane and Arabidopsis (Fig. 29).

(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 idea to enhance the performance under water deficit stress conditions. In response to abiotic stresses, plants 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. Seventy six putative transgenic events were developed for *codA* gene (Fig. 30). Transgenic events are in vegetative multiplication stage (V_0). Part of these codA transgenic events was confirmed for presence of transgene.

As suggested by expert members new construct was developed for *EaDREB2* gene. In this

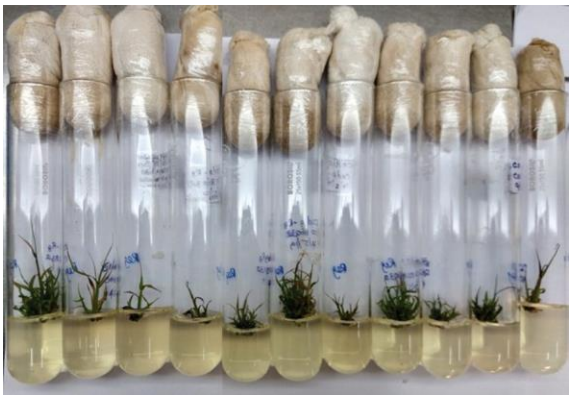


Fig. 30. Vegetative multiplication of codA sugarcane transgenic events

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 development.

(C. Appunu and R. Valarmathi)

Novel application of sugarcane vacuolar targeting technology for recombinant protein

The project was started in July 2019 in collaboration with Tranalab Private Limited, Bengaluru (a Startup Company) with the financial support of DBT-BIRAC, New Delhi. A Project Assistant was recruited in August 2019 under the project. The project was initiated with the idea to validate vacuolar technology 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 ICAR-SBI, Coimbatore. At ICAR-SBI, the 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: S*ugarcane variety Co 86032 was used for transformation with *GCS, Insulin* and *Ifn2A* gene constructs through either through *Agrobacterium* mediated or particle bombardment method of transformation. Calli are in different stages of selection.

(C. Appunu and G.S. Suresha)

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

Eight different sugarcane clones varying in lignin content and expression of lignin encoding genes were chosen as the study material. Out of which three sugarcane clones (IK 76-91, IK 76-99, IK 76-81) has been collected from the fields of ECC, ICAR-Sugarcane Breeding Institute, Coimbatore. The pith portion and outer rind portion of these clones were manually separated

after the juice extraction. Later they were finely chopped and air dried for a period of two weeks powdered in the pulverizer and stored in an air tight container. Simultaneously lignin degrading microbial cultures has been received from Tamil Nadu Agricultural University, Coimbatore and these cultures are maintained as mother stocks and serial dilutions are made for preliminary screening purpose. The mineral media plate and Czapeck Dox media plates were prepared and the 100 µl of serial diluted media from 10^{-1} to 10^{-4} were plated and the plates were incubated at 50° C for 7-8 days. Microbial growth was observed only after the 5th day of incubation. To get the pure culture of microbes it has been isolated from the mother plate to get individual colonies using zig-zag streaking and kept in 50°C for 3 days. Simultaneously we have isolated 43 individual microbial strains which were streaked on Guaiacol and $CuSo_4$ incorporated PDA plates to identify the Laccase producing isolates. Later we observed in brown colour zone of clearance in 20 isolates. Later, these twenty strains were streaked on minimal medium enriched with the substrate (sugarcane or *Erianthus* baggase) in the medium. In which 19 fungal strains were grown and visualized in the plate. These strains were grown in broth and the genomic DNA has been isolated. ITS primers are being designed to perform genus identification and the strains are subjected to PCR amplification.

(K. Lakshmi)

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

For GISH analysis the mitotic slides were prepared and slides having cells with division were freeze dried in liquid nitrogen. Genomic DNA has been isolated from *S. spontaneum* (Coimbatore) and *Erianthus* (IK 76-62 and IK 76- 91). After checking the quality and quantity ofthe DNA it has been fragmented to 500-1000bp size by sonication. The fragmented DNA has been labeled with biotin and the probe efficiency was tested in the mitotic slides of respective species.

Genomic *in situ* hybridization has been done in two varieties, Co 86032 and Co 0238. The probe used for the study was *S. spontaneum*. In Co

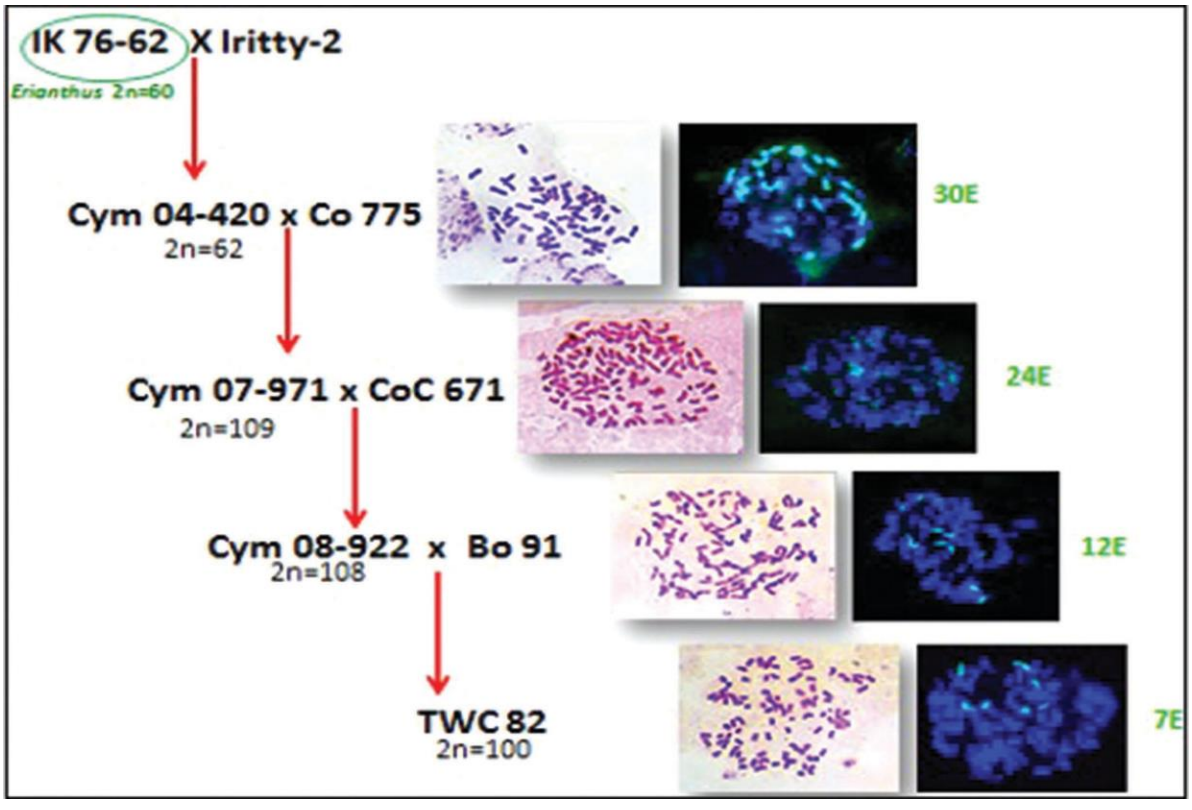


Fig. 31. Somatic chromosome number determined in different generations

86032 around 16 *S. spontaneum* chromosomes were observed with recombinant chromosomes. In Co 0238 the *in situ* hybridization revealed that the number of *S. spontaneum* chromosomes was lesser than Co 86032. As the homology between the species was very high, differential staining was not that clear to distinguish all recombinant chromosomes. The work is in progress with *in situ* hybridization of ISH clones.

Repeated hybridization events with biotin labeled IK 76-62 probe in a hybrid between CoC 671 x IK 76-91(Clone GU (04) 72-CoE-1) revealed the absence of *Erianthus* chromosomes in this hybrid. The presence of *S. spontaneum* chromosomes was confirmed with labeled probe of *S. spontaneum*. So this hybrid may be an ISH with unusual somatic chromosome number 2n=~140.

Introgression pattern of *Erianthus* chromosomes in the back cross progenies of *Erianthus* x *S. spontaneum* has been analyzed by using biotin labeled probe of IK 76-62. In F1 30 *Erianthus* chromosomes were there. It has reduced to 24, 12 1nd 7 in the second, third and fourth generations respectively. Somatic chromosome number was also determined in different generations (Fig. 31).

(V.P. Sobhakumari)

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. This revealed that there are two cry genes coding for protein viz. *cry8Sa1* and *cry8Ib*. Further to identify the individual toxicity, the project was initiated with approved objective on cloning and expression of cry8 toxin (cry8Sa1 and cry8Ib) genes in cry negative (acrystalliferous) strain *B. thuringiensis* HD73- and/or *E. coli* system.

Based on the whole genome sequence generated and with full length DNA sequence of cry8Sa1 and cry8Ib, these cry genes were cloned in shuttle vector pSTK. Later this vector was transformed in to *E. coli* DH5α. Before transforming in *B. thuringiensis* (acrytalliferous strain), recombinant plasmid was isolated

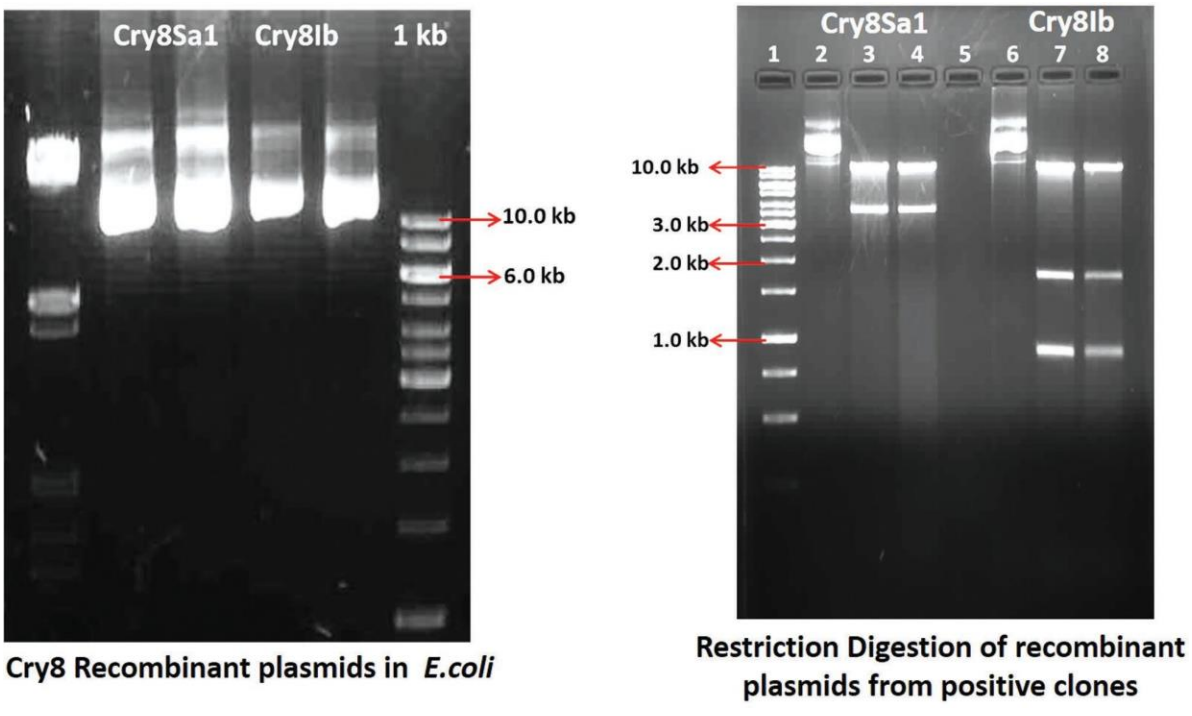


Fig. 32. PCR amplification and confirmation of cry8Sa1 and cry8Ib genes through restriction digestion analysis of recombinant plasmids. Lane 1 -1 kb ladder, 2 and 6 Undigested plasmid of cry8Sa1 and

cry8Ib, 3,4, 7 and 8 Digested plasmids of cry8Sa1 and cry8Ib with BamH1 and Sal1

from DH5α and transformed into *E. coli* strain E7 (*Dam*$^{-}$*DCM*$^{-}$) to remove methylation sensitivity in *Bacillus* background. The plasmids obtained from the E7 were transformed into *B. thuringiensis* (acrytalliferous strain). After confirming the recombinant plasmid by colony PCR and restriction digestion analysis (Fig. 32), the *B. thuringiensis* (acrytalliferous strain) was subjected to microscopic observation to further confirm the protein expression and presence of crystal and spores. Spore crystal mixture was isolated from the recombinant clones and identified the protein expression through SDS page using HD73^{-} as negative control and Bt 62 strain (wild type) as positive control. From this analysis, it is evident that the cry8Sa1 and cry8Ib was successfully cloned and their protein expressed under the *B. thuringiensis* (acrytalliferous strain) background.

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

5.2 DIVISION OF CROP PRODUCTION

5.2.1 Agronomy, Microbiology and Farm Machinery and Power

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

Characterization of rhizosphere of selected sugarcane genotypes

Ten varieties of sugarcane namely Co 86032, Co 8371, Co 06022, Co 85019, Co 0238, Co 09004, Co 10026, Co 86010, Co 11015 and CoC 671 were used grown under hydroponic conditions to study the effect of PEG on osmolyte accumulation and ROS enzymes activity. In leaf (PEG treatment) proline content varied from 10µg/g CoC 671 to 18µg/g Co 86032. Proline content increased in all the varieties studied in leaf tissue, in PEG treatment. In root, PEG treatment it varies from 11µg/g CoC 671 to 19.25µg/g Co 86032. Total phenolics in leaf, ranged from 10µ/g CoC 671 to 17µg/g in Co 8371 in control while in treatment it varies from 14µg/g CoC 671 to 19µg/g Co 06022. In root total phenolics varied from 10.26µ/g CoC 671 to 16µg/g in Co 8371 in control while in treatment it varies from 14.8µg/g CoC 671 to 20µg/g Co 06022. Superoxide dismutase activity varied from 0.6 units/g/min in Co 06022 to 0.7units/g/min in Co 09004 in leaf tissues and control plants. In PEG treatment the SOD activity ranges from 0.8 to 1.1 units/g/min and showed significant variation among treatments. Peroxidase a general oxidase recorded a higher activity in Co 85019 (16/Δ changes in absorbance/g/hr.) and lowest in CoC 671 (11/Δ changes in absorbance/g/hr.) in leaf tissues of control plants. In PEG treatment peroxidase activity increased in all the varieties. Real time PCR indicated that SOS1 gene expression suggest an increasing trend in leaf tissue up to 96 hours and the fold increase varied with the variety. Co 85019 showed maximum fold increase at 72 hours after treatment (50 fold) While, Co 10026 registered up to 12 fold increase only. SOS2 gene expression was high at 24 hours after PEG treatment in leaf tissue and thereafter varying trend was observed among the varieties. In root tissue also the expression levels indicated up regulation at 24 hour after treatment. Expression of SOS3 gene was much lower compare to SOS1 and SOS2. At 72 hours a peak was recorded and definite trend could not be elucidated in root tissue with respect to SOS3.

The effect of selected plant growth promoting microbes on growth and development of sugarcane in hydroponic system is reported. The hydroponically grown plants of sugarcane varieties Co 09004 and Co 086032 were inoculated with nine number of plant growth promoting microbes such as *Methylobacterium* spp., (SBI-MET-3), *Pseudomonas fluorescence* (PF-1), *Gluconacetobacter diazotrophicus* (Pal-5), *Azospirillum brasilense (*KACC 13364*), Azotobacter spp*., (ST002), *Bacillus megaterium, Beijerinckia derxii* (BE-003), *Acetobacter* spp., *(SBI-ACE-01) and Gluconacetobacter xylinus* (KACC 12367) along with uninoculated control. In general, inoculation of microbes recorded higher root and shoot biomass. Significantly higher biomass was recorded by *Gluconacetobacter diazotrophicus* (Pal-5), *Azospirillum brasilense (KACC 13364), Acetobacter* spp., *(SBI-ACE-01)* compared to *Bacillus megaterium, Azotobacter* spp., (ST002), *Beijerinckia derxii* (BE003), *Gluconacetobacter xylinus* (KACC 12367) and control in both Co

09004 and Co 86032. Inoculation has resulted in increased activity of peroxidase, super oxide dismutase (SOD), total phenol and proline in the roots compared to uninoculated. Root exudate samples were concentrated using lyophilizer and analysed using HPLC. HPLC analysis of root samples indicated the presence of phenolic acids *viz*., galic, caffeic, vanilic, syringic and ferulic acids; organic acids such as citric acid, oxalic acid, alpha keto glutaric acid; and phytohormones like gibberalic acid 3, indole acetic acid and kinetin. These substances were found very small levels hence analysed only qualitatively. Most of the samples gave large amounts of unknown interfering substances. Overall study indicated that sugarcane can be successfully grown in hydroponic system for studies that require handling of undisturbed root system.

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

Development and promotion of tools and machinery for sugarcane mechanization

A mini tractor operated EPN applicator for applying the EPN formulation using a mini tractor continuously at the root-zone of the sugarcane crop grown in wide row spacing has been developed. This will apply the EPN formulation at the root-zone which is below 15-20 cm deep from the surface. The fabrication of the unit was carried out at ICAR- Central Institute of Agricultural Engineering, Regional Centre, Coimbatore. This equipment is consisting 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 and 5 feet). The EPN (Entomopathogenic nematode) powder is diluted in water tank with help of agitator. The agitator is powered by 12 V torque DC motor at maximum rpm of 150 rpm. A shoe type furrow openers 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 4lit/min. The solution outlet is taken from the bottom side of the tank through pump to behind of the furrow opener. The capacity of the tank is 75 lit. The field capacity of the equipment is 0.16 ha h^{-1} at the operating speed of 2 km h^{-1}. The developed unit was field tested in the ratoon sugarcane crop field at ICAR-SBI, Coimbatore and further modification is in progress (Fig. 33 and 34).

Fig. 33. Mini tractor operated EPN Applicator-1

Fig. 34. Field testing of Mini tractor operated EPN Applicator

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

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

Experiments were conducted to study the effect of sett treatment with selected microbial inoculants by using ICAR-SBI sett treatment device. Seedlings were raised from chip bud and single bud of seven varieties, Co 8371, Co 2001-13, CoC 671, Co 0403, Co 0238, Co 06022, Co

86032 and treated with six microbial cultures *viz*., *Gluconacetobacter* spp. (GX), *Methylobacterium spp.* (PPFM), *Beijerinckia* spp. (BE 03), *Feturia* spp. (FA), *Bacillus subtilis* (BA), *Gluconacetobacter diazotrophicus* (GD), *Azospirillum brasilense* (AB) along with uninoculated control. Microbial cultures were grown in appropriate media for 48 h old and were used for inoculation. Sett treatment was given for 15m at 200 Hg/m pressure with 0.1% concentration of microbial culture. Overall results indicated a significant increase in the germination percentage of sugarcane setts by sett treatment with inoculants. Sett treatment with inoculants in Sett Treatment Device had significant influence on settling vigor of both the single bud and bud chips. *Beijerinckia* spp. has recorded significantly higher germination of 69.5% and 66.5% (single bud and chip bud) respectively. With regards to the performance of varieties, Co 2001-13 has recorded significantly higher germination of 86.5% and 76.5% (single bud and chip bud). *Beijerinckia* spp. inoculation has recorded higher settling vigor of single bud and bud chip settlings on fresh weight (5134.8 and 2861.7) and dry weight basis (1410.0 and667.9) respectively. Among the inoculants, higher microbial count was observed in *Beijerinckia* spp. followed by *Gluconacetobacter diazotrophicus* and *Methylobacterium* spp. Among the inoculants, higher microbial count was observed in *Beijerinckia spp.* followed by *Gluconacetobacter diazotrophicus* and *Methylobacterium* spp. Similarly, in the case of varieties, Co 2001-13 has recorded higher microbial count (1.8 x 10^{-4}cfu), followed by Co 0403 (1.8 x 10^{-4}cfu). Overall results indicated that setts treated with *Beijerinckia* spp. has advantage for 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 started during February 2019 to study the effect of new herbicide molecules like topramezone, halosulfuron methyl and tembotrione in sugarcane. The experiment consists of nine treatments laid out in randomized block design with three replications. Treatments are (1)Three hand weeding 30, 60 and 90 DAP (2) Unweeded control (3) Topramezone 21 g ha^{-1} + atrazine 250 g ha^{-1} at 65 DAP *fb* one hand weeding at 120 DAP (4) Topramezone 25.2 g ha^{-1} + atrazine 250 g ha^{-1} at 65 DAP *fb* one hand weeding at 120 DAP (5) Topramezone 29.4 g ha^{-1} + atrazine 250 g ha^{-1} at 65 DAP *fb* one hand weeding at 120 DAP (6) Ethoxysulfuron 60 g ha^{-1} + atrazine 250 g ha^{-1} at 65 DAP *fb* one hand weeding at 120 DAP (7) Tembotrione 120 g ha^{-1} + atrazine 250 g ha^{-1} at 65 DAP *fb* one hand weeding at 120 DAP (8) Ametryne 2.4 kg ha^{-1} + 2,4-D 1 kg ha^{-1} at 65 DAP *fb* one hand weeding at 120 DAP (9) Halosulfuron methyl 67.5 g ha^{-1} + metribuzin 750g ha^{-1} at 65 DAP *fb* one hand weeding at 120 DAP. Early post emergence application of metribuzin 1.25 kg ha^{-1} at 20 days after planting was common in all treatments from T_3 to T_9. The mean germination in all plots at 45 DAP was more than 60 per cent. Major weed flora observed in the field was *Datura metel, Cleome gynandra, Parthenium hysterophorus, Trianthema portulacastrum, Commelina benghalensis, Cyperusrotundus, Brachiaria reptans, Dactyloctenium aegyptium, Chloris barbata, Digitaria sanguinalis* and *Cyanadon dactylon*. 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 (8.2) and dry matter (7.2 g m^{-2}) and was found at par with the application of new herbicide molecules like topramezone, halosulfuron methyl and tembotrione. Highest cane yield of 125.6 t ha^{-1} was recorded in case of sugarcane raised with three hand weeding at 30, 60, 90 DAP which was on par with metribuzin 1.25 kg ha^{-1} EPOE *fb* topramezone 29.4 g ha^{-1} + atrazine 250 g ha^{-1} at 65 DAP *fb* one hand weeding at 120 DAP (121.3 t/ ha). Sucrose content did not show any significant variation owing to weed management options. All the herbicides at the tested dose did not exhibit any phytotoxic symptoms in sugarcane variety Co 86032.

(S. Anusha and P. Geetha)

Doubling income of small farms through sugarcane based farming system (NADP/ RKVY)

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 of varied agro-based enterprises at ICAR- Sugarcane Breeding Institute, Coimbatore and for empowering human resource for sustenance of the proposed activities through on-farm capacity development programs. The farm layout for establishment of sugarcane based farming system model with various components such as intercropping of pulses, trash mulching for organic matter addition and weed control and allied enterprises like dairy, goat / sheep, mushroom production using sugarcane trash, apiary, jaggery production has been prepared. For cropping system component, cultivation of short duration paddy has been planted.

Fig. 35. Goat shed

Fig. 36. Cow shed

Fig. 37. Mushroom shed

Animal component: Construction of animal component – cow shed, goat shed, Farm house and Mushroom shed has been completed. Two Dairy (Holstein friesian) cows of local cross have been purchased for the farming system (Fig. 35-37).

Cropping system: Paddy (Var. Co 51) has been cultivated and harvested with a yield of 5.75 t/ ha during samba season.

Sugarcane - intercropping system: Planting of sugarcane intercropping system under sub-surface drip irrigation was taken up and the intercrops such as mint, coriander and black gram has been cultivated. The yield of intercrop mint was 1548 kg/ac, coriander was 864 kg/ac and black gram (grain) was 127 kg/ac which fetched an interim income of Rs. 61,920, Rs. 34, 560 and Rs. 8,920 per acre respectively. In terms of economics mint crop is the best for higher interim income.

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

NFSM demonstration of pulses intercropping with sugarcane

Under NFSM project, demonstrations on sugarcane + pulses intercropping in 50 haof sugarcane farmer's field were conducted. The six villages i.e., Vellode, Aval Poondurai, Erode, Modakuruchi, Ganapathypalayam and Chennimalai from Erode and Kangeyam were chosen. These villages come under the Sakthi sugars factory Unit. Wide row spacing of 150 cm was followed for sugarcane which was planted in the furrows and the intercrops were sown on both sides of the ridges on the third day after planting sugarcane. At 10^{th} 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. The black gram, 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 the black gram. 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 + black gram intercropping. Recommended irrigation and plant protection measures were followed.

In sugarcane based intercropping system, black gram can be grown as an intercrop under wide row spacing (150 cm) without affecting the main crop yield. Black gram can be harvested within 70 days before the tillering phase of sugarcane which gives an additional interim income to the farmer. Sugarcane + black gram recorded significantly higher CEY (143.20 t/ha) than the sole sugarcane (127.57 t/ha). Improvement in cane yield to the extent of 12.25 % due to Sugarcane + Black gram intercropping was observed. The economic benefits were worked out for sugarcane + black gram cropping systems registered the highest gross returns (375184 Rs/ha), net return (168857 Rs/ha) and B: C ratio (1.81) than sole sugarcane crop.

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

Inter Institutional Collaborative Research

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 in Field No. 22 in main farm area at ICAR-SBI, Coimbatore has been identified and 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-baring using the IISR model disc type ratoon management device in the ratoon crop during 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 (Fig. 38-39).

Fig. 38. IISR-Ratoon Mangement Device in field operation-2

Fig. 39. Field view of Ratoon crop

Performance evaluation of IISR Two row deep furrow sugarcane cutter planter

To evaluate the IISR model two row deep furrow sugarcane cutter planter, a field experiment was

Fig. 40. IISR-Sugarcane planter in field operation

laid out in Field No. 33 in additional land area at ICAR-SBI, Coimbatore. The experiment was planned in split plot design. The field trial was designed in such a way that it compares the different planting methods (Four main plots) namely IISR sugarcane planter method, SBI settling planter method, manual sett planting method and manual settling planting method. Two different spacing (sub plots) *viz*., 4 feet and5 feet were followed with three replications (Fig. 40).

(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. Accordingly an initial model

Fig. 41. Prototype of Mini tractor operated whole cane harvester

Fig. 42. Field testing of Mini tractor operated whole cane harvester

of mini tractor operated sugarcane harvester has been developed for harvesting sugarcane crop growing in wide row spacing in the field. 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 to 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 ICAR- Sugarcane Breeding Institute, Coimbatore (variety: Co 86032, age/maturing of cane: 14 months) and the performance of the harvesting system is satisfactory and still further study on influence of cutting blade thickness on cutting of sugarcane in terms of smooth cut/partial cut/broken cut has to be conducted and Intensive field trails are in progress (Fig. 41-42).

Conceptual design of tractor operated whole cane harvester: The Computer aided drawing (CAD) for development of whole cane harvester has been prepared with individual components. The Conceptual tractor operated whole caneharvester consists of Main frame, Power transmission system, Base cutting unit, cane conveying system, Detopping system, cane collection box. The fabrication of individual components is in progress.

(T. Senthilkumar (ICAR-CIAE RC, CBE), T. Arumuganathan; A.K. Singh and M.K. Singh – (ICAR-IISR, Lucknow))

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

Five ITMC meetings were conducted to discuss different aspects pertain to technology disclosures, patent applications and commercialization of technologies developed by ICAR-SBI. Presented the progress of ITMU in

the ZTMU review meeting chaired by DDG (CS) on 16th Sep 2020. Recently ICAR-SBI, through Agrinnovate India Limited, has received a request from a private firm for certain sugarcane varieties to be exported to Africa. Efforts were taken to commercialize the varieties to foreign countries through Agrinnovate India Limited. For this purpose technology disclosures were obtained from Innovator / Breeder for three varieties viz., Co 86032, Co 0238 and Co 0118. Five new technologies received for commercialization viz., (a) Liquid jaggery (b) Cane jam from sugarcane juice, (c) Freeze dried sugarcane juice, (d) Cane dietary fibre food products and (e) Spray dried sugarcane juice are being processed. Application for the variety Co 11015 (Atulya) has been submitted to PPV&FRA. Two patent applications filed with Patent Office, Chennai. As per the ICAR-SBI and Agrinnovate, techno commercial meeting totally 6 technologies were finalized. Of the six technologies, the liquid jaggery technology will be commercialized directly by ICAR-SBI and other five will be taken up by Agrinnovate India Limited. Licensed the Soil Moisture Indicator technology to five firms, EPN biopesticide formulation to three firms, liquid jaggery technology to five firms and Two Row Tractor drawn mechanical planter to one firm. In total a revenue of Rs. 19, 83, 782/- has been realised through commercialization of ICAR-SBI technologies.

(K. Hari, K. Rathnavel [CICR RS, Coimbatore], G. Hemaprabha, J. Srikanth, A. Ramesh Sundar, P. Murali 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 to continue up to harvest. Soil samples were drawn during cycle of irrigation in all the treatments.

Physiological traits: Chlorophyll SPAD index reduced by 18% 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 the 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 during the period. In species clones the variations for chlorophyll fluorescence were marginal and irrigation treatments effects were not pronounced. Canopy temperature increased by 2-4 units in I_1 and I_2 during formative phase in Co hybrids as well as species clones (Fig. 43). However, the differences vanished during grand growth phase. The climate influence could be observed in reducing the canopy temperature in restricted irrigations.

Juice Sucrose: Sucrose % juice at 11th month ofthe crop showed reduction by 7% in I_2 and 4% in I_1 as compared to Co hybrids. Among the co hybrids studied Co 09004, Co10026, Co 12009, Co 11015, Co 14002 and Co 15007 registered higher juice sucrose over the treatment mean

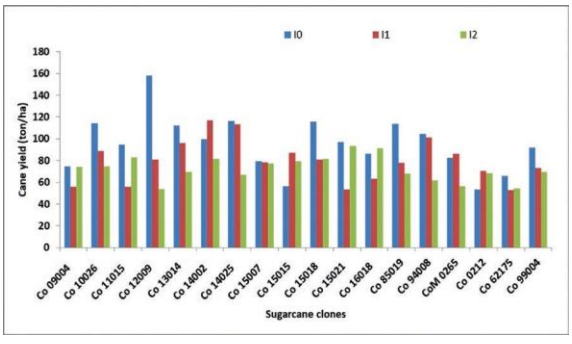


Fig. 43. Cane yield in Co hybrids in restricted irrigation treatments

(15.6). Species clones showed better stability with minor reduction in juice sucrose. ISH clone ISH 107, ISH 111, ISH 23, ISH 58, ISH 9, Khakkai, Nargori and Lalri recorded comparable sucrose % in all the treatments (>11.6%).

Cane yield: Cane yield (Year 2021) at harvest reduced by 18% and 24% in I_1 and I_2 as against I_0. Cane yield varied from 53t/ha (Co 0212) to 158t/ha (Co 12009) with a mean of 93.3t/ha in control (I_0). In 50% volume restriction irrigation it varied from 53t/ha (Co 62175) to 116.7t/ha (Co 14002) and in I_2 it varied from 54t/ha (Co 62175) to 93.5t/ha (Co 15021) with a mean of 70.4t/ha. Reduction in cane yield was 17.7% and 24.4% in I_1 and I_2 respectively over I_0. Among the co hybrids, Co 12009, Co 14002, Co15015, Co 15018 and Co 15021 performed better in both the restriction irrigation treatments.

IWUE and WP for 2019-2020 crop: From among the co hybrids Co 15021, Co 15015, Co 14002, Co 15018 and Co 10026 were found to be good for IWUE registering higher efficiency in both I_1 and I_2, (over the treatment mean). Kheli, ISH 107, ISH 58, Gungera, and ISH 111 had higher IWUE for both the treatments and recorded higher IWUE than treatment means from the species clones studied. Co 15021, Co 15015, Co 14002, Co 15018 Co 12009 and Co 10026 recorded higher WP than treatment mean and are better types for WP. Kheli, ISH 107, ISH 58, Gungera, ISH 111 registered higher WP over and above the mean value of the treatments.

(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

Physiological observations were recorded at early growth stages in 296 sugarcane clones (Plant breeding and Physiology trials consisting of diverse genetic background) for identification of plant architectural traits in relation to conceptualization of sugarcane ideotype. The range of canopy temperature, SPAD index, Chlorophyll content, mean leaf angle TVD1, TVD2, TVD3 were (28.88-37.60), (11.20- 41.38), (0.005-0.040) and (4.56˚-17.22˚) respectively. Further the biomass, leaf area, number. of tillers was also recorded at grand growth phase for enriching database.

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

Comparative physiological analysis of tropical and sub tropical varieties of sugarcane

Experiment at tropical condition: During 2019 planting season, 10 tropical and 8 sub- tropical varieties were planted for multiplication. Initiated field experiment by 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 FRBD design.

Juice quality parameters: Data on juice quality parameters at 12th month showed that the tropical group recorded higher juice quality parameters *viz*., juice volume (451.75g/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, the variety 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: At maturity phase, data on partitioning efficiency towards stem was found comparatively higher in tropical group (78.43%) than sub-tropical group (73.43%), while sub-tropical group showed higher leaf and sheath partitioning efficiency of 15.75 and 11.01% compared to tropical group (12.65 and 8.92%). Among the varieties studied in tropical, Co 13006 recorded highest single cane weight of 1.18 kg/cane and this was closely followed byCo 14012 (1.17 kg) and Co 06022 (1.10 kg) with average SCW of 1.01 kg/cane (Table 16). In sub-

Table 16. Yield and yield components of tropical and sub-tropical varieties at harvest

Varieties	Internodal length (cm)	Cane girth (cm)	No. of internodes	SCW (kg)	Yield (tons/ha)
Tropical					
Co 86032	8.20	2.7	22.0	0.836	70.50
Co 0212	9.45	2.8	18.0	0.862	86.15
Co 14012	10.10	2.9	20.0	1.17	90.12
Co 06022	9.30	3.3	19.0	1.10	75.68
Co 11015	10.50	3.0	21.2	0.862	87.50
Co 13006	11.00	3.20	23.00	1.18	92.90
Mean	**9.75**	**2.98**	**20.50**	**1.01**	**85.53**
Sub-Tropical					
Co 0238	6.76	2.9	13.0	0.716	65.41
Co 15027	8.62	3.2	15.0	0.862	74.50
Co 15023	7.60	2.6	15.0	0.760	70.40
Co 98014	10.02	2.5	19.0	1.02	82.00
BO 91	5.28	2.4	14.0	0.640	63.50
CoLk 8102	6.28	2.2	16.0	0.528	67.12
Mean	**7.43**	**2.63**	**15.33**	**0.754**	**70.48**
Over all mean	**8.59**	**2.85**	**17.91**	**0.882**	**78.05**
G	**1.12****	**0.08***	**0.7***	**0.031***	**4.15***
V	**1.40****	**0.06***	**0.6***	**0.056***	**8.56***
G x V	**2.25****	**0.12***	**1.2***	**0.10****	**9.18****

tropical group, highest SCW was recorded in Co 98014 (1.02 kg/cane) and this was 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 highest cane girth of 3.20 cm and CoLk showed 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, highest number of internodes found in Co 11015 (23.00/cane) and lowest found in Co 0212 (18.0/cane). In sub-tropical group, the variation was 13.00 (Co 0238) to 19.00/cane (Co 98014). Cane yield was comparatively high in tropical group (85.53 tonnes/ha) than sub-tropical group (70.48 tonnes/ha). Among the tropical group, the variety Co 13006 able to record higher cane yield of 92.90 tonnes/ha and lowest cane yield found in Co 06022 (75.68 tonnes/ha). In sub-tropical group, highest cane yield was found in Co 98014 (82.0 tonnes/ha) and it was closely followed by Co 15027 (74.50 tonnes/ha) and lowest value noticed in Co 0238 (65.41 tonnes/ha).

Experiment during 2020-21: During 2020-21 planting season, a field experiment was taken up by using same 6 tropical and sub-tropical varieties in FRBD design and the work is on progress.

Biometric observation at formative and GGP phases of tropical and sub-tropical varieties: Growth and biometric observations were recorded formative, GGP and maturity phases of crop in both tropical and subtropical varieties in replicates. Similarly physiological and biochemical parameters *viz.,* total chlorophyll content, SPAD value, NRase activity & Total phenolics content were assayed at important growth phases of crop. At GGP, data on total chlorophyll content in tropical varieties was varied from 1.65 mgg^{-1} (Co 13006) to 1.90 mgg^{-1} (Co 11015) and sub-tropical

Table 17. Variation in biochemical traits for tropical and sub-tropical varieties during FP and GGP phases & of the crop

Varieties	Total Chlorophyll content (mgg^{-1})		Chlorophyll SPAD value		NRase activity (μg^{-1} $frwt^{-1}$ h^{-1})		Total Phenolics (μg g^{-1} $frwt^{-1}$)	
Tropical	FP	GGP	FP	GGP	FP	GGP	FP	GGP
Co 86032	1.45	1.70	25.5	28.0	18.5	26.2	73.2	85.5
Co 0212	1.40	1.68	24.7	26.5	24.5	30.7	95.0	102.6
Co 14012	1.55	1.75	26.2	29.8	24.0	32.5	82.5	89.7
Co 06022	1.60	1.82	28.2	30.8	22.2	31.0	90.0	95.5
Co 11015	1.75	1.90	29.5	32.5	26.8	35.7	78.5	95.6
Co 13006	1.35	1.65	24.2	27.5	19.6	28.5	84.0	101.0
Mean	**1.51**	**1.75**	**26.38**	**29.18**	**22.60**	**30.76**	**83.86**	**94.98**
Sub- Tropical								
Co 0238	1.56	1.65	23.0	26.5	19.5	22.5	94.4	100.0
Co 15027	1.60	1.72	28.7	31.2	21.0	26.0	97.4	110.5
Co 15023	1.40	1.52	23.6	25.4	18.0	22.5	99.5	109.3
Co 98014	1.70	1.8	24.0	30.2	24.5	26.0	104.5	112.0
BO 91	1.44	1.60	22.1	24.0	21.8	24.0	95.0	99.0
CoLk 8102	1.55	1.62	25.8	26.0	23.0	25.0	91.2	105.6
Mean	**1.55**	**1.65**	**21.53**	**27.16**	**21.3**	**24.6**	**97.10**	**106.6**

varieties was 1.60 mgg^{-1} (BO 91) to 1.8 mgg^{-1} (Co 98014) (Table 17). The variation in NRase activity at GGP was from 26.2 (Co 86032) to 35.5 μg^{-1} $frwt^{-1}$ h^{-1}(Co 11015) in tropical varieties, while in subtropical varieties, the variation was 22.5 (Co 15023) to 26.0μg^{-1} $frwt^{-1}$ h^{-1} (Co 98014). Data on total phenolics content showed that the tropical varieties had higher phenolics in sub-tropical group as 97.10, 106.6 $\mu gg^{-1}frwt^{-1}$ than tropical varieties (83.86 & 94.98 $\mu gg^{-1}frwt^{-1}$) at FP and GGP respectively. Quality of irrigation water was estimated in terms of pH, EC, carbonate and bicarbonate and it was recorded as 8.7, 2.56 dS/m, 127 ppm and 560 ppm respectively.

Experiment at sub-tropical condition: For identification of acclimatization potential in order to interchanging the promising tropical clones to sub tropical condition and vice- versa, six subtropical clones (Co 0238, Co 15023, Co 15027, Co 98014, BO 91 and CoLk 8102) and six tropical clones (Co 11015, Co 0212, Co 06022, Co 13006, Co 14012 and Co 86032) were planted during first fortnight of April, 2020 in factorial randomized block design at field conditions of Sugarcane Breeding Institute, Regional Centre, Karnal. Germination percent was recorded from 50% (Co 15027) to 66% (BO 91) in subtropical clones whereas in tropical clones germination percent ranged from 18% (Co 86032) to 65% (Co 0212) at 45 days after planting (DAP). Germination % and establishment of crop was poor in Co 14012, Co 06022 and Co 86032.

Biometric observation during formative phase: At 120 DAP, in subtropical clones average no. of tillers (000/ha) were 115000/ha. Maximum tillers were recorded in CoLk 8102 (180000) followed by BO 91 (132.5), Co 0238 (129.9) and Co 15023 (128.4). In tropical clones, average no. of tillers were

96500/ha and maximum tillers were recorded in Co 11015 (125900/ha) followed Co 0212 (117900/ha). During formative phase (FP), leaf area index (LAI) varied from 1.15 to 1.46 while in tropical clones it ranged from 0.86 to 1.46. During grand growth phase (GGP), LAI ranged from 1.61 to 2.91 in subtropical clones whereas it varied from 1.18 to 1.79 in tropical clones (Fig. 44). In subtropical clones, Dualex values for chlorophyll content ranged from 33.53 (Co 98014) to 43.90 chlorophyll ug/cm^2 (Co 15027) while in tropical Co-clones 31.00 (Co 86032) to 43.0 (Co 11015). Phenolic content was recorded from 113.6 (Co 98014) to 156 ugg^{-1} F.W. (Co 0238) in subtropical clones whereas in tropical clones it ranged from 107.3 (86032) to 163.4 ugg^{-1} F.W. (Co 06022)

Biometric observation during grand growth phase: At 180 DAP, plant population was recorded from 92100/ha (Co 15027) to 155100/ha (CoLk 8102) in subtropical clones and from 119000/ha (Co 11015) to 47300/ha (Co 86032) in tropical clones plant population varied. Among all the studied Co-clones at 190 DAP, maximum plant height was recorded Co 98014 (280 cm) followed by Co 0238 (247 cm), Co 0212 (244 cm), CoLk 8102 (243 cm) and Co 14012 (233 cm), while minimum in Co 86032 (158.33 cm). During grand growth phase average Dualex values chlorophyll content (ug/cm^2) was 37.89 ug/cm^2. Maximum chlorophyll content (ug/cm^2) was recorded in Co 15027 (48.01) followed by Co 0238 (45.80), Co 15027 (48.01) and Co 11015 (43.00) whereas minimum in Co 86032 (34.20) and Co 06022 (32.40). Phenolic content range from 141.5 (Co 98014) to 227 ugg^{-1}F.W. (Co 0238) in subtropical clones while it ranged from 155.9 (Co 86032) to 251.12 ugg^{-1}F.W. (Co 06022) tropical clones.

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

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

An experiment was initiated at field condition in ICAR-SBI during 2020 with five Co canes *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. Line quantum sensors (LICOR) along with digital data logger (LI- 1400) were used to record the light interception data. The cumulative global photosynthetically active radiation (PAR) was recorded during the germination phase, formative phase, grand growth phase and maturity phase. Significant differences 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%) (Fig. 45). Better leaf area index (more than 1.0) was observed during early stage in narrow spacing (75cm and 90cm), while the 150 cm spacing was recorded with less leaf area index (<0.8). Dry matter production and shoot

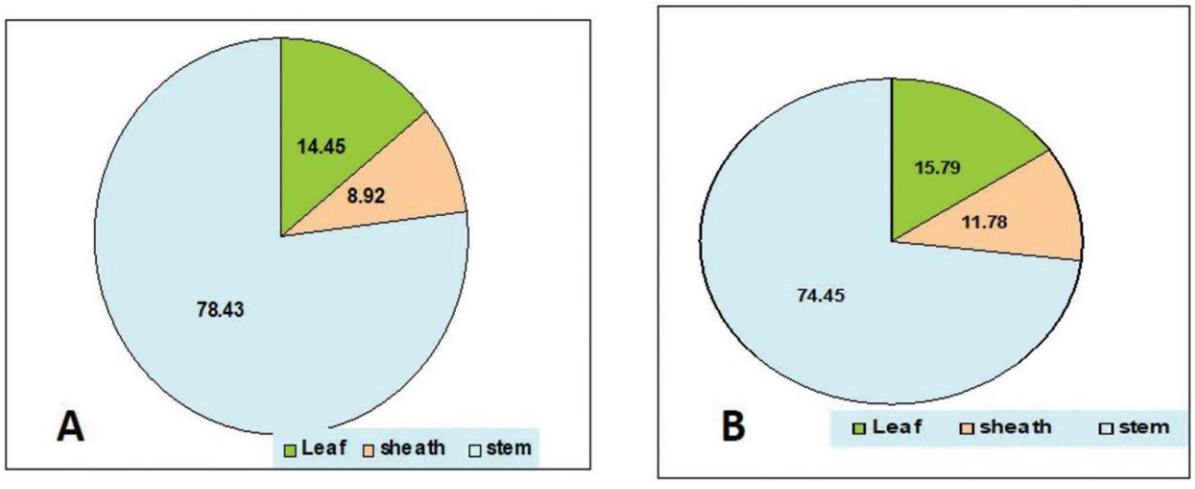


Fig. 44. Partitioning efficiency (%) of dry matter production in tropical (A) and sub-tropical (B)

varieties at maturity phase of the crop

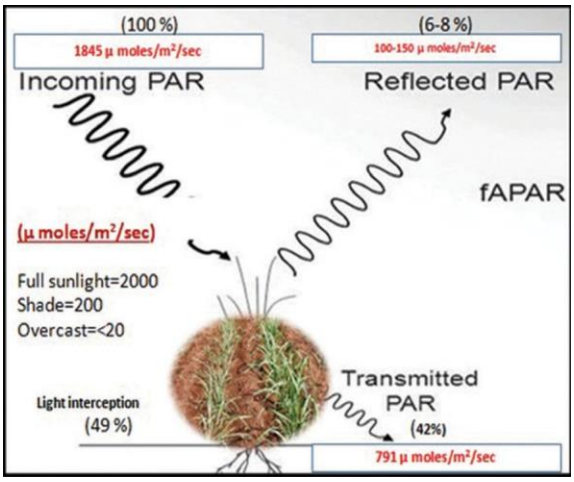


Fig. 45. Light distribution budget in sugarcane during early phase in 90cm row to row spacing

population was also recorded during formative, grand growth and maturity phase. 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. Juice analysis and harvest is under progress. 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, Khakkai, ISH 107, ISH 111 and Pathri showed better biomass production under severe water deficit condition (skipping alternate irrigation and irrigation with 50% crop evapotranspiration replacement).

(R. Arun Kumar and P. Geetha)

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 inhydroponics culture (Fig. 46) condition (Tank size: LxBxH=20x20x50cm) and Hoagland solution

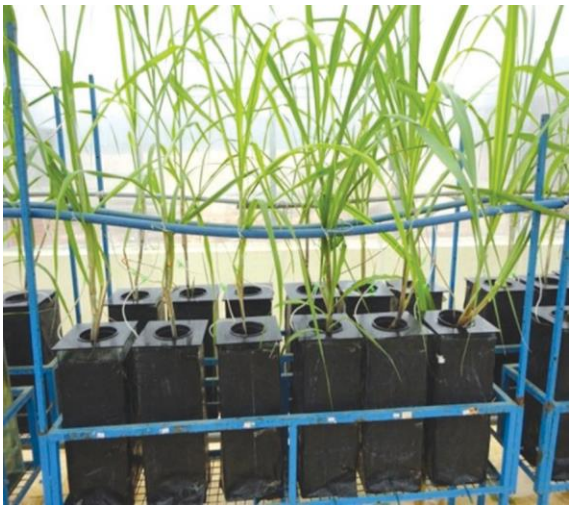


Fig. 46. Sugarcane clones in hydroponic culture

KNO_3, $MgSO_4.6H_2O$, KH_2PO_4, Fe EDTA, Minor nutrient: H_3BO_3 $MnCl_2.4H_2O$ $ZnSO_4.7H_2O$ $CuSO_4.5H_2O$ (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 is provided and the tanks were covered by black color for avoiding algal growth. Morphological traits *viz*., plant height, root length, number. of leaves, leaf length and leaf width were recorded. Chlorophyll content was recorded through SPAD meter. The drought susceptible genotype Co 8021 showed significantly less biomass along with other traits. The tolerant clones Co 86032 and Co 10026 showed significantly better leaf area and leaf number. and total biomass compared to Co 8021. The clones are being kept for drought treatment

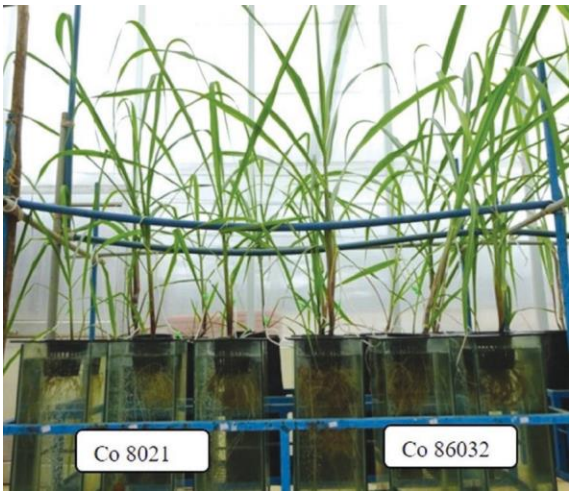


Fig. 47. Sugarcane clones, Co 8021 (less root andshoot growth) , Co 86032 (better root and shoot growth) in hydroponic culture

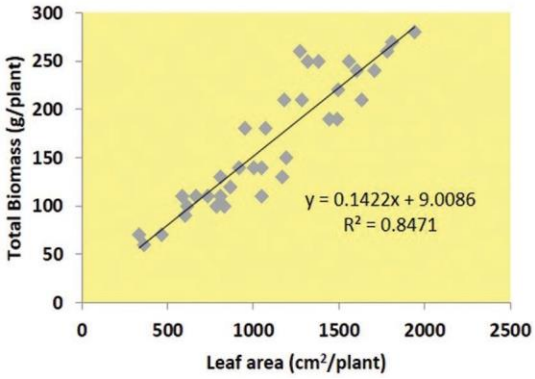


Fig. 48. Correlation between leaf area and total fresh biomass (included whole root system) in sugarcane clones grown under hydroponic culture

(using PEG) and subsequent observations are under progress. Significant correlation coefficient (R^2 =0.847**) between leaf area and total fresh biomass (included whole root system) was observed in sugarcane clones grown under hydroponic culture (Fig. 47-48).

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

Deciphering the physiological basis of nutrient use efficiency in sugarcane

In this experiment, Co 86032 plants were raised in with nutrient media and subjected to increasing concentrations of nitrogen (N), phosphorus (P) and potassium (K) (0 to 2000 µM). The set-up was placed in glass house under controlled condition. Three month old plants were harvested to record biomass partitioning and root traits. Typical deficiency symptoms observed in sugarcane leaves are presented in Fig. 49. Increasing N levels significantly affected SPAD index, plant height, number of tillers, leaf area, shoot dry weight, root volume, root dry weight, root-to-shoot ratio and total biomass, but not root depth. With increasing N, SPAD chlorophyll index, leaf area and shoot height varied from 18.6 to 38.1, 181.9 to 548.8 cm^2 and 36.7 to 94.9 cm, respectively. Similarly, P nutrition had a significant effect on all recorded traits except root-to-shoot ratio. With increasing P levels, SPAD index, leaf area and shoot height ranged between 41.0 to 32.0, 119.4 to 548.8 cm^2 and 48.2 to 95.6 cm, respectively. Influence of K was significant on all traits except number of tillers, root depth, root volume and root-to- shoot ratio. With increasing K levels, SPAD index, leaf area and shoot height varied from 28.3 to 33.3, 122.0 to 536.8 cm^2 and 57.4 to 91.3 cm, respectively. Deficiencies of macronutrients significantly reduced shoot dry weight which varied from 2.20 to 23.27 g, 3.96 to 18.03 g and 3.68 to 18.44 g in response to increasing levels of N, P and K, respectively (Fig. 50). With increasing levels of N, the root-to-shoot ratio on dry weight basis ranged between 0.226 and 0.201.

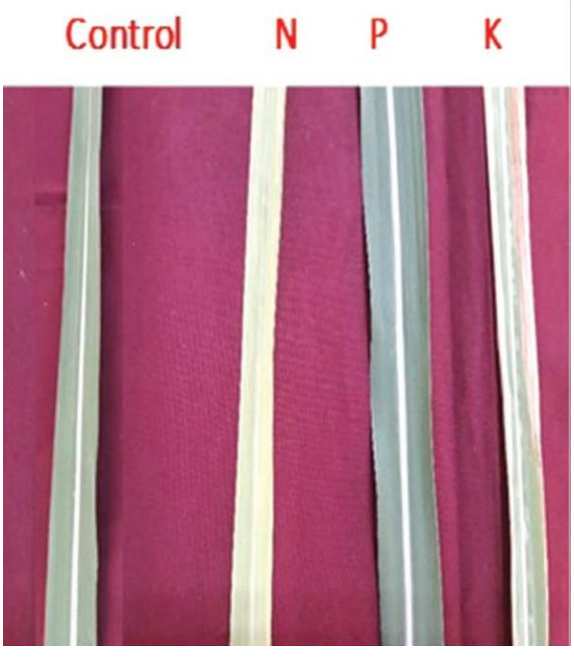


Fig. 49. Typical deficiency symptoms for N, P and K observed in Co 86032

Cate-Nelson analysis of relative shoot dry weight and leaf nutrient content led to the identification of critical threshold levels of nutrient concentration in media as 375, 87.5 and 175 µM for N, P and K, respectively (Fig. 50B-D). Based on data recorded in standard variety Co 86032, three treatment levels were determined (deficiency: 20 µM N, 2 µM P and 10 µM K; critical threshold: 375 µM N, 87.5 µM P and 175 µM K; sufficiency: 2 mM N, P and K). Varietal evaluation for nutrient use efficiency is in progress.

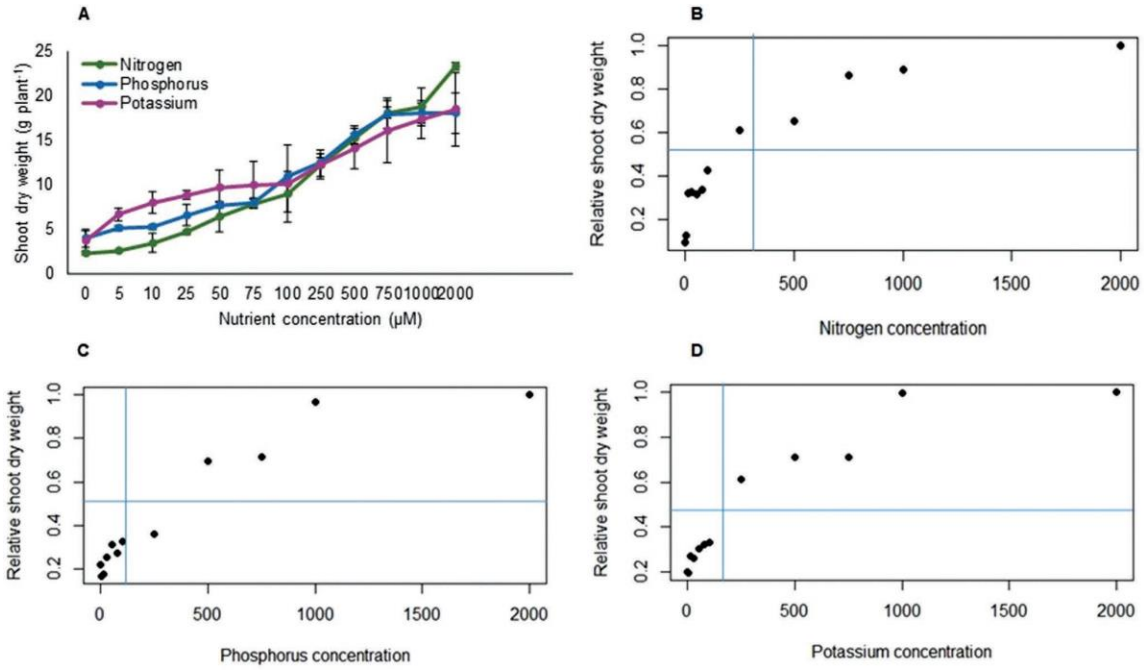


Fig. 50. Variation in shoot dry weight with increasing concentration of N, P and K (A), Critical threshold of nitrogen (B), phosphorus (C) and Potassium (D)

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

Characterisation of root system traits in sugarcane germplasm

Physiological traits, enzyme activity and above-ground biomass accumulation and partitioning was recorded in the formative (60-150 days), grand growth (150-240 days) and maturity (240-360 days) phases. Canes were harvested at maturity phase to record the yield attributing traits. Among the germplasm studied, total chlorophyll content averaged at formative and grand growth phases was highest in *Erianthus* spp. clones (1.95 and 2.11 mg g^{-1} FW) while *S. spontaneum* recorded least values (1.11 and 1.29 mg g^{-1} FW). Epicuticular wax deposition in leaves was more in the intergeneric hybrid with *Bambusa* spp. at formative phase (15.018 µg cm^{-2}). Total soluble protein, nitrate reductase activity and antioxidant enzyme activity showed wide variation among the tested germplasm. At formative phase, *S. officinarum* clones exhibited highest average activity of the enzymes sucrose synthase (33.50 µg g^{-1} FW h^{-1}), sucrose phosphate synthase (40.31 µg g^{-1} FW h^{-1}), acid invertase (31.20 µg g^{-1} FW h^{-1}) and neutral invertase (36.61 µg g^{-1} FW h^{-1}) followed by *S. sinense* and *S. barberi*. Leaf dry weight varied from 2.507 to 99.567 g, the mean value being 32.602 g. At grand growth phase, leaf dry weight varied from 8.59 g (*Pennisetum* spp.) to 98.23 g (*Erianthus* spp.), the mean being 45.07 g. Highest sheath dry weight (58.45 g) was recorded in *Erianthus* spp., while cane dry weight was maximum in *S. officinarum* (241.06 g).

On the whole, *S. officinarum* clones exhibited thick canes and highest single cane weight, while internode length was highest *S. spontaneum*. On the whole, stress tolerance traits with respect to antioxidant enzyme activity and biomass accumulation potential is higher in related genera such as *Erianthus spp.* and *Pennisetum* spp., whereas *S. officinarum*, *S. barberi* and *S. sinense* clones exhibit superior sucrose metabolism and yield attributes. *S. officinarum* clones were thick canes, with high single cane weight and superior in terms of sucrose metabolising enzymes. It showed moderately developed root morphology, with highest cortex-to-stele ratio and least number of metaxylem elements. *S. barberi* clones had moderately developed root system which also reflected as least leaf area and biomass accumulation, and yield attributing traits such as cane thickness, height, internode number and length. *S. spontaneum* clones showed deep rooted morphology with thin roots, least

cortex-to-stele ratio in the formative stage, but high root volume at grand growth stage. It also put forth thin canes with long internodes and least single cane weight. *E. arundinaceus* and *E. bengalensis* clones and inter-generic hybrid of *S. robustum* and *Bambusa* spp. exhibited superior root morphology and anatomical features, with least cortex-to-stele ratio and more metaxylem elements. Biomass accumulation in leaf and sheath was high, with mediocre single cane weight.

(V. Krishnapriya)

5.2.3 SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Natural Resource Management for Enhancing Productivity and Sustainable Sugarcane Production

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

Planted 31 genotypes for multiplication in 20 February 2020. Infestation of sedges (*Cyperus rotundus*) was very predominant over other

Fig. 51. a) Before spraying

Fig. 51. c). 30 DAS

weeds in the plot (Fig. 51). Hence, post-emergence application of Halosulfuron Methyl 75% WG

Fig. 51. b) 7 DAS

and Metribuzin 70% WP was carried out at the rate of 67.5 g and 1000 g a.i. per hectare on 42 days after planting (DAP). Lower leaves of some of the genotypes were found to show injuries on 5 days after spraying (DAS). Phytotoxicity was recorded in visual scoring scale of 0 to 10 at 7, 15, 21 and 30 DAS. Phytotoxicity rating of the 31 genotypes studied ranged between 0 and 4. Nine genotypes showed no visual injury and found tolerant, while eight genotypes showed moderate toxic effect (rating 4). All the genotypes (14 nos.) that showed phytotoxicity rating of 1 to 3 recovered visually (leaf injuries) except Co 06027 at 30 DAS, while all the genotypes that showed moderate phytotoxicity did not recover completely except Co 94008. The genotypes with Co 7201 and Co 775 as one of the parents showed phytotoxicity rating ranging from 1 to 4. The genotypes, Co 06030, Co 86032, Co 11015, Co 92005 and Co 09004 did not exhibit phytotoxicity symptoms, while their parent, CoC 671 exhibited phytotoxicity.

These 31 genotypes were planted in Additional Land on 04 March 2020 in two replications. The CO_2 flux was recorded before planting and 3 DAP. The average (n=7) CO_2 flux before planting (dry) and 3 DAP (moist) was 2.4 and 14.68 µM/m2/s, respectively. Tiller count was performed on 06 June 2020. Recorded CO_2 flux and collected soil samples on 23 October 2020. Counting of NMC was done on 24 October 2020. NMC differed significantly (p=0.05) among genotypes while CO_2 flux, soil pH, EC and SOC did not differ significantly (Table 18).

(C. Palaniswami and A. Vennila)

Table 18. NMC, CO_2 flux, soil pH, EC and soil organic carbon content under different sugarcane genotypes at 230 DAP

Genotype	NMC/ha	CO_2 Flux (µM/ m^2/s)	Soil pH	Soil EC (dS/m)	Soil OC (%)
Co 0112	119000	8.23	8.21	1.18	0.99
Co 0113	138000	7.87	8.41	0.89	0.49
Co 0115	127000	7.35	8.33	0.96	0.75
Co 0212	125000	7.18	8.29	0.85	0.63
Co 0218	143000	9.31	8.43	0.85	0.76
Co 0238	77000	7.31	8.38	0.68	0.70
Co 0240	107000	6.84	8.30	0.90	0.67
Co 0314	104000	9.18	8.29	0.77	0.75
Co 0403	132000	7.54	8.33	1.15	0.88
Co 06022	83000	7.66	8.39	0.93	0.81
Co 06027	97000	5.95	8.26	0.98	0.72
Co 06030	105000	8.15	8.22	0.88	0.78
Co 09004	117000	5.22	8.48	0.92	0.89
Co 11015	102000	9.04	8.37	0.76	0.64
Co 62175	128000	8.54	8.13	2.01	0.69
Co 6806	114000	7.90	8.34	1.30	0.83
Co 7219	96000	6.78	8.33	0.72	0.80
Co 8021	131000	7.82	8.36	0.72	0.67
Co 8338	74000	9.22	8.36	0.66	0.75
Co 85019	84000	7.70	8.43	0.67	0.63
Co 86032	100000	8.81	8.36	0.59	0.56
Co 86249	118000	11.88	8.36	0.72	0.72
Co 87025	83000	5.22	8.33	1.03	0.55
Co 91010	70000	4.73	8.30	0.72	0.70
Co 92005	117000	9.70	8.33	0.85	0.89
Co 94008	82000	8.32	8.34	0.92	0.80
Co 97010	112000	9.53	8.16	0.82	0.87
Co 99004	77000	6.92	8.38	1.49	0.69
Co 99006	117000	5.86	8.31	1.02	0.92
CoC 671	84000	10.65	8.36	1.02	0.56
CoM 0265	108000	4.60	8.34	0.85	0.81
Mean	105516	7.77	8.33	0.93	0.74
F test	5.05**	NS	NS	NS	NS

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

Soil inference system (SIS) software with soil constraint identification and management measures was developed in Microsoft Visual Studio Professional 2017 in C#. Management measures for subsurface hardening, sulphur nutrition and calcareousness were incorporated apart from regular nutrient recommendations and problem soil management measures in the SIS software. The developed SIS software provides soil health card with soil constraint management and nutrient recommendations in Tamil. Analysed the 106 soil samples from the command area of Amaravathi Cooperative

Sugar Mills, Udumalaipettai and generated soil health cards with soil constraint management suggestions. Analysed 102 soil samples received from Kothari Sugars and Chemicals Limited, Kattur Unit (55 nos.) and Sathamangalam Unit (47 nos.), generated soil health cards and sent on 11 August 2020 and 21 September 2020, respectively. Soil moisture constants were analysed using pressure plate apparatus. Field capacity, permanent wilting point and available moisture content ranged from 4.92 to 30.39, 2.30 to 15.88 and 2.28 to 15.20%, respectively. All the soil moisture characters (FC, PMP, AWC and SMC) showed positive correlation with clay and silt content, and negative correlation with sand content (Table 19).

(A. Vennila, C. Palaniswami and I. Rajendran)

Demonstration of crop production technologies for sugarcane

The regular drip irrigation, fertigation, monitoring and maintenance was carried out for the second ratoon crop which was ratooned on 20 September 2019. Flood irrigation was provided to set soil condition to perform earthing up operation on 18 March 2020 in the northern section of the field. Severe lodging occurred. Hence, harvested the canes in that section on 20 March 2020. Total cane yield at 180 DARI was 56.19 t/ha (Northern section). Trash shredding using tractor drawn shredder was carried out on 06 April 2002 and urea broadcasting @ 50 kg/ha was carried out on 07 April 2020. Third ratoon was initiated with stubble shaving and off-barring on 15 April 2020. Nutrient (N, P and K) requirement was calculated based on the STCR target of 125 t/ha. Basal application of single super phosphate and 25% excess urea, FYM@12.5t/ha, $FeSO_4$ (@100 kg/ha) and $ZnSO_4$ (@40 kg/ha) were carried out. Fertigation started in the first week of ratooning with 30% N and K till 12th week and remaining dose from 13 to 25th week. The intercropping could not be taken up in the third ratoon because of the untimely harvest of the crop and the complete lockdown due to COVID 19 pandemic. Clump-wise ratoon sprouting was counted on 06 June 2020 and tiller count was taken on 25 June 2020. The second ratoon crop in the southern section of the field was maintained and recorded the biometric data and analyzed the juice quality on 24 June 2020 at 270 days after ratoon initiation (DARI) and the crop was harvested during 13-16 July 2020. Cane height, cane diameter, number of internodes, single cane weight, number of millable canes, cane yield and CCS yield did not differ significantly (p=0.05) among intercropping

Table 19. Simple correlation matrix for the soil moisture constants with basic properties of soil profiles studied (n=75)

	OC	BD	Clay	Silt	Sand	FC	PWP	AMC	SMC
OC	1								
BD	0.31	1							
Clay	-0.01	-0.03	1						
Silt	-0.06	0.06	0.62	1					
Sand	-0.1	-0.07	-0.91	-0.84	1				
FC	0.08	0.21	0.51	0.79	-0.7	1			
PWP	0.12	0.26	0.46	0.77	-0.65	0.96	1		
AMC	-0.07	0.01	0.44	0.56	-0.57	0.74	0.52	1	
SMC	0.15	0.21	0.45	0.72	-0.65	0.94	0.91	0.66	1

OC: organic carbon; BD: dry bulk density; FC: Field capacity; PWP: Permanent wilting point; AMC: Available moisture content; SMC: Saturation moisture content

Table 20. Cane height, cane diameter, internode nos., SCW, NMC, cane yield and CCS yield at 270 DARI (Second ratoon crop)

	Cane height (cm)	Cane diameter (mm)	Internode nos.	SCW (kg)	NMC/ha	Cane Yield (t/ha)	CCS yield (t/ha)
Black Gram	202.30	27.13	20	1.20	88262	105.39	13.90
Coriander	180.65	28.11	20	1.09	85394	93.35	11.93
Green Gram	172.20	27.02	18	1.01	96505	92.55	12.13
Sole sugarcane	180.75	28.69	20	1.18	69982	81.57	10.59
Mean	183.98	27.74	20	1.11	85036	93.22	12.14
F test (p=0.05)	NS	NS	NS	NS	NS	NS	NS

SCW - Single cane weight; NMC - Number of millable canes; CCS - Commercial cane sugar

treatments and the mean values are 183.98 cm, 27.74 mm, 20, 1.11 kg, 85036/ha, 93.22 t/ha and 12.14 t/ha, respectively at 270 DARI (Table 20). The intercropping did not affect significantly the juice quality and the mean Brix, sucrose, purity and CCS was 20.91%, 18.67%, 89.28% and 12.14%, respectively at 270 DARI. The soil samples were collected after the harvest of second ratoon and analysed for organic carbon content in the ridges and furrows separately. This type of sampling was carried out since the ridges received mulched trash (after detrashing) and the shredded trash while the furrows received the shredded trash for the past three seasons. The ridges (0.78%) had higher SOC than the furrows (0.57%). Among intercropping, black gram treatment (0.74%) showed higher SOC than others (Table 21). Severe lodging was observed and hence, suggested to take up new planting in the next planting season in the southern section with single planting at 5 feet spacing. Trash shredding was taken up using terminator in the southern section on 25 July 2020 and the plot was ploughed. The new planting in the southern section is initiated and third ratoon crop in the northern section is being maintained.

(A. Vennila, S. Anusha, C. Palaniswami and Bakshi Ram)

Development of simulation model for sugarcane production system

The base temperature was estimated using the planting and flowering date of the clones flowered during flowering season in 2019 and 2020. General base temperature for flowering was estimated by minimizing the standard deviation (SD) for variation in growing degree days (GDD) of paired clones of flowering seasons 2019 and 2020, where a range of base temperature from 1 to 39 °C was used to calculate GDD. The

Table 21. Soil organic carbon content (%) in the ridges and furrows after three seasons of cropping (1 Plant + 2 ratoons)

	Furrow	Ridge	Mean
Black gram	0.59	0.89	0.74
Coriander	0.63	0.70	0.66
Green gram	0.54	0.76	0.65
No intercrop	0.54	0.76	0.65

Mean	0.57	0.78	

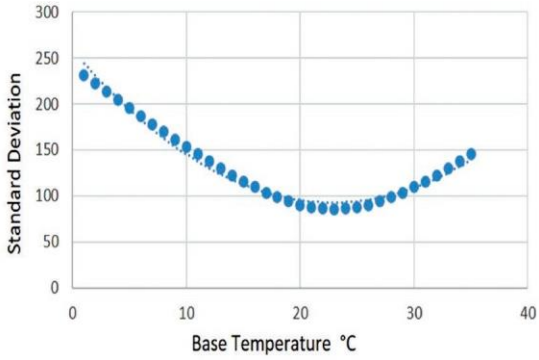


Fig. 52. Variation in standard deviation for different base temperature across the sugarcane clones

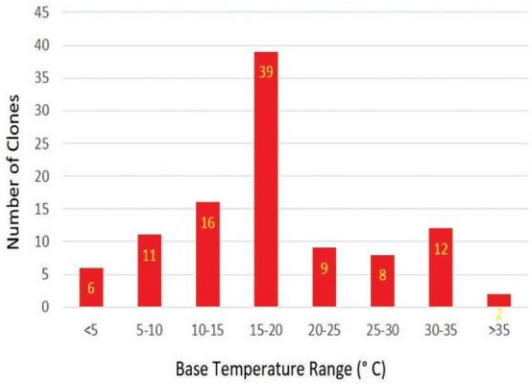


Fig. 53. Number of sugarcane clones in the different range of base temperature for flowering phase

temperature that provided the lowest SD was selected as the base temperature for across the clones. The estimated base temperature by this method is 23 °C (Fig. 52). Caveat in this method is the majority of clones had base temperature for flowering phase is 23 °C but individual clones base temperature may vary.

Base temperature for flowering in individualclone was estimated by minimum absolute deviation in GDD between flowering seasons2019 and 2020 where a range of base temperature from 1 to 39°C was used to calculate GDD. Among the flowering clones thirty-nine had the base temperature for flowering between 15-20 °C. Among the flowering sugarcane clones, 3.5, 6.4, 9.4, 22.8, 5.3, 4.7, 7 and 1.2 per cent clones had the base temperature range <5, 5-10, 10-15, 15-20, 20-25, 25-30, 30-35 and >35 °C, respectively (Fig. 53). There about 68 clones for which the base temperature was not able to estimate by this method. Fifty six clones did not respond to the variation in base temperature which included mostly regular and intensive flowerers. About 12 clones mostly of tropical showed flat response to base temperature variation. Amid the clones which responded to the base temperature, highest number of clones (21) were in the range around 20 °C. Around 25 % of the clones responded to the base temperature variation below 20 °C and another 25 % were above 20 °C. The clones originated from subtropical region were mostly concentrated on either in most responsive base temperature category of 20 °C or in the category nonresponsive to variation in base temperature. However, the clones originated from tropical region spread in all the categories of response to base temperature variation

(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)

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

As per the recommendation of the 50th Sugarcane Research & Development Workshop of Tamil Nadu and Puducherry, a project to standardize nutrient management package for Co 11015 including micronutrients for ratoon crop has been planned. Two experiments have been initiated simultaneously, one for plant crop and another for ratoon crop. Another experiment specifically for micronutrient management in ratoon crop of Co 11015 was initiated at ECC Farm on 12 March 2020. Initial soil properties were analyzed and STCR dose for the target yield of 150t/ha were worked out. The plant crop experiment was planned with eight treatments in three replications. The treatments consisted of STCR dose and blanket dose with and without Fe and Zn application. The soil and foliar application of Fe and Zn as were included in the treatments. FYM, phosphatic fertilizer

Table 22. Effect of different nutrient treatments on germination, Tiller numbers, SPAD Value and number of millable canes of Co 11015

Treatment		Germination (%) at 30 DAP	Tiller numbers/ ha at 90 DAP	SPAD Value at 120 DAP*	NMC/ ha at 150 DAP	NMC/ ha at 300 DAP
T1	STCR 150 + basal FYM @5t/ ha	57.69	107778	24.52[a]	87685	80926
T2	STCR 150 + basal FYM @5t/ ha + Soil Fe and Zn	56.30	116852	29.32[b]	90926	80278
T3	STCR 150 + basal FYM @5t/ ha + Foliar Fe and Zn	57.04	112963	34.02[c]	91944	88981
T4	Blanket + basal FYM @5t/ha	52.87	99861	23.06[a]	88139	87500
T5	Blanket + basal FYM @5t/ha + Soil Fe and Zn	56.48	106111	28.69[b]	88472	76667
T6	Blanket + basal FYM @5t/ha + Foliar Fe and Zn	60.46	116574	34.45[c]	91389	82222
T7	FYM treatment @5t/ha	54.07	103611	28.45[b]	82639	80000
T8	Absolute control	52.41	101759	28.49[b]	82130	81389
Mean		55.91	108189	28.88	87916	82245
SEd		1.78	3707	1.44	2186	3370
CD5%		NS	NS	3.08	NS	NS

* Cells with same letter did not differ significantly (p=0.05).

(SSP), and soil application of $FeSO_4$ and $ZnSO_4$ were applied in furrows before planting as per the treatment plan. The two-budded setts ofCo 11015 were planted in 1.5 m row spacing on 11 February 2020 with normal seed rate (7 setts/m). The N (Urea) and K (MOP) fertilizers were applied as top dressing in three splits (45, 90 and 135 DAP). First two split doses imposedas per the plan in furrows during earthing up. Third split dose of N, K and the additional doseof FeSO4 and ZnSO4 @ 50 and 20 kg/ha was imposed as pocket manuring. Foliar spray ofFe and Zn was imposed to the foliar treatments with the symptomatic application strategy. The experiment required five sprays (30, 60, 75, 90 and 120 DAP). Spray fluid concentration
used was 1% (0.4, 0.4, and 0.2% Urea, $FeSO_4$ and $ZnSO_4$) till 60 DAP and 1.5% (.6, 0.6 and 0.3% Urea, $FeSO_4$ and $ZnSO_4$) from 75 DAP to 120 DAP. Germination, number of tillers and number of millable canes while SPAD Value differed significantly (Table 22). The juice quality at 300 DAP did not vary significantly among treatments and the mean Brix, sucrose, purity and CCS per cent were 22.39, 20.73, 92.60 and 14.65, respectively. Significant positive correlation between total chlorophyll content and theSPAD Value was observed and the second order polynomial equation fitted well (R^2 = 0.6255) and SPAD Value can be used to predict the chlorophyll content (Fig. 54). This will be useful in developing nutrient management package to maintain threshold level of chlorophyll toattain the targeted yield. Leaf colour chart of Royal Horticulture Society (RHS), London was used to find out any difference in leaf colour with nutrient treatments and found to fall under Yellow Green Group. The nutrient treatments showed differential flowering behaviour and hence, the data on flowering was recorded. Cane and leaf samples were also collected for analyzing the difference if any with respective to nutrient accumulation among flowered and non-flowered canes in the treatments showing more than 5% flowering.

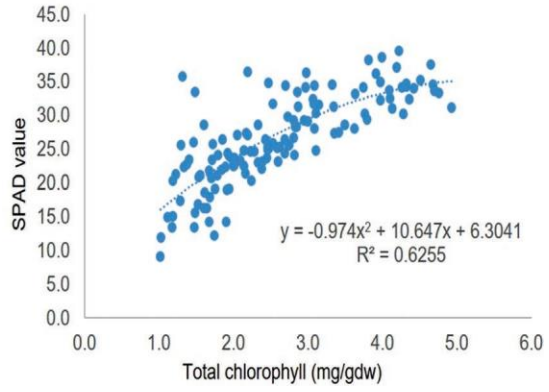


Fig. 54. Relationship between total chlorophyll and SPAD value of top visible dewlap leaf of Co 11015 at 170 DAP

Another experiment specifically for micronutrient management in ratoon crop of Co 11015 was initiated at ECC Farm on 12 March 2020. The ratoon sprouting of Co 11015 showed profuse yellowing. Hence, three blocksof Co 11015 were used for imposing the nutrient treatment. Foliar application of Fe and Zn, Soilapplication of Fe and Zn and a Control withoutFe and Zn. Standard practice of application of N, P and K was followed in all the treatments. Imposed the treatment of soil application of $FeSO_4$ and $ZnSO_4$ in furrows as basal and covered with soil. Foliar Spray I with urea, $FeSO_4$ and $ZnSO_4$ (0.3, 0.3 and 0.15%) on 10 April 2020 and Foliar Spray II with urea, $FeSO_4$ and $ZnSO_4$ (0.4, 0.4 and 0.2%) on 01 May 2020 was

carried out. Clump and Tiller count was made on 23 June 2020. SPAD reading was recorded on 03 June 2020. SPAD readings were recorded from 20 top visible dewlap leaves from each treatment and one-way ANOVA showed no significant difference and the mean SPAD value was 32.58. The crop recovered and showed no micronutrient deficiency symptoms.

Water quality of all bore wells of the Institute

Water samples were collected on 26 February 2020 from three active bore-wells in the additional land (Field No. 35, 30 and 36), one each from Field No. 25 (Main) and Narasampathi pond. Water quality of all the three bore-wells in additional land was found to fall under C4S2 suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops shouldbe selected. Medium-sodium water (S2) show appreciable sodium hazard in fine-textured soils of high cation exchange capacity, especially under low-leaching conditions, unless gypsum is present in the soil. This water may be used in coarse-textured or organic soils that have good permeability. Water quality of Narasampathi bore-well falls under the class C3S1 and the one in Field No. 25 (Main) falls under C4S1. High-salinity water (C3) can be used on soils with good drainage.

(A. Vennila, C. Palaniswami, I. Rajendran and G. Hemaprabha)

Analysis of liquid jaggery

Analyses of mineral, heavy metal and vitamins were done at Indian Institute of Food Processing Technology, Thanjavur for the parameters of calcium, phosphorous, sodium, selenium, iron, potassium, magnesium, manganese, zinc and copper; Heavy metals of lead, mercury and arsenic; Water soluble vitamins (B complex).

Minerals

class of irrigation. Salinity class C4 is not

Parameter analyzed	Results mg / kg	Parameter analyzed	Results mg / kg
Ca	667.50	K	6535.71
P	409.29	Mg	1168.39
Na	204.64	Mn	2.68
Se	3.93	Zn	90.00
Fe	23.93	Cu	ND

Heavy metals

Parameter analyzed	Results mg/kg
Pb	3.75
Hg	ND
As	ND

Water soluble vitamins

Parameter analyzed	Results mg/kg
D-Pantothenic acid, (Vitamin B5)	ND
Nicotinic acid, (Vitamin B3)	ND
Thiamine hydrochloride, (Vitamin B1)	104.68
Riboflavin, (Vitamin B2)	ND
Cyanocobalamine, (Vitamin B12)	13.49

(I. Rajendran, A. Vennila and C. Palaniswami)

Standardization of methodology for analysing sucrose content in amla juice incorporated liquid jaggery

Liquid jaggery prepared by incorporating amla juice (*Phyllanthus emblica*) in sugarcane juice showed difficulty in clarification for the analysis of sucrose content polarimetrically. Hence, an experiment was conducted with different levels of amla juice incorporation. Juice was extracted from 500 g of amla by adding distilled water and juice+water weight was adjusted to 800 g. the pH of amla juice was 2.8. Sugarcane juice (Co 86032) was added with different levels of amla juice (0, 28, 64, 112, 128 and 160 g/kg of sugarcane juice) to know at what level of amla juice incorporation causes the clarification issue. The combined juice was filtered after adding lead acetate (basic) as a clarifying agent for analysing sucrose content using polarimeter.

The sample added with amla juice @ 112 g/kg or more produced turbid filtrate. Liquid jaggery was prepared using sugarcane juice with the different levels of amla juice addition. Analysed the liquid jaggery for Brix, sucrose and reducing sugar (RS) content at 0 and 30 days of storage (DoS). The liquid jaggery samples also, with the incorporation of 112 g/kg or more amla juice showed turbidity with lead acetate (basic) addition to the N/2 jaggery solution for the analysis of sucrose both in 0 and 30 DoS. The pH of the corresponding N/2 solution were below 4.0. Then the solution was adjusted topH 4.0 using lime milk [$Ca(OH)_2$] and analyzed the POL value. The sugar crystallization has occurred to the extent of 75% in SCJ+0AJ (75%), SCJ+1AJ (50%) and SCJ+1AJ (50%) on 30 DoS.

The sucrose content was found to decrease and the reducing sugars to increase over 30 DoS. It is concluded that adjusting the pH is essential to determine sucrose content of the liquid jaggery incorporated with amla juice 11%w/w or more (Table 23).

Jaggery

About 450 kg of jaggery were produced on various lots of sugarcane juice. Two recipes, i. Badam jaggery and ii. Grape juice jaggery were standardised from sugarcane juice on lab scale for upscaling of the methodology.

(I. Rajendran, A. Vennila and C. Palaniswami)

Table 23. Quality of amla juice incorporated liquid jaggery up to 30 days of storage

Treatment	0 Day of storage			30 Days of storage		
	Sucrose (%)	Reducing Sugar (%)	pH*	Sucrose (%)	Reducing Sugar (%)	pH*
SCJ+ 0AJ	68.77	2.48	5.11	57.31	4.14	4.60
SCJ+ 1AJ	66.92	3.32	4.61	60.92	4.27	4.62
SCJ+ 2AJ	59.38	5.20	4.28	58.77	7.40	4.15
SCJ+ 3AJ	54.69	8.55	3.92	50.38	10.99	3.79
SCJ+ 4AJ	49.69	10.40	3.82	46.46	14.79	3.69
SCJ+ 5AJ	45.08	13.74	3.66	43.31	16.72	3.5

SCJ - Sugarcane juice; 0AJ-5AJ: 0, 28, 64, 112, 128 and 160 g Amla juice added per kg SCJ *pH of the N/2

soultion (13%w/v liquid jaggery solution)

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

In order to study the effect of invertase inhibitor over expression and subcellular targeting on juice quality and cane yield, we have successfully developed transgenic events in sugarcane (Fig. 55). As part of this study, we have screened the 68 putative transgenic events for the presence of transgene through PCR using three sets of primers specific for the regions within the gene, promoter and hygromycin resistance marker. Out of these putative transgenic evets, 29 events were positive for the presence of transgene which were taken for further studies (Fig. 56). We have studied the expression of invertase inhibitor genes in transgenic events through Real-Time PCR and the results revealed that the significant increase in the expression of transgene (1-10 folds) over the wild type control (Fig. 57). Further, in order to validate the vacuolar targeting of invertase inhibitor proteins, we have performed the transient expression assay

Fig. 55. Transgenic plants developed by overexpression of invertase inhibitor genes in sugarcane

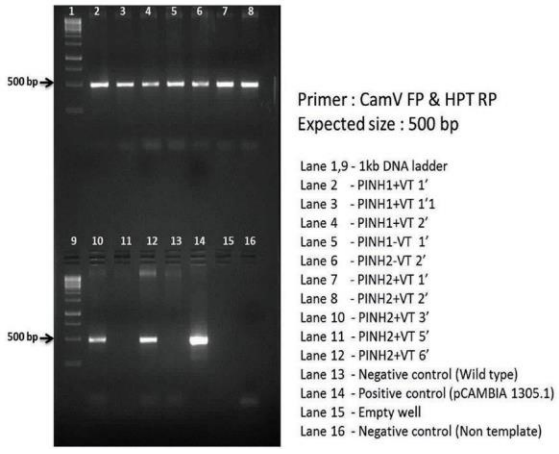


Fig. 56. PCR confirmation of putative transgenic events overexpressed with sugarcane invertase inhibitor genes

by fusing the invertase genes with GFP. The results revealed that ShINH1 and ShINH2 fused with GRP signal peptide and vacuolar targeting sequence (VT) showed strong GFP fluorescence signal in the vacuole in comparison with the cells targeted without VT which showed GFP fluorescence throughout the cytoplasm and cell wall respectively (Fig. 58). Analysis of HR Brixin the transgenic events revealed the variation among the events with maximum of 22.2^0 in the event number 28 as compared to wild type control (17.8^0) aged at 7^{th} month after planting. Although these data indicating the positive effect of overexpression on sucrose yield, further detailed studies are required in subsequent generation to validate the transgenic events for juice quality parameters and biotic and abiotic stresses tolerance.

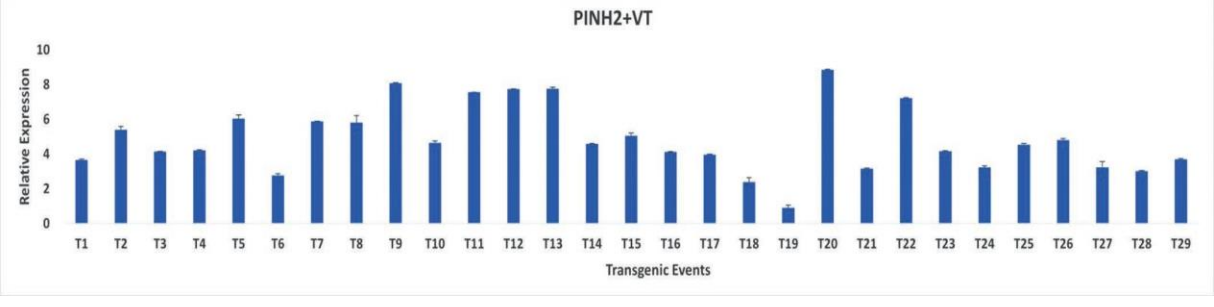


Fig. 57. Transcript expression analysis of transgene in invertase inhibitor over expressed sugarcane transgenic events through Real-Time PCR

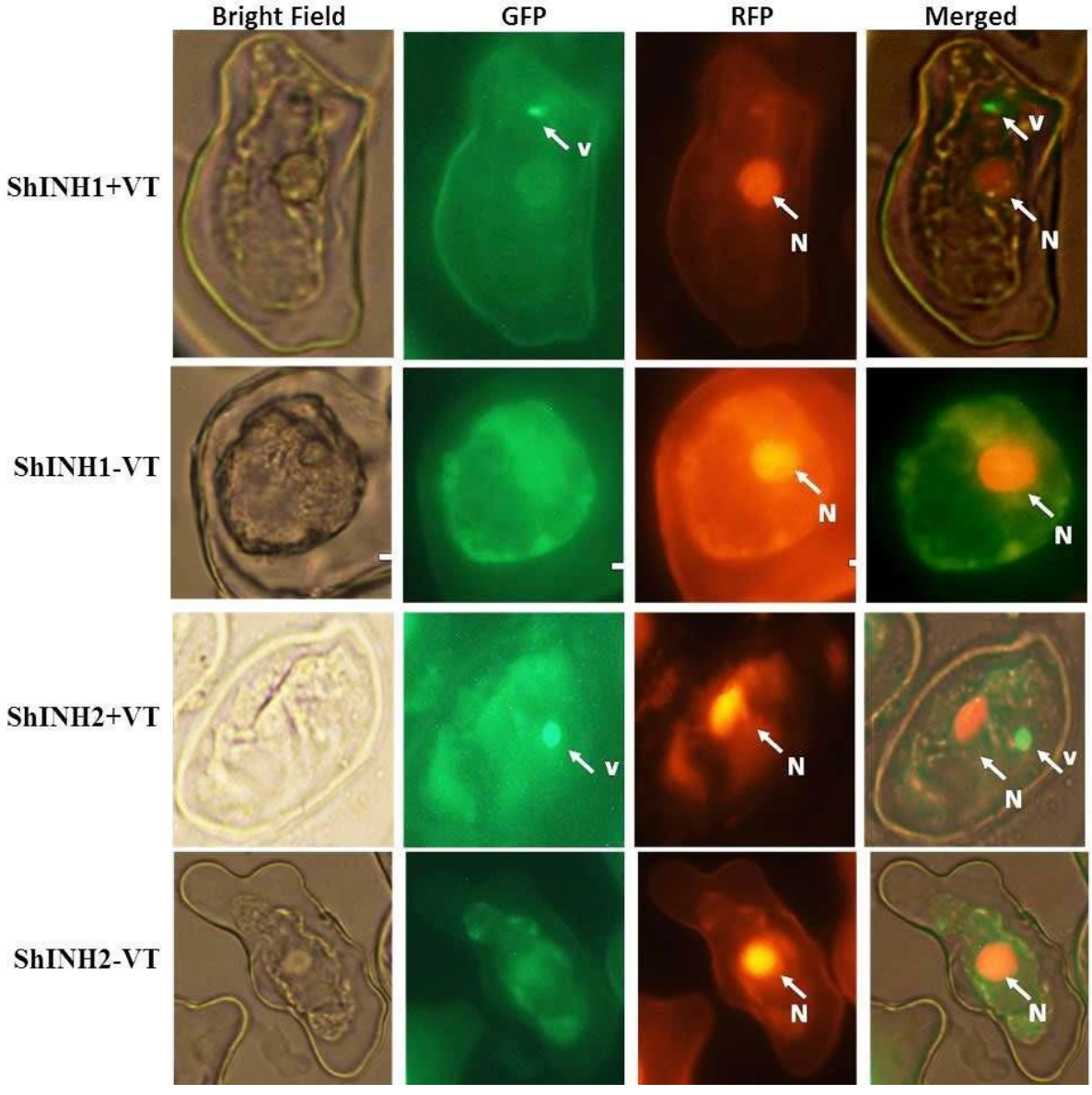


Fig. 58. Validation of sub-cellular targeting of invertase inhibitor proteins in over expressed sugarcane lines through transient expression of ShINH1/ShINH2 genes fused with GRP signal peptide, vacuolar targeting sequence and GFP. V- Vacuole and N- Nucleus

(G.S. Suresha)

5.3 DIVISION OF CROP PROTECTION

5.3.1 PLANT PATHOLOGY

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

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

Screening for red rot resistance: About 3061 clones from different trials of Crop Improvement Division comprising clonal trials, PZVT, elite hybrids, parental clones from NHG, allied genera, inbreds, genetic stocks etc were screened for red rot resistance under controlled conditions against CF06 (Cf671) pathotype. Disease development was ideal during the season and identified ~1524 clones as resistant to red rot (Fig. 59).

Fig. 59. Screening of sugarcane progenies for red rot resistance under controlled conditions: Clear phenotyping of R and S types

About 98 parental clones were evaluated against sugarcane smut during the crop season 2019-20 under field conditions by following standard inoculation method. Among the 98 entries, 14 entries *viz.,* Co 11005, Co 14028, Co 15002, Co 15003, Co 15013, Co 15023, BO 130, CoLk 8102, CoLk 94184, CoM 88121, CoN 10571, CoPant 97222, CoSnk 03754 and CoTl 1153 were identified as resistant, whereas three clones *viz.,* Co 12014, CoSnk 14103 and CoV 09356 were identified as moderately resistant. Of the remaining clones, 20 were found to be moderately susceptible, 17 were susceptible and 44 were highly susceptible.

Field tolerance to red rot: Detailed field experiments were conducted to assess red rot development from *C. falcatum* inoculum applied in the soil involving 11 varieties varying in red rot resistance and 12 fungal isolates with different virulence spectrum. Most of the isolates caused reduction in sprouting of buds, whereas the variety Co 11015 followed by Co 0238, CoC 671 and CoV 09356 recorded drastic reductions in germination due to the impact of soil inoculum. Apparently, the variety Co 0212 did not show reduction in bud germination. The isolates CfM0265-RK Pet followed by Cf86027-VLP, Cf06031-PRBR and CfC24 –MDTU exhibited more virulence on the sugarcane varieties and CfC24-Athimur, Cf94012-Guruva and Cf06022-Penna exhibited poor virulence. Mean maximum disease incidence was recorded in the cv. Co 94012, followed by Co 6304, CoC 671 and Co 86032. All the affected varieties except Co 6304 were infected by all the isolates and caused disease in varying proportions. The cv. Co 11015 picked up red rot against seven isolates, among them it showed more vulnerability to the isolates Cf86032-SKPM, CfC24-MDTU and CfM0265-RKPet. Among all the isolates CfV09356 –ENGR caused disease in nine varieties followed by the isolates Cf86032-SKPM and CfC24-Athimur infecting seven varieties. When compared to previous season, the disease development was very poor under field conditions, probably due to climatic factors and that needs to be investigated

Fig. 60a. C. falcatum inoculum (Cf86032-SKPM) applied to the soil caused poor crop stand of the cvs CoC 671 and Co 94012 against normal crop stand of Co 0238

Fig. 60b. Sugarcane cv Co 6304 exhibited poor crop stand as compared to better crop stand of the cvs Co 86032, Co 0212 and Co 0238 in response to C. falcatum inoculum (Cf86027-Vellalapalayam) applied to the soil

in detail. When data on plant survival in the plots were critically analysed, it was found that the susceptible variety Co 94012 recorded very poor crop stand due to death of red rot affected canes with loss of cane population to a tune of 58.93% and it was followed by 37.75% in Co 6304, 33.76% in Co 11015, 31.4% in CoC 671 and 28.28% in Co 86032 (Fig. 60). Except Co 0212, Co 0238 and CoV 92102, the crop stand in other varieties Co 09004 and CoV 09356 was affected significantly in the field even though the disease occurrence was less.

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

Yellow leaf disease (YLD)

Epidemiology: Yellow leaf severity on various germplasm and parental lines maintained at Coimbatore and Agali Centre was assessed during this crop season. In DUS reference lines, out of 236 entries 31.35% (74 entries) were apparently free, 14.83% (35 entries) were S, 16.52% (39 entries) were MR and 24.57% (58 entries) were MS. In Co canes, out of 210 entries 44.76% (94 entries) were apparently free, 7.61% (16 entries) were S, 18.57% (39 entries) were MS and 19.52% (41 entries) were MR; In Co allied canes, out of 270 entries, 65.18% (176 entries) were apparently free, 8.14% (22 entries) were S, 11.85% (32 entries) were MS and 8.14% (22 entries) were MR. Most of the species clone entries *viz*., *S. officinarum, S. barberi*, *S. sinense*, and *S. robustum* were apparently free from yellow leaf, however, in *S. officinarum,* out of 230 entries 9.13% (21 entries) were S, 5.6% (13 entries) were MS and 8.2% (19 entries) were MR. In, *S. barberi,* 6.66% were MS and 22.21% were MR. At National Hybridization Garden, 18.63% YL incidence was recorded in the parental clones during the season. Out of 424 parental lines, 3.30% (14 lines) were HS, 9.43% (40 lines) were MS, 1.65% were MR and the remaining 81.3% were apparently free from yellow leaf.

Impact of YLD on cane growth and yield: Detailed studies were conducted on the impact of YLD on cane growth and yield in three popular sugarcane varieties Co 86032, Co 0238 and Co 11015. Disease affected setts were planted along with disease-free setts (tissue culture derived) and different growth parameters were recorded during different growth stages. These varieties recorded a loss of 36.31, 19.35 and 30.21% in germination and 29.17, 17.14 and 13.08% in NMC and 81.06, 37.89 and 21.55% in flowering, respectively. The healthy plots recoded YLD incidences of 11.1, 1.4 and 30.7% as against 62.7, 16.1 and 28.0% in the diseased plots, respectively in the three varieties. In the cv. Co 0238, both the healthy and diseased plots exhibited YLD severity in the grade of '1', YLD severity grades in the cv. Co 86032 were '1' and '3' and 2 and 4 in Co 11015 respectively. The study revealed a rapid build-up YLD in the cv. Co 11015 followed by Co 86032. Further analyses on cane yield and juice parameters in the plots will be recorded at the time of harvest.

Impact of YLD on various morpho-physiological and yield parameters were recorded in virus-free, apparently healthy and symptomatic plants of the cv. Co 86032 in a separate study. Significant declines in cane height, cane girth, single cane weight, leaf length, leaf width, number of green leaves, leaf weight, sheath weight, root length/cane, root girth, number of roots/ cane, root weight/cane, juice weight/ cane, juice volume/cane, brix % and Pol % were observed in YLD affected canes compared to the apparently healthy and healthy canes.

Detailed observations on build up ScYLV titre and disease incidence in four succeeding vegetative generations after tissue culture were made in a field trial in the popular cv. Co 86032. YLD affected seed canes from severe (YLD grades 3-4) and very severe (YLD grade 4-5) categories were included as infected controls in the trial. The tissue culture derived plots have recorded sett germination in the range of 65- 85%, whereas the virus infected seed cane plots had 50.0- 63.7% germination. The plots of first and second generation seed canes after tissue culture were free from YLD, third generation plot had an incidence of 32.6 % and the fourth generation recorded 29.8% with YLD severities in the grade less than 1. About 49% YLD was recorded with severity grades in the range of 3-4 in the infected control (severe), whereas in

the control plot ~80% YLD was recorded with disease severities in the range of 4-5. Further, flowering is affected in the YLD-affected plots and also in the 3rd and 4th generation seed plots. In the very severe YLD control plot no flowering was recorded due to excess stunting, retardation of plant growth and severe bunching of leaves in the spindle. Regarding crop stand, when compared to the first generation TC seed canes, other treatments recorded low NMC, where the 2nd generation TC seed plot showed 14.12% reduction, whereas very severe YLD seed plot recorded highest reduction of ~40%. RT-qPCR assays to quantify the virus titre revealed that over the generations, the virus titre increased however, the symptomatic plants recorded multifold virus titre as compared to the tissue culture- derived plants.

A large plot study was conducted with YLD affected and healthy planting materials of 40 rows each at the main field to demonstrate the benefit of planting healthy materials to achieve the targeted cane yield in sugarcane varieties. YLD affected plot exhibited reductions of 15.6%, 21.43% and 84.31% in germination, NMC and flowering. The diseased plot exhibited 47.7% YLD with the severity grades in the range of 3-4 whereas in the healthy plot the disease incidence was restricted to 2.6 with the severities less than grade 1. Overall, a drastic reduction in cane growth was observed with poor crop stand in the affected plot (Fig. 61). Also the size of the arrows and number of spikelets were significantly reduced in the virus-infected plants (Fig. 62). Further, emergence of arrows was delayed by 7-10 days in the diseased plots with significant incomplete spikelet emergence.

Dynamics in aphid population: Sugarcane aphid, *Melanaphis sacchari* population dynamics were monitored under field conditions on a set of 17 varieties. Few varieties exhibited aphid colonization in trace during May and the population increased during June and July and later it declined. During September to October only few varieties exhibited a low aphid colonization and others were free from the insect colonization. November and December months were almost free from aphid colonization due to extended monsoon. Overall, aphid colonization during this year was low during this season and among the varieties, Co 86032, CoC 671 and CoTl 85411 susceptible to YLD recorded comparatively higher aphid count, although less compared to the previous seasons.

(R. Viswanathan and K. Nithya)

Fig. 61a. Crop stand of sugarcane cv. Co 86032 raised from YLD-free (left) and YLD-affected seed canes (right) during November 2020. Healthy crop maintained a vigorous crop stand and early flowering in

comparison to stunted growth with severe YLD in the diseased plot

Fig. 61b. The YLD affected canes exhibit a poor cane growth due to reduced number of internodes, internodal growth and cane girth (left) and YLD-free canes show luxuriant growth with elongated and uniform internodes (right)

Fig. 62. Arrows from virus-free canes exhibit normal growth (left) as against poor emergence of spikelets with reduced peduncle growth in the virus-infected plants (right)

Characterization of red rot pathotypes

C. falcatum isolates numbering 35 from tropical region were tested on 32 sugarcane varieties showed broad pathogenic variation. Unlike last season, it was found that comparatively more isolates behaved as less virulent during this season. The Tamil Nadu isolates *Cf*C24-Mandagapattu, *Cf*86032-Srikandapuram and *Cf*94012 (CF12), Cf95020 isolate from Gujarat and Cf86032 from Odisha behaved as more virulent whereas the isolates *Cf*V09356-Ellanganur, *Cf*C24-Radhapuram, *Cf*92061-NKM, *Cf*95020-Koogalur, *Cf*V92102-Muttakudi, *Cf*C24-Thandavarayanpattu, *Cf*94012-Guruvareddiyur, *Cf*94012-Cholachiramani, *Cf*671-G and *Cf*94012-G that exhibited high virulence during the last season showed a reduced virulence. Only the three isolates *Cf*C24-Mandagapattu, *Cf*95020-G and *Cf*86032-Srikandapuram maintained higher virulence. *Cf*V09356-Paripalli isolate from Odisha exhibited total avirulence whereas another isolate from the same state *Cf*86032-Nayagargh exhibited a gained virulence during the season.

Overall 16 isolates including the reference pathotype CF12 exhibited poor virulence as compared to nine during 2018-19 and 11 in 2017-18 seasons. The known susceptible varieties Co 419, Co 658, Co 997 and Co 6304 also exhibited MR/MR reactions against different isolates (Fig. 63). similarly MS varieties like Co 7805,

Fig. 63. Reaction of sugarcane cv. Co 658 to different C. falcatum pathotypes; the disease reactions were phenotyped 60 days after plug method inoculation

Co 86002 and Co 86032 behaved more towards resistant reactions. The variety Co 11015 behaved moderately susceptible to *Cf*671-pathotype and it exhibited S to HS reactions to some of the isolates (Fig. 64).

(R. Viswanathan and R. Selvakumar)

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

To gain a new insight into host defense mechanism against *C. falcatum* we studied the role of sugarcane microRNAs during compatible and incompatible interactions by adopting NGS platform. We have sequenced a total of 80 miRNA families that comprised 980 miRNAs and the putative targets of the miRNAs include transcription factors, membrane bound proteins, glutamate receptor proteins, lignin biosynthesis proteins, signaling cascade proteins, transporter proteins, mitochondrial proteins, ER proteins, defense related, stress response proteins, translational regulation proteins, cell proliferation and ubiquitination proteins. Further, qRT-PCR analyses of 8 differentially regulated miRNAs and 26 gene transcript targets expression indicated that these miRNAs have a regulatory effect on the expression of respective target genes, in most of the cases. Also, the results suggested that certain miRNAs regulate many target genes that are involved in inciting early responses to the pathogen infection, signaling pathways, endoplasmic reticulum stress and resistance gene activation through feedback response from

Fig. 64. Reaction of sugarcane cv. Co 11015 to different C. falcatum pathotypes; the disease reactions were phenotyped 60

days after plug method inoculation

various cellular processes during compatible and incompatible interaction with the red rot pathogen *C. falcatum* (Fig. 65). The study revealed the role of sugarcane miRNAs and their target genes during sugarcane - *C. falcatum* interaction and provided new insight into the miRNA mediated defence mechanism in sugarcane, for the first time.

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

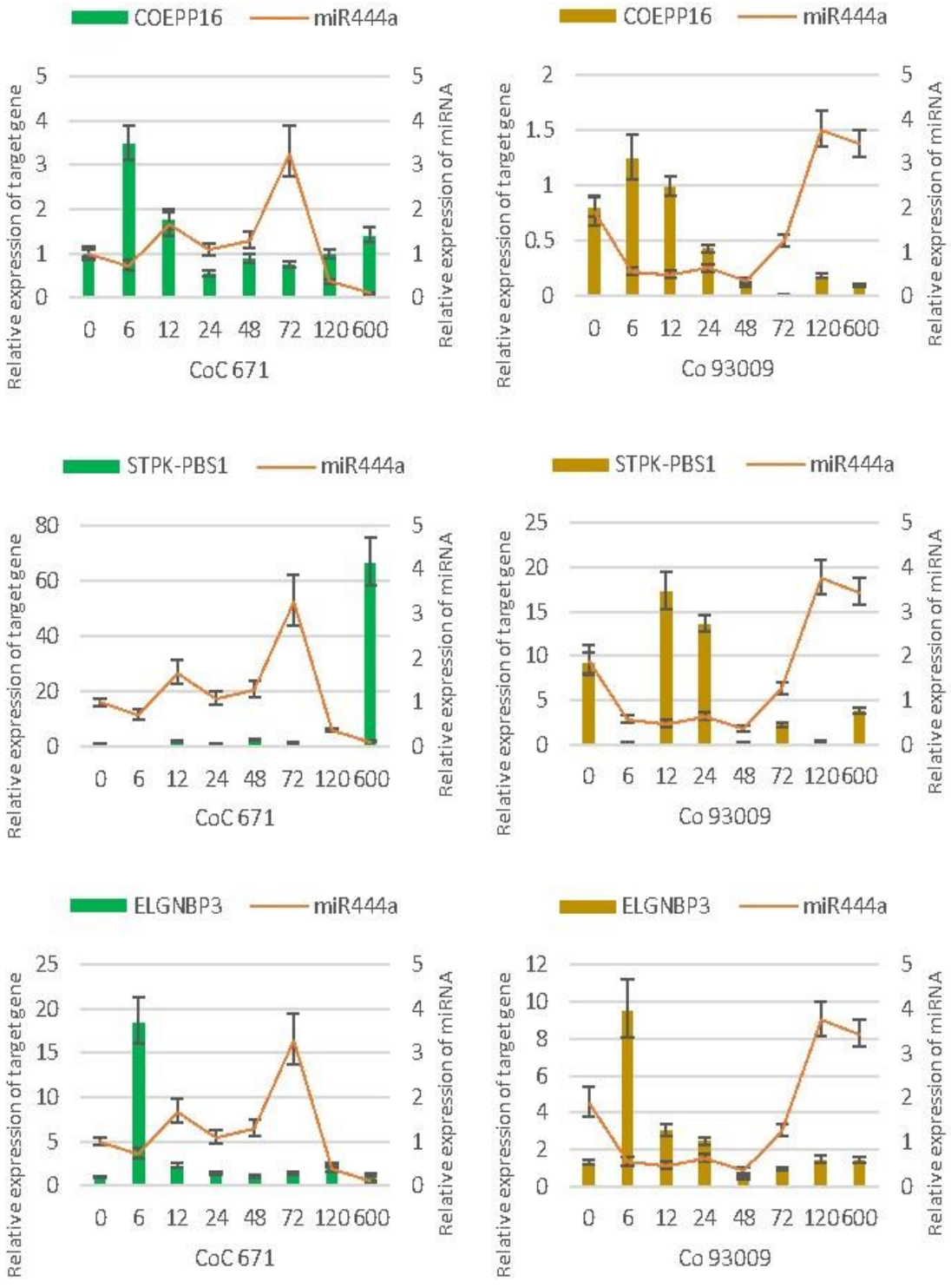


Fig. 65 Expression profile of differentially regulated miRNAs and their targets during interaction between sugarcane and red rot pathogen; the figures depict temporal expression of miR444a and their targets chloroplastic outer envelope protein 16-1 (COEPP16), serine/threonine kinase PBS1 (STPK-

PBS1) and extra-large guanine nucleotide binding protein3 (ELGNBP3)

Developing chitosan based nano-delivery systems for disease management and enhancing nutrient use efficiency in sugarcane. (a) Inducer nano-particles as smart delivery system for harnessing red rot resistance in sugarcane

Evaluating SAR inducer nanoparticles against major diseases of sugarcane: Nano formulations of 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. In pot experiments the sugarcane setts were treated with individual nanoparticles formulation, challenge inoculated with pathogen and planted along with pathogen inoculated and healthy control. The disease incidence was recorded at fortnight interval till 360 days. The results showed that BTH nano formulation could control smut and wilt incidence by 100%, red rot by 50%, while SA nano formulation controlled smut incidence up to 80%.

Field experiments: The tested nano formulations were further modified to improve the efficacy and their efficacies were assessed in field in two different set of treatments. In set I of red rot trial four treatments were taken, *i.e.*, T_1- BTH nano formulation, T_2- SA nano formulation and T_3- Fungicide (Thiophanate methyl- 0.1%) applied as sett treatment and 2 sprays and T_4 was pathogen inoculated control. The experiments were imposed on two red rot susceptible varieties *viz*., Co 95020 and CoC 671. The pathogen was challenge inoculated during planting as grain inoculum and the disease incidence was recorded at fortnight interval.The BTH nano formulation application reduced

Fig. 67. Field stand of sugarcane varieties treated with SAR inducer nano formulations against red rot

red rot incidence by 65% and 63.8% in variety Co 95020 and CoC 671, respectively, while SA nano formulation reduced red rot by 42.3% and 52.5% in variety Co 95020 and CoC 671, respectively (Fig. 66). The field stand of two sugarcane varieties showed significant control of red rot and crop loss was low in nano BTH and SA formulations applied rows when compared to fungicide application and pathogen inoculated control (Fig. 67). For smut trial the similar treatments were imposed on smut susceptible varieties Co 97009 and Co 96007, in which the

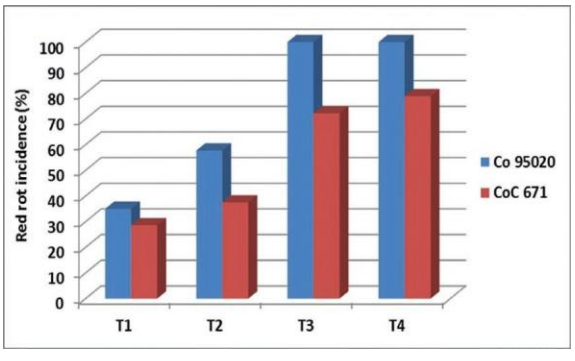


Fig. 66. Field efficacy of SAR inducer nano formulation treatment on incidence of red rot

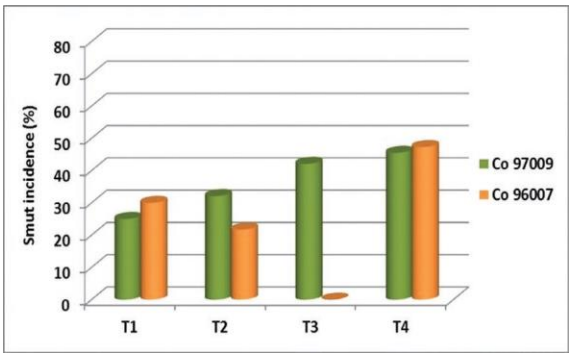


Fig. 68. Field efficacy of SAR inducer nano formulation treatment on incidence of smut

fungicide (T_3) Thiophanate methyl was replaced with Propiconazole (Tilt®- 100ppm). The smut pathogen was challenge inoculated on treated setts as dip inoculum, planted and disease incidence was recorded at fortnight intervals. BTH nano formulation reduced the smut incidence in the range of 36.6% to 45.1%, while SA nano formulation reduced smut in the range of 29.5% to 54.1% (Fig. 68). In general the nano formulation application not only reduced the disease incidence but also reduced the progress of disease throughout the crop season.

In set II of red rot trial four treatments were taken, *i.e.*, T - BTH nano formulation, T - SA nano formulation and T_3- Fungicide (Thiophanate methyl - 0.1%) were applied as 3 sprays and T_4 was pathogen inoculated control. The treatments were imposed on varieties Co 6304, CoC 671, the pathogen was inoculated by plug and nodal cotton swab method and disease incidence was scored 60 days after inoculation. In plug method, when disease intensity was scored in 0-9 scale the pathogen inoculated control canes (T_4) exhibited highly susceptible reaction (score of 8.1) in CoC 671 and susceptible reaction (score of 6.8) in Co 6304, while in T_1 and T_2 the canes exhibited only moderately susceptible reaction in both the varieties (Table 24). Scoring of disease resistance in cane by nodal cotton swab method also showed that both the nano formulations sprayed canes showed resistant reaction, while pathogen inoculated control exhibited susceptible reaction. These results reconfirmed the previous year findings that nano formulations of BTH and SA induce the host resistance and reduce the intensity of red rot substantially. Both the results of set I and set II experiments of red rot field experiments revealed that the disease control potential of nano formulations is significantly higher than fungicide application. The set II of smut trial and set I and II field trials against wilt disease are in final stage of evaluation. The results so far clearly indicated that the nano formulations of SAR inducer molecules, particularly the BTH nano formulation is consistently effective in inducing the host resistance of sugarcane crop against red rot, smut and wilt diseases.

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

Molecular characterization of phytoplasma associated with sugarcane

Sugarcane grassy shoot (SCGS) disease is caused by SCGS phytoplasma, *Candidatus* Phytoplasma sacchari. During the year 2020, SCGS incidence was observed at 85.71% at zonal varietal trial IVT, 60% at AVT I plant, and 61.11% at AVT II plant. Detailed scanning electron microscope (SEM) analysis was done from the plants showing symptoms of initial chlorosis to moderate and severely affected leaves with complete loss of chlorophyll along with tip drying symptoms in the cv. CoC 671.

Table 24. Field evaluation of SAR inducer nano formulation treatment on sugarcane for red rot incidence by plug and nodal method of inoculation

Treatment	Plug method		Nodal cotton swab method
	Score in 0-9 scale	Disease reaction	Reaction
CoC 671			
BTH nano formulation	5.0	MS	R
SA nano formulation	5.6	MS	R
Fungicide (Thiophanate methyl - 0.1%)	6.5	S	S
Pathogen inoculated control	8.1	HS	S
Co 6304			
BTH nano formulation	4.9	MS	R
SA nano formulation	5.5	MS	R
Fungicide (Thiophanate methyl - 0.1%)	6.6	S	S

Pathogen inoculated control	6.8	S	S

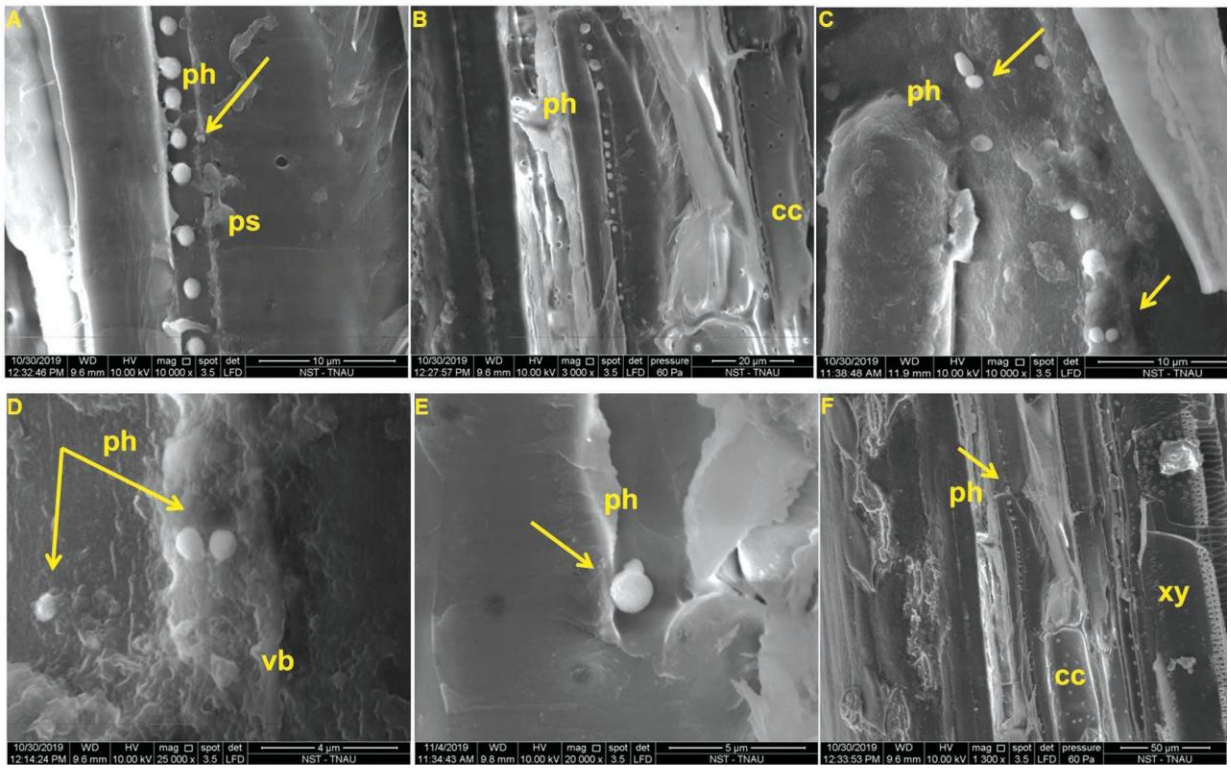


Fig. 69. SEM images of SCGS phytoplasma from cv. CoC 671 leaf tissues ultrathin vertical sections. Images were taken from 500 - 25000x magnifications at 4 -100 µm scale levels at constant 10kV. (A) Appearance of oval /spherical shaped isolated particles at 10,000x, 10µm scale. (B) Adherence of phytoplasma in phloem tissues like chain of beads at 3000x, 20µm scale. (C&D): Presence of phytoplasma in phloem nearby surrounding areas of vascular bundles at 10,000X, 10µm scale and 25,000X, 4µm scale, respectively. (E): Initial stage of cell division of phytoplasma by budding at 20,000x, 5µm scale (F): Overview of ultrathin vertical sections of leaf in 500 to 1300X magnification at 50 -100 µm scale. The presence of phytoplasma could be seen at 1300X, 50 µm scale. Abbreviations used in pictures: ph-SCGS phytoplasma; ps-phloem sieve tube; cc-companion cell; xy-xylem; vb-ground tissues surrounding the vascular bundles

All the leaf samples were taken from tillering phase of the crop and ultrathin vertical/ longitudinal sections were made and fixed in 2% glutaraldehyde (v/v) in 0.1M potassium phosphate buffer (pH 7.2) and specimens were dried well and sputter coated with gold particles (EMITECH SC7620). Prepared specimens were scanned at constant 10kV with magnification range from 1000x to 25000 x at 4 to 50 µm scale levels by scanning electron microscope with EDAX (FEI Quanta 250, USA) at Tamil Nadu Agricultural University, Coimbatore and digital images were obtained. Phytoplasma cells were observed in the phloem regions of leaf vascular bundles and visible at 1000x magnifications at 50 µm scale, however, more clearly visible from 10000 to 20000x magnification at 5-10 µm scale. The SCGS phytoplasma appeared like oval/ spherical bodies arranged in chain of beads in phloem sieve tubes in some specimens and as isolated particles nearby companion cells, and ground tissues surrounding the vascular bundles (Fig. 69). The estimated size of phytoplasma cells ranged from 0.816 to 1.603 µm diameter. Besides, the process of cell division of phytoplasma by budding was observed in nearby phloem regions.

All the leaf samples (+1 to +5) showing different intensity of symptom expressions *viz*. the top two young leaves totally turned into creamy colour with tip drying due to complete loss of chlorophyll following the adjacent 2nd and 3rd leaves with partial loss of chlorophyll mixed with green and creamy colour, and 4th and 5th leaves exhibiting gradual shift from green to chlorotic

were subjected to SEM analyses; Among those samples, the pathogen was located only in the 4th and 5th leaves. From this study, it can be inferred that probable absence of pathogen in severely affected young leaf samples may be due to its switch over movement into adjacent leaves through phloem sieve pores or the cells might have died along with host leaf tip drying. This kind of information will be useful while sampling host tissues for SEM analysis to assess efficacy of any management methods and its influence over pathogen cells other than the molecular based diagnoses like nested PCR and qPCR assays.

(K. Nithya and R. Viswanathan)

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

Epidemiology of sugarcane rust: During the year 2020, the minimum temperature was above 20°C but maintained below 25°C throughout the crop season. The maximum temperature was in the range of 24-37°C and the July month recorded lowest maximum temperature (24°C) and the May recorded the highest maximum temperature of 37.5°C which is not favourable for rust development. The rainfall started in the month of August and continued upto November which favoured the rust development in the field and heavy rainfall of 48 mm was recorded in March 2020. The relative humidity was in the range of 62% in July and 97% in May 2020. The dry weather was observed in April (30% RH) and the June month recorded high RH of 93% in the afternoon (Fig. 69a). There was no rust till the month of April and in June 2nd week only rust symptoms appeared on the newly planted crop. Then the severity increased during August and in October there was higher rust severity of 20% on few susceptible clones. However, it was observed that the newly developed leaves showed less rust infection than the older leaves indicating the role of temperature, relative humidity and rainfall on disease development.

Occurrence of rust in newly developed sugarcane clones: In Zonal varietal trial, the rust was observed in traces on 18 entries and many entries were free from any disease. The entries 2019-5, 2019-16 and 2019-24 showed 5-10% rust severity on older leaves only and the new leaves were free from infection. Out of ~2000 clones including 'Co canes' and ISH clones screened, only 143 clones expressed rust symptoms from traces to mild form. In PZVT multiplication trials, the rust was observed in traces in 72 clones out of the 170 entries, but the severe rust was observed only on 10 clones. In arrowing plot, only 32 clones expressed rust in traces to mild form and remaining clones were rust free. In IVT trial, the clones Co 17010 and Co 17014 were severely rust infected and other 15 clones showed mild rust severity.

Detached leaf assay in vitro under controlled conditions: Natural screening for rust resistance is not fool proof in a location where disease development is poor. To ascertain the rust resistance in the newly developed clones, a low cost artificial method of rust screening was developed which is fast and accurate, repeatable, reliable and the screening period is 20 days only. In this method, top leaves from the clones which were free from rust symptoms were collected and cut into 15 cm. The surface of leaf bits were rubbed with fingers and sprayed with the water containing uredospores (10^5 per ml) on both the sides. After inoculation, three leaf bits per clones were kept vertically in a sterile transparent cylindrical jar (20 cm height and 8 cm diameter) containing 100 ml of sterile cooled water. The jars were kept in dark for 24 hours at 22±0.5ºC and then transferred to a plant growth chamber maintained with 80% RH and 8 hrs of fluorescent light and 16 hrs dark at 22±0.5ºC (Fig. 69b). The symptoms for rust development was observed starting 5 days after spraying and up to three weeks. The plants were grouped as resistant and susceptible based on rust symptoms expressed on leaves.

Rust urediniospores trapping on vaseline coated slides: The rust spores were observed during January and February and there was absence of spores from March to August. The high temperature and low relative humidity arrested the germination of urediniospores and the frequent rainfall during July and August minimized the spread of urediniospores in the air (Fig. 69c). The presence of urediniospores in wind is a

predisposing factor for secondary infection in sugarcane. In our earlier study, the sticky traps helped in trapping the rust spores present in air and confirmed using compound microscope. The availability of low price paperfold handheld microscope (Foldscope) in the market helped in observing the coloured urediniospores of rust fungi in the field itself without any help of compound microscope. This tool will help in monitoring the rust movement in the field and making decision for management of sugarcane rust through fungicidal spraying based on rust severity.

(R. Selvakumar and T. Lakshmi Pathy)

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

Application of Sett Treatment Device (STD) for the delivery of physical, chemical and biological agents was evaluated in order to envisage the mechanized sett treatment for integrated disease management in sugarcane.

Persistence of fungicide in setts by mechanized sett treatment: As mechanized sett treatment was found to be equally effective to overnight soaking, persistence of fungicide by both the treatments was compared by estimating the fungicide thiophanate methyl residue as such (TPM) and its metabolite carbendazim (CBM) in the treated setts as well as at different intervals till 90 days after planting (Fig. 70). Results showed that the initial residue level of both TPM and CBM was above 500 ppm and gradually reduced to 50-100 ppm at 90 DAP by overnight soaking. While it was 160 and 100 ppm in the treated setts immediately after planting and got reduced to 20 and 10 ppm at 90 days after planting by mechanized sett treatment. Since thiophanate methyl was found to completely arrest the growth of fungal pathogens causing red rot, smut and wilt in sugarcane at 5-10 ppm concentration, persistence of residue level at 90 DAP will be adequate to protect the setts from primary source of inoculum. It confirms our earlier results on the efficacy of thiophanate methyl in protecting the setts against soil borne inoculum of red rot till 90 DAP.

Delivery of liquid formulation of biocontrol agents: Field experiments were laid out to evaluate mechanized means of sett treatment with *Trichoderma harzianum* and *Paenibacillus alvei* individually and in combination, fungicide alone and its combination with *P. alvei* with suitable healthy and infected/ inoculated controls for the management of red rot and smut using susceptible varieties CoC 671 and Co 97009, respectively. For fungicidal treatment, thiophanate methyl – 1000ppm was used against red rot and propiconazole – 100 ppm was used against smut. In both the experiments, sett treatment with both the biocontrol agents and fungicide individually or in combination were

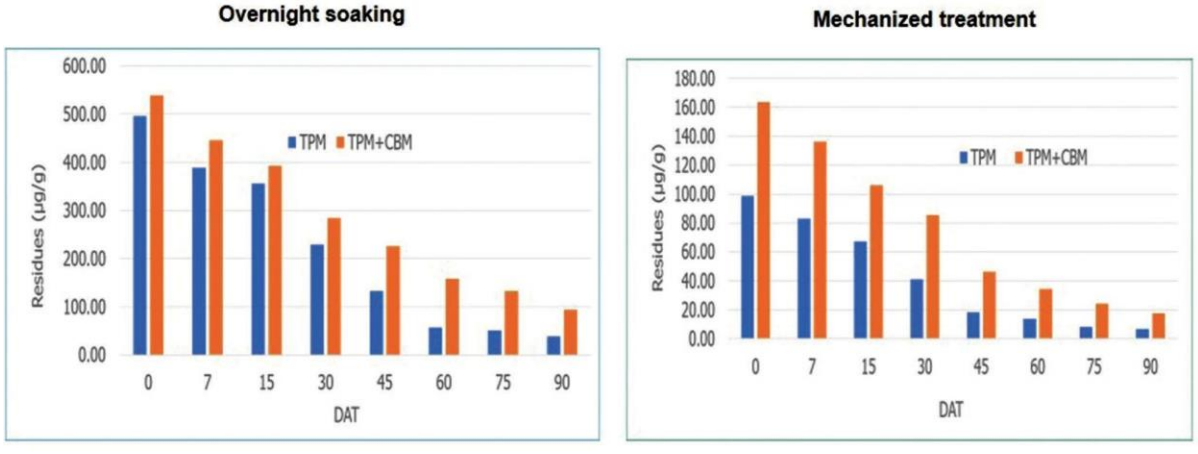


Fig. 70. Persistence of residues of the fungicide thiophanate methyl (TPM) and its metabolite carbendazim (CBM) after mechanized sett treatment in comparison with overnight sett soaking in the

fungicide

Fig. 71. Newly fabricated sett treatment device with provision for hot water treatment

found to be not deleterious and were effective in reducing the disease incidence, improving plant growth and yield attributes. However there was no significant difference among treatments due to lower disease incidence in both the experiments.

In continuation in 2020, field experiment on red rot management with above said treatments has been laid out. Preliminary results indicated that treating setts in the Sett Treatment Device (STD) with the combination of thiophanate methyl and *P. alvei* was found to be significantly superior

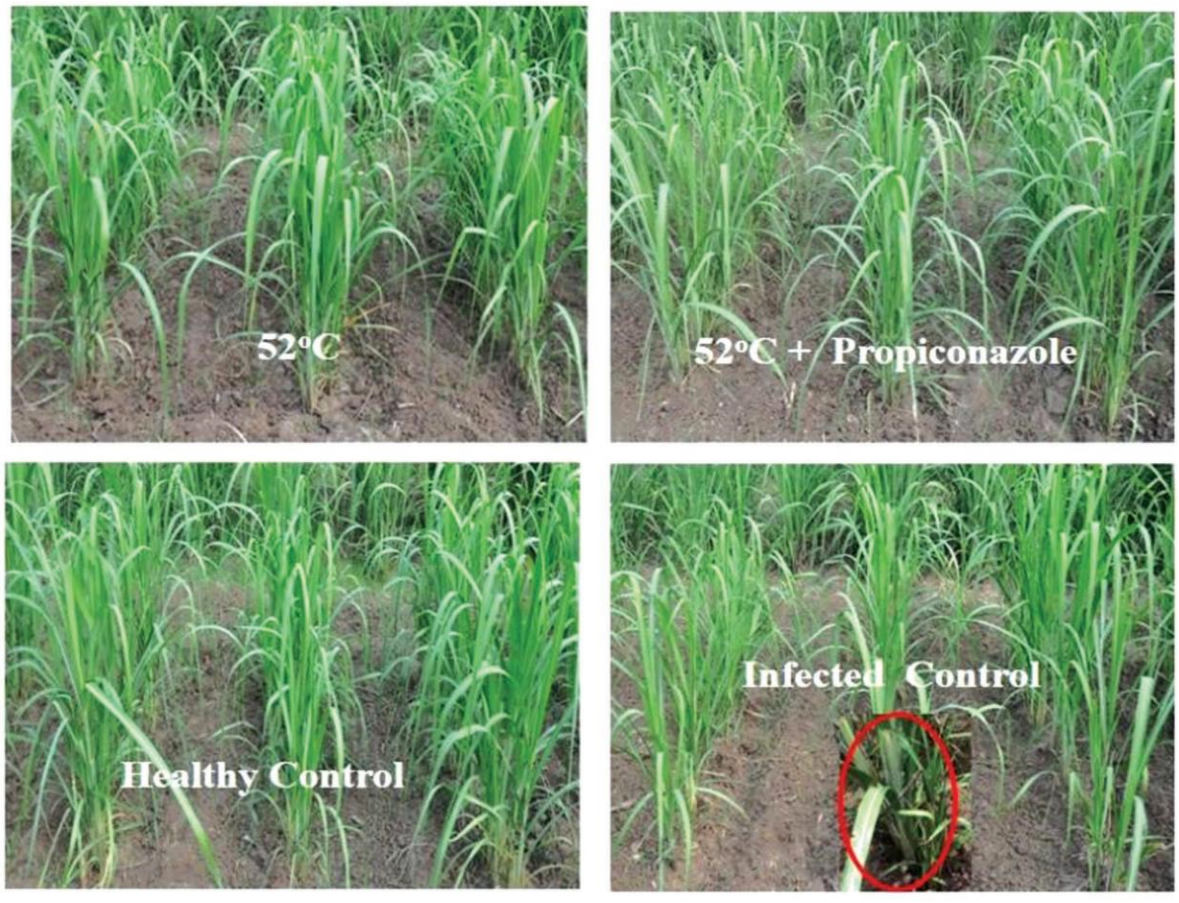


Fig. 72. Field trial on efficacy of sett treatment with fungicide in hot water against sugarcane smut

followed by combination of *P. alvei* and *T. harzianum* in protecting the setts from soil borne inoculum and improving plant survival.

Fabrication and validation of STD with hot water treatment (STD-HWT): A new STD with provision of hot water treatment, agitation and suitable sensors to provide uniform treatment was fabricated with our technical inputs and guidance from CIAE RS, Coimbatore. STD- HWT unit has been standardized for different temperature regime with vacuum from 48 to 54°C, for which temperature uniformity was maintained by agitation and then vacuum was applied with 5 min pick-up to reach 200 mm/ Hg, 15 min hold at this level and 5-10 min release to reach a vacuum level 0 (Fig. 71). During entire course of vacuum application, only required temperature was maintained without agitation. Treatment of different varieties with STD-HWT revealed that, there was a significant improvement in germination and plant growth irrespective of varieties till 52°C. However it was effective till 54°C with the addition of nutrients and it has been proved under field conditions with the cvs Co 11015, Co 0238, Co 0212 and Co 86032. Besides, preliminary results indicated that the STD-HWT unit is effective in improving germination and plant growth of smut infected setts of Co 97009 with reduction in disease incidence (Fig. 72). However, the hot water treatment failed to inactivate grassy phytoplasmas and ratoon stunting bacterium, since the treated plots also exhibited typical phenotypic symptoms of the respective diseases as like untreated controls. Further, in PCR assays, the phytoplasma were amplified from both the treated and untreated ones before symptom expression, indicating that the inactivation of the pathogen by the heat treatment was transient and need to focus on physical elimination of the pathogen.

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

Epidemiology and management of *Fusarium* diseases in sugarcane

Epidemiology of wilt: The following 25 parental clones MS 68/47, Co 775, Co 1148, Co 62198, Co 8353, Co 86002, Co 88025, Co 94012, Co 97015, Co 0237, Co 0327, Co 10026, Co 11015, CoC 671, CoC 90063, CoOr 03152, CoP 9301, CoS 8436, CoT 8201, 85 R 186, ISH 100, LG 14482, ISH 69, ISH 229 and 87 R 40 exhibited 70-100% wilt in the crossing block of National Hybridization Garden. The infections were found to be both sett borne as well as soil borne (Fig. 73). Some

Fig. 73. Wilt susceptible parental clones Co 0237 and Co 97015 exhibit typical wilting due to sett and soil borne inocula of F. sacchari as compared to healthy stand of resistant cv CoPant 97222. Wilt affected canes show stunting and narrowing of leaves before drying symptoms. A clear rind

discolurarion is seen in the affected canes due to systemic infections of the pathogen

of the clones like Co 775, Co 1148, Co 62198 etc exhibited severe wilt in different plots numbering 5-7 in the block indicating their highly susceptible behaviour. Similarly, the susceptible clones Co 86002, Co 0237, Co 11015,
CoC 671, CoOr 03152 etc recorded 100% disease in the rows. Another 101 parental clones like C 79218, C 81615, Co 86032, Co 86033, Co 86249, Co 88013, Co 88025, Co 88028, Co 90018, Co 91010, Co 92007, Co 94007, Co 98010, CoA 92081, CoA 13321, CoC 24, CoC 08336, CoM 9206, CoM 9220, CoM 0265, CoPb 09181, NB 94-545 etc exhibited disease ranging from 30 to 70%. The disease started from third month onwards and progressed to highest incidence by 5 to 6 months. Although many of the clones exhibited pokkah boeng symptoms, fungicide spray has reduced the impact caused by the disease. However fungicides sprays or soil drenching did not show any ameliorative effect in the field on wilt. Soil application of antagonistic *Trichoderma* along with sett treatment with fungicide at the time of planting usually reduces wilt incidence. However, the antagonist was not applied while planting in the season and that has led to wilt development from the soil.

Simulation of wilt: Healthy and wilt-affected setts of 11 varieties were planted in the field trial to assess disease development in the canes and also on crop stand. *F. sacchari* infection in the setts reduced germination in all the varieties and loss in germination was more than 50% in the cv. CoJaw 270 and in other varieties it was in the range of 20-40%. All the varieties exhibited typical yellowing and stunting due to the systemic infection of the pathogen in the plots planted with diseased setts during different crop growth stages (Fig. 74). Wilt affected plants exhibited significant reduction for plant height, number of leaves, leaf length and leaf width. Application of *F. sacchari* inoculum inthe soil in the form of infected crop debris or multiplied on sorghum grains also simulated wilt in the field trials. Soil borne inoculum also reduced sett germination and crop stand in the plots. However, wilt development from the soil inoculum was not severe during the season like sett borne infections.

Management: Wilt affected setts were given mechanized fungicide (Propiconazole; 0.4 ml/L; 250 mmHg, 15 min) treatment and planted along with infected and healthy controls to assessthe benefit of sett treatment with fungicide on sett germination and crop establishment. Fungicide treatment in the wilted setts showed an improvement in bud germination in four

Fig. 74. Sett borne infections of F. sacchari in MS 68/47 resulted in poor cane growth with shortened leaves, pale canopy, poor tillering and stunted growth (right). Plants from disease-free setts show

normal crop growth and expressing typical phenotype of the variety (left)

Fig. 75. Impact of fungicide treatment to wilt affected seed canes on disease recovery (cv C 79218); Left: Healthy seed cane planted, Centre: crop raised from wilt-affected canes which completely failed; right: diseased seed canes with fungicide treatment (Propiconazole)

of the six varieties and better crop stand in two varieties. In the cv. C 79218 diseased plot completely failed whereas sett treatment with fungicide showed a better crop stand like healthy plot (Fig. 75). Fungicide treatment improved various morpho-metric parameters in the treated plots as compared to the control plots. The following conclusions were drawn from the field trial *viz*. 1. Beneficial impact of the fungicide for sett treatment depends on the inoculum load in the setts, 2. Apart from sett treatment, subsequent fungicide sprays or soil drenching is required for complete recovery of the plants from *F. sacchari* infection.

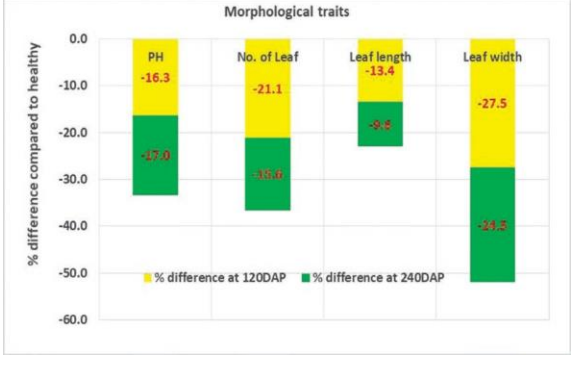


Fig. 76. Morphological responses (plant height (PH), number of leaves, leaf length and leaf width) of sugarcane varieties to* F. sacchari *infection at 120 and 240 days after planting

Morpho-physiological observations on wilted and healthy sugarcane: Morphological and physiological observations were recorded in 10 sugarcane clones of both healthy and diseased types under field conditions. Morphological traits *viz*., plant height, leaf length, leaf width, number of leaves, number of millable canes were recorded in both the healthy and wilt-affected sugarcane cvs Co 419, 69 A 591, ISH 100, MS 68/47, Co 775, CoJ 83, CoJaw 270, Co 86010, CoT 8201, C 79218, and CoPant 97222. The mean plant heights of sugarcane varieties at 120 DAP were 218 and 182 cm in healthy and diseased plants, respectively. Significant differences of 16.34, 21.10, 13.40, and 27.53 % in plant

height, number of leaves, leaf length, leaf width were recorded in wilt affected as compared to healthy plants (Fig. 76).

The healthy plants recorded mean leaf area index of 4.83, whereas in the diseased plants it was
2.12 at 240 DAP showing an impact of systemic infection of *F. sacchari* on leaf growth. Among all the studied varieties the cvs Co 86010, CoT 8201 and C 79218 have shown better LAI in both healthy and diseased plants (Fig. 77).

SBIRC, Kannur: Chlorosis phase of Pokkah boeng was noticed during 2020 in ten clones *viz.* Fiji B, Fiji 30, 51 NG 130, 51 NG 133, 51 NG 155, 57 NG

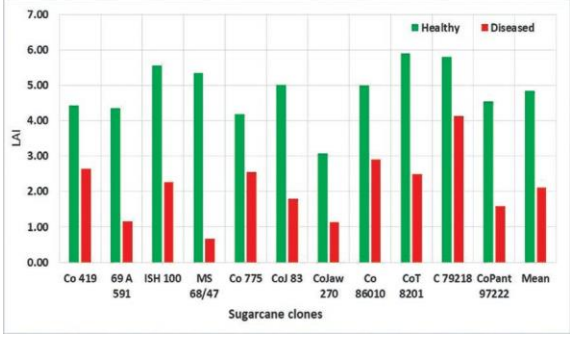


Fig. 77. Leaf area index in healthy and wilt-affected sugarcane varieties at 240 days after planting

74, 57 NG 116, 57 NG 136, 57 NG 140, NG 77 125 of *S. officinarum* and 7 clones *viz.* Ajax, Q 45, Q 56, Q 64, B 208, B 35-276, B 41-242 of foreign hybrid and also in NG 77 237 of *S. robustum*. 1 or 2 canes were mostly affected in each plant. However, maximum of four infected canes were found in 57 NG 74 of *S. officinarum*.

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

ICAR-CRP on Development and application of Diagnostics to viruses infecting Sugarcane

Recombinant SCMV and SCYLV coat protein expression and polyclonal antibody (pAb) production: SCYLV-CoC 671-CP gene and SCMV-Co 740-CP gene sequences were codon optimized and ligated into synthetic pET28b (+) vector using the Nde-I and Xho-I restriction enzyme sites at 5'-3' end and transformed into *E. coli* Lemo21 (DE3) cells by following the standard transformation procedure. Positive colonies were identified by Kannamycin /Chloramphenicol selection and the protein expression was standardized under 1M IPTG inductions at various time intervals viz 1 to 4 hrs. The expressed protein was analyzed under coomassie brilliant blue (CBB) stained SDS gels. Both viral protein expressions were found good after 4 hrs induction and the size of the SCYLV-CP was estimated as 21.7 kDa and the SCMV-CP was around 24 kDa (Fig. 78). After confirmation of the expected size of both viral proteins, CPs were induced at large scale and the crude proteins were extracted in the form of inclusion bodies (IB) and further purified by Ni-NTA agarose (resin) based affinity chromatography. Both the SCMV and SCYLV purified viral proteins will be used for the polyclonal antibody (pAb) production in the rabbits.

New report of sugarcane viruses on its closely related host species: Detailed studies were continued on spectrum of viruses infecting sugarcane and their infections in related grass hosts, especially sorghum and maize grown in the vicinity of sugarcane ecosystem. Infections of sugarcane mosaic disease associated viruses SCMV and SCSMV were confirmed in sorghum and maize samples collected from different places in RT-PCR assays using the respective viral coat protein primers followed by the sequencing. Likewise, infection of ScYLV was confirmed in sorghum and maize samples. During the period, *Maize yellow mosaic virus* (MaYMV) (*Polerovirus*; *Luteoviridae*), a new virus infecting sugarcane was confirmed by RT-PCR assay using the coat protein primers (Fig. 79) followed by the sequencing of the isolates infecting both the maize and sugarcane crops. It had shown 99.78% identity with the MaYMV complete genome of the isolate Beijing, China (KY378940.1).

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

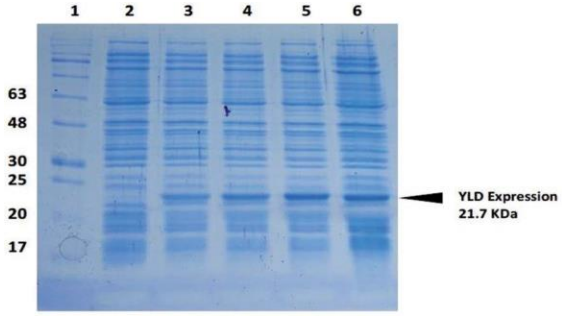


Fig. 78. SCYLV coat protein run on 14% SDS gel stained with CBB. Lane 1: Protein ladder (kDa, Lane 2: Un induced; Lane 3: 1 hr induced; Lane 4: 2 hrs induced; Lane 5: 3 hrs induced; Lane 6: 4 hrs induced.

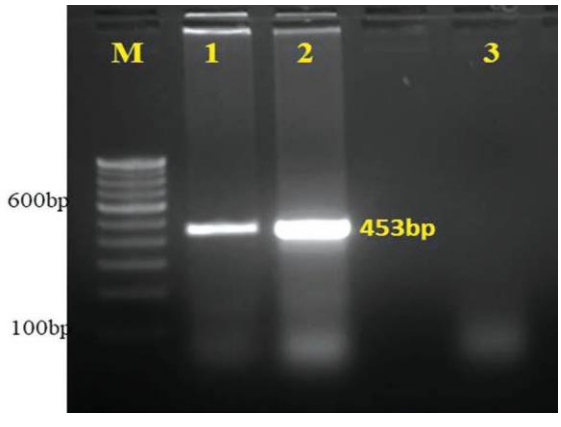


Fig. 79. RT-PCR amplification of MaYMV (coat protein and movement protein gene, partial). Lane M: 100 bp ladder; Lane 1: CoSnk 03044; Lane 2: Maize (Positive control); Lane 3: Negative control

Dissecting the molecular interface between the biotrophic pathogen *Sporisorium scitamineum* and its host – sugarcane

Whole transcriptome sequencing of S. scitamineum: Whole transcriptome sequencing was carried out to decipher the transcriptome of two *S. scitamineum* isolates, a high virulent Ss97009 and a low virulent SsV89101, during distinct developmental stages under *in vitro* conditions and during its interaction with sugarcane by employing Next generation sequencing technology. A total of 14 samples comprising 5 *in vitro* samples (Ss97009 MAT-1, SS97009 MAT-2, Ss97009 DM, SsV89101 MAT-1 and SsV89101 DM) and 9 *in planta* samples (2 dpi, 5 dpi and 60 dpi samples of Ss97009, SsV89101 and control) in triplicates were sequenced on Illumina HiSeq 4000 to obtain 2x150 bp PE (5-10 GB quality reads/sample). Approximately 324 million reads (97 GB) and 653 million reads (196 GB) were generated in total for *in vitro* and *in planta* samples, respectively. After pre- processing of the raw data, reference-based assembly was performed for the fungal reads recovered from *in planta* samples and all *in vitro* sample reads, whereas *de novo* assembly was carried out for host reads from *in planta* samples (*S. scitamineum* – sugarcane interaction samples). Differential gene expression analysis (DGE) of *in vitro* samples and fungal reads recovered from *in planta* samples was carried out using edgeR with the following parameters; FDR<0.05 and >2LogFC<-2. DGE analysis between non-infectious haploid sporidia (MAT-1/MAT-2) and infective DM resulted in higher number of differentially expressed genes (500-600 Nos.) for both high and low virulent isolates indicating significant differences in transition stages between these two isolates. A representative image of the DGE analysis of Ss97009 MAT-1 vs Ss97009 DM is given in Fig. 80. Interestingly, 63% of the DGEs (533 Nos.) were found to be up-regulated with the whip emergence stage of the high virulent isolate (60dpi-Ss97009) against the *in vitro* reference sample (Ss97009 DM). Conversely, the low virulent, SsV89101 DM vs 60dpi-SsV89101 resulted in 508 Nos. of DEGs out of which, only 2% were up-regulated.

Histology of GFP-tagged S. scitamineum in sugarcane: Green fluorescent protein (GFP) tagging has been proven useful for increasing the knowledge on key events of fungal life cycle

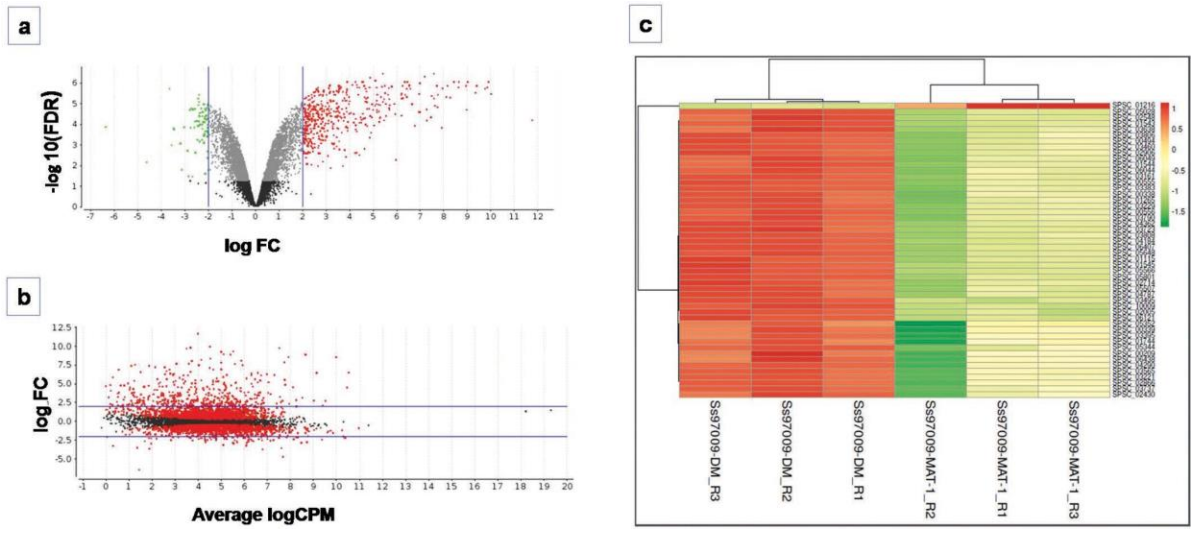


Fig. 80. Representative differential gene expression plots of Ss97009 MAT-1 vs Ss97009 DM carried out using edgeR by following the parameters; FDR<0.05 and >2LogFC<-2. (a) Volcano plot depicting genes with large fold change that are also statistically significant: significantly up-regulated genes are highlighted in red and significantly down-regulated genes in green; (b) MA plot representing log fold change vs mean expression: black dots represent no significant differences between two treatments and, red and green dots represent significantly up-and downregulated genes, respectively, and, (c) heatmap based on gene expression patterns; red and green represent an increase and decrease

in the gene expression levels, respectively

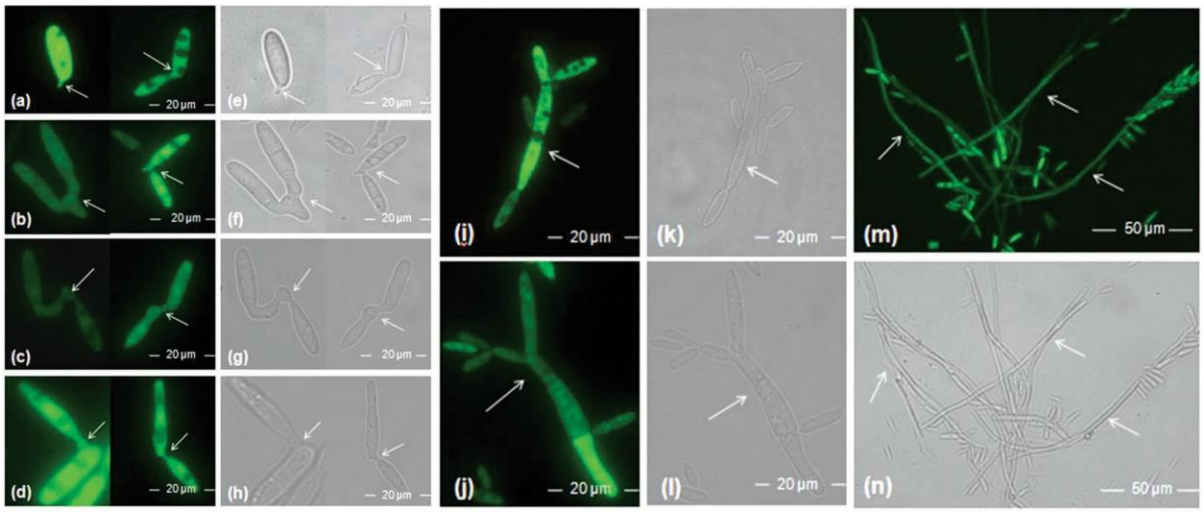


Fig. 81. Expression of GFP in* Sporisorium scitamineum *during hyphal fusion and dikaryotic mycelia formation in vitro. a-h) Formation of conjugation hyphae and fusion of compatible mating types (Ss97009 MAT-1gfp and Ss97009 MAT-2gfp) during 4-8 h incubation; (i-l) initiation of dikaryotic mycelia after 8 h; (m-n) mycelial clumps formed after 12 h. a-d, i-j, m - images under GFP filter; e-h, k-l, n – images under bright field.

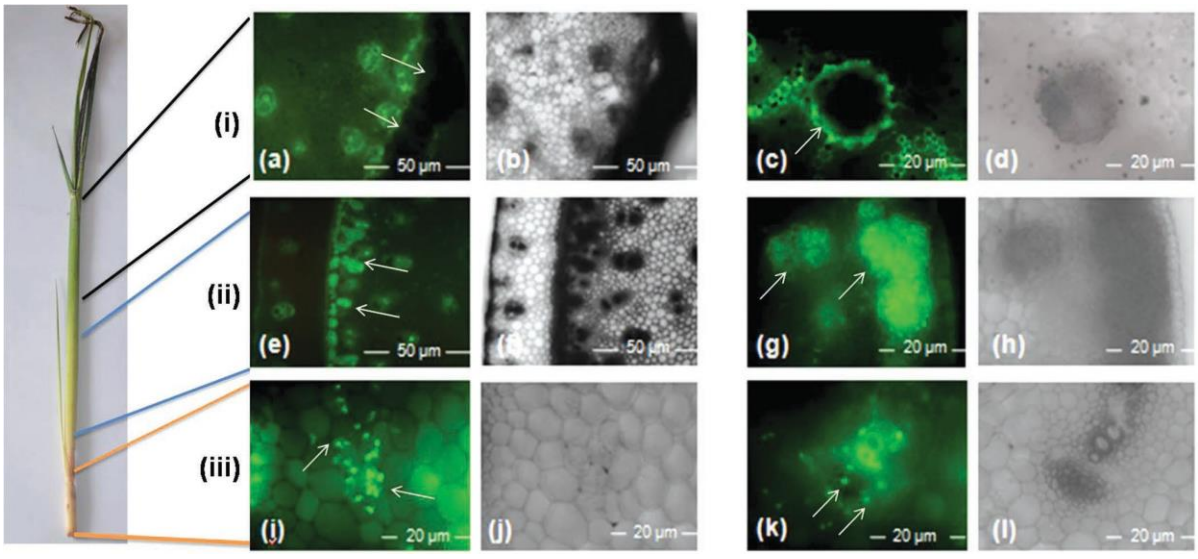


Fig. 82. Fluorescence microscopic analyses of GFP-tagged* S. scitamineum *in three distinct portions of smut whip developed at 80 dpi (i) apical region (ii) basal region and (iii) young stem beneath whip. (a-b) apical region of the whip with mature teliospores showing no green fluorescence; (c-d) sporulation pockets with non-fluorescing mature teliospores in the center; (e-h) basal region of the whip with active sporogenesis in the peripheral part showing green fluorescing hyphal fragmentation and non-melanized immature teliospores; young stem beneath sporogenesis displaying inter- and intra-cellular colonization of (i-j) parenchyma cells and (k-l) vascular tissues. Both basal and apical portions of the whip also exhibited inter- and intra-cellular colonization of parenchyma cells and vascular tissues in the central part. a, c, e, g, i and k- images under GFP filter; b, d, f, h, j and l – images under bright field

and pathogenesis. Hence, MAT-1 and MAT-2 haploid sporidia of *S. scitamineum* isolate Ss97009 was tagged with eGFP by protoplast-based PEG mediated transformation and used for probing the fungal developmental stages. The GFP-tagged *S. scitamineum* mating types (MAT-1gfp

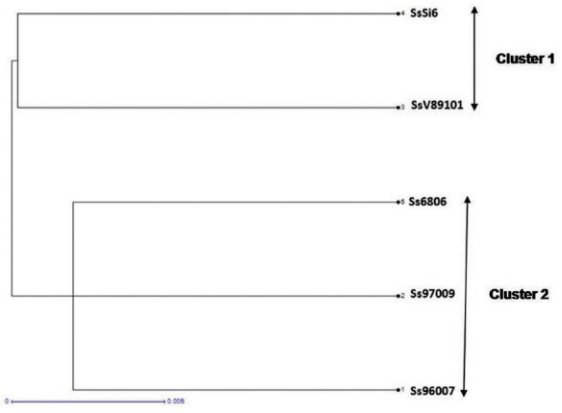


Fig. 83. Dendrogram constructed for 5 isolates (1-Ss96007, 2-Ss97009, 3-SsV89101, 4-SsSi6 and 5-Ss6806) of S. scitamineum from SRAP data assembled by unweighted pair-group method using DARwin version 6.0.14. The low virulent isolate, SsV89101 is clustered in a different clade from the other high virulent isolate, Ss97009

and MAT-2gfp) were able to fuse successfully resulting in the formation of dikaryotic mycelia and enabled the visualization of the critical steps of *in vitro* developmental stages *viz.,* formation of conjugation hyphae, haploid fusion and dikaryotic mycelia formation (Fig. 81). The GFP expressing fungi also facilitated the demonstration of the infection process in a susceptible variety, Co 97009, enabling precise and direct detection of distinct stages of *in planta* colonization viz., colonization of external bud surface, inter- and intra-cellular colonization during early stages and sporogenesis at the whip emergence stage. An image displaying the fluorescence microscopic analyses of GFP tagged *S. scitamineum* during whip emergence stage at 80 dpi (Fig. 82).

Molecular variation in S. scitamineum isolates using SRAP markers: To assess the genetic variation between the *S. scitamineum* isolates (Ss6806, Ss96007, Ss97009, SsV89101 and SsSi6) from different hosts, Sequence Related Amplified Polymorphism (SRAP) markers were used. Based on the binary matrix obtained by scoring the SRAP gel profile, the genetic similarity between the isolates was estimated using Jaccard's coefficient and relatively low level of genetic distance was detected. Similarity coefficient was utilised to generate a dendrogram using UPGMA (Unweighted Pair Group Method of Arithmetic means) through the programme, DARwin version 6.0.14. UPGMA based cluster analysis grouped the isolates into two clusters, 1- SsV89101 & SsSi6 and 2 - Ss96007, Ss97009, Ss6806 (Fig. 83). Interestingly, the low virulent isolate, SsV89101 is clustered in a different clade from the other high virulent isolate, Ss97009. This is in correlation with the virulence pattern obtained earlier by phenotyping of the disease symptoms on a susceptible variety, Co 97009.

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

Deciphering *in planta* secretome of *Sporisorium scitamineum* x sugarcane interaction

Apoplastic protein extraction from S. scitamineum infected sugarcane: Considering the significance of secretome in understanding the enigmatic panorama of this sugarcane- *S. scitamineum* interaction and with the absence of a standard protocol for apoplast wash fluid extraction from sugarcane meristem, in this project, we have developed a standard protocol for apoplast protein extraction from smut whip emerging meristematic tissue (cv. Co 97009). Three different buffers *viz.,* Sodium phosphate, potassium phosphate, calcium chloride + sodium acetate was used to evaluate the extraction efficiency of apoplastic wash fluids employing two different methods of extraction *viz.*, syringe infiltration and vacuum infiltration. Results of quantitative and qualitative assessment of extracted proteins by Bradford assay, cytoplasmic markers *viz.,* Glucose-6-phosphate dehydrogenase (G6PDH) protein and malate dehydrogenase (MDH) protein and by western blot with UDP-glucose pyrophosphorylase indicated that syringe method of extraction with calcium chloride + sodium acetate buffer yielded maximum quantity of proteins with less than 20% of cytoplasmic contamination. This development of significant and novel methodology for isolating apoplastic proteins from sugarcane meristems would comprehensively help in

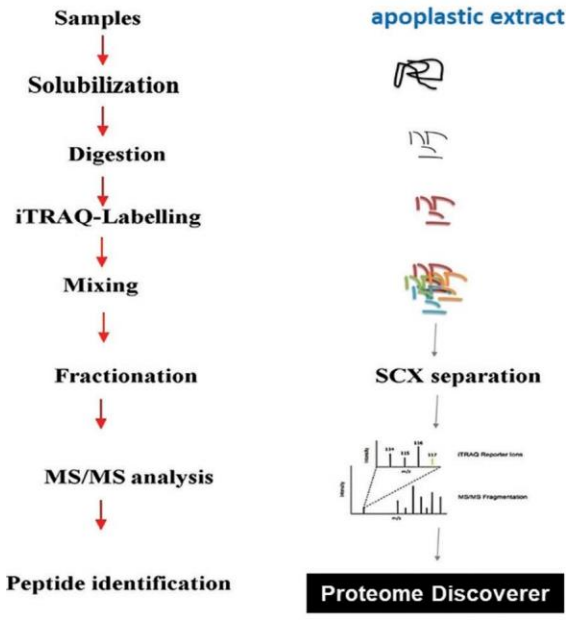


Fig. 84. Workflow of iTRAQ labelling, SCX fractionation and LC MS/MS

understanding pathogenicity and disease resistance mechanisms operated during host-pathogen interaction and may also be applicable for other related monocots as well.

Apoplast protein identification through iTRAQ based LC-MS/MS analysis: As per the above method, apoplastic proteins were extracted from the infected (during whip emergence) and uninfected meristematic samples of Co 97009 using syringe method and subjected to quantitative proteome analysis using iTRAQ labeling coupled with LC-MS/MS method. In-solution tryptic digested apoplastic protein samples were desalted by Sep-Pak C18 columns and vacuum dried for labelling and MS/MS analysis. iTRAQ labeling and SCX fractionations (AB Sciex, USA) were performed as per manufacturer's protocol. Subsequently, LTQ-Orbitrap XL (MS/MS) (Thermo scientific, USA) with CID fragmentation was performed with proteome discoverer tool for data acquisition and peptide identification by using the *S. scitamineum* protein database and an in-house generated *Saccharum* specific amino acid database as reference (Fig. 84). Comparative analysis of the output data using the tool Proteome discoverer (Thermo Scientific) is under progress.

Transient expression and localization of candidate apoplastic proteins in model plants: Sub-cellular localization of a protein is an integral part of functional characterization of any protein. Especially, in our case, the identified candidate protein's localization of apoplast (extracellular space) has to be validated. Apart from this, transient gene expression can provide valuable data about various characteristics of these proteins, such as expression levels, stability and degradation, interaction with other proteins, and induction of hypersensitive response (HR), if any. Hence, as part of the third objective of this project, pCAMBIA1302 binary vector was constructed with the insertion of GFP gene between the constitutive transcriptional promoter CaMV (Cauliflower Mosaic virus) 35S and Nos (Nopaline synthase) terminator with few restriction sites at the upstream of GFP for expression of candidate apoplastic protein. This construct would be used to validate one or two candidate apoplastic proteins screened above from comparative proteomics study.

(A. Ramesh Sundar, R. Viswanathan and G.S. Suresha)

Deciphering interacting partners of PAMPs/Effectors of *Colletotrichum falcatum* that trigger innate immunity in sugarcane

Transient expression and in planta localization of C. falcatum *CfEPL1 and CfPDIP1:* The project envisages dissecting the functional role of a putative pathogen associated molecular pattern - PAMP (EPL1) and a putative effector (PDIP1) of *Colletotrichum falcatum* in inducing PAMP-triggered immunity (PTI)/Effector-triggered immunity (ETI) in sugarcane. For exploring *in planta* localization of *Cf*EPL1 & *Cf*PDIP1, the candidate genes together with their native signal peptide coding sequence were cloned into pCAMBIA1302 binary vector to conduct agroinfiltration and transient expression in *Nicotiana tabacum.* Further, pCAMBIA1302_EPL1_GFP and pCAMBIA1302_PDIP1_GFP constructs were mobilized into electrocompetent *Agrobacterium tumefaciens* LBA4404 cells. Subsequently, agroinfiltration was carried out in

N. tabacum leaves, which revealed that the fusion proteins- EPL1:GFP and PDIP1:GFP confined external to cytoplasm, whereas pCAMBIA1302 GFP (empty vector control) was found to be localized in nucleus and cytoplasm. The result corroborates with the predicted apoplastic nature of *Cf*EPL1 and *Cf*PDIP1 using the *in silico* tool, Apoplast P v 1.0.1.

C. falcatum *protoplast isolation and gene transformation:* A novel protocol was developed for isolation of protoplasts from germinating conidia and high efficiency transformation of constructs in *C. falcatum* isolate *Cf*671. Rich protoplasts recovery was obtained from *Cf*671 germinating conidia using lysing enzyme (20 mg/ml) and β-glucanase (5 mg/ml) in osmotic medium (1.2M $MgSO_4$, 10mM Sodium phosphate buffer, pH 5.8) when incubated at 28°C for 4-6 hrs at 80 rpm. The isolated protoplasts were resuspended in STC solution (1.2 M Sorbitol, 10 mM $CaCl_2$, 10 mM Tris-HCl, (pH 7.5)) and were stained using cell wall binding dye, calcofluor white & observed under UV epifluorescence microscope. The protoplasts remained unstained due to lack of cell wall, in contrary the control *Cf*671 germinating conidia took up the stain (Fig. 85). Following which, PEG mediated transformation of protoplasts was carried out using *E. coli-Aspergillus* shuttle vector, pAsp and the veracity of hygromycin-resistant transformants was confirmed by fluorescence of GFP under fluorescent microscope (Fig. 86).

CfEPL1 and CfPDIP1 mutagenesis vectors: Development of EPL1 and PDIP1 mutants

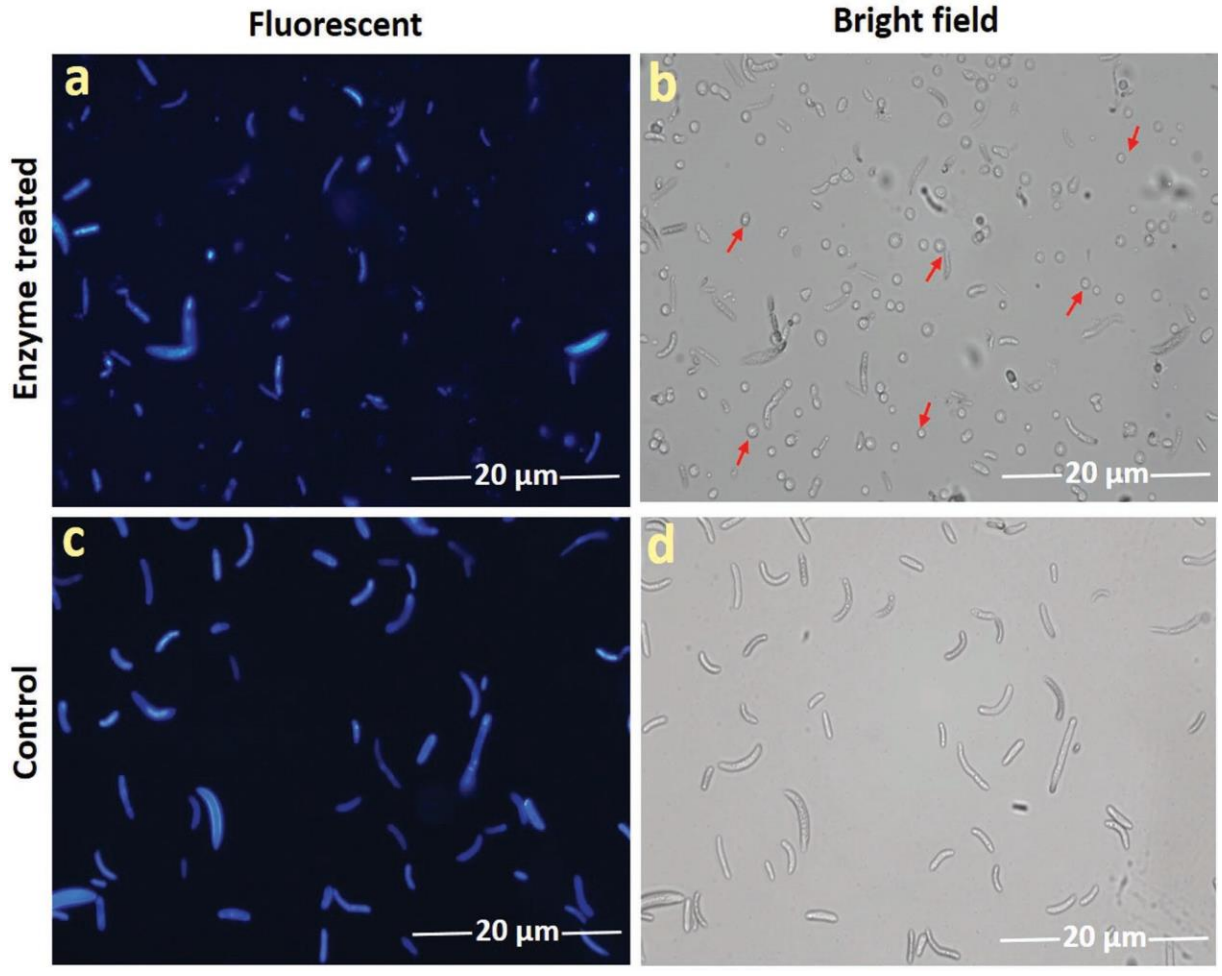


Fig. 85. Isolation of protoplasts from* C. falcatum *671 and transformation using pAsp vector. Protoplasts suspended in STC viewed under fluorescent microscope: The enzyme-treated (a and b) and the control (c and d) fractions were stained with calcofluor white, which specifically binds with fungal cell wall. The protoplasts (b- indicated by red arrows) did not take-up the stain and hence no

fluorescence could be detected under UV

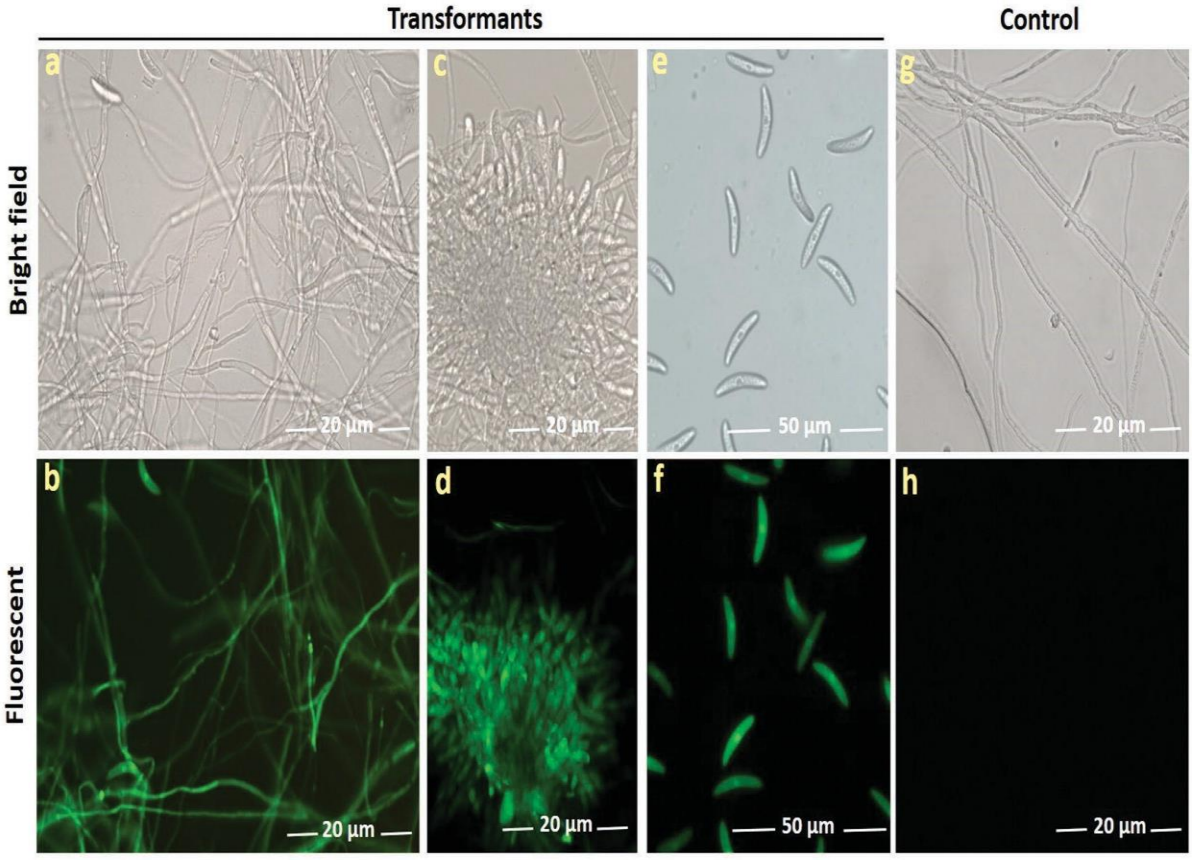


Fig. 86. Microscopic analysis of* C. falcatum *transformants and the wild type for GFP fluorescence. Transformed mycelial hyphae (a and b), conidiophore (c and d) and conidia (e and f) exhibiting GFP fluorescence, while the non-transformants did not fluoresce (g and h) under fluorescent microscope

of *C. falcatum* would delineate their roles in survival, pathogenicity and loss or gain of virulence of pathogen. Thus, for generation of fungal mutants by homologous recombination of gene with hygromycin B phosphotransferase (HPTII) gene, customized mutagenesis vectors, pUC19_mut_EPL1and pUC19_mut_PDIP1 were designed. The mutagenesis vector was designed with 1 kb upstream flanking region (UFR) and downstream flanking region (DFR) of gene at 5' and 3' end of hygromycin B phosphotransferase (HPTII) cassette respectively, using pUC19 as the vector back bone and synthesized by GenScriptTM (USA). Molecular confirmation of these gene mutagenesis vectors was carried out by restriction digestion, and PCR using hygromycin gene (HPTII) and gene_UFR _DFR sequence specific primers.

Ectopic expression of CfEPL1 and CfPDIP1 on tobacco: To study PTI/ETI mediated immune responses of *Cf*EPL1/*Cf*PDIP1 in sugarcane, a novel dexamethasone-based inducible vector, pC1302DEX was constructed and its chemical inducibility for GFP expression was assessed by agroinfiltration in *N. tabacum.* Hence, the tight regulation of expression of transgene through GVG cassette in pC1302DEX was ascertained. For inducible ectopic expression in sugarcane, the candidate genes were cloned into pC1302DEX vector and mobilized into electrocompetent *A. tumefaciens* LBA4404. Thereafter, *Agrobacterium* mediated transformation of embryogenic calli of sugarcane will be carried out to generate transgenic lines to investigate the mechanism of PTI/ETI possibly operating in compatible and incompatible interactions in sugarcane as illustrated in Fig 87.

(A. Ramesh Sundar, R. Viswanathan, P. Malathi, C. Appunu, ICAR-SBI and Dr. Rajeev Sukumaran, NIIST, Trivandrum)

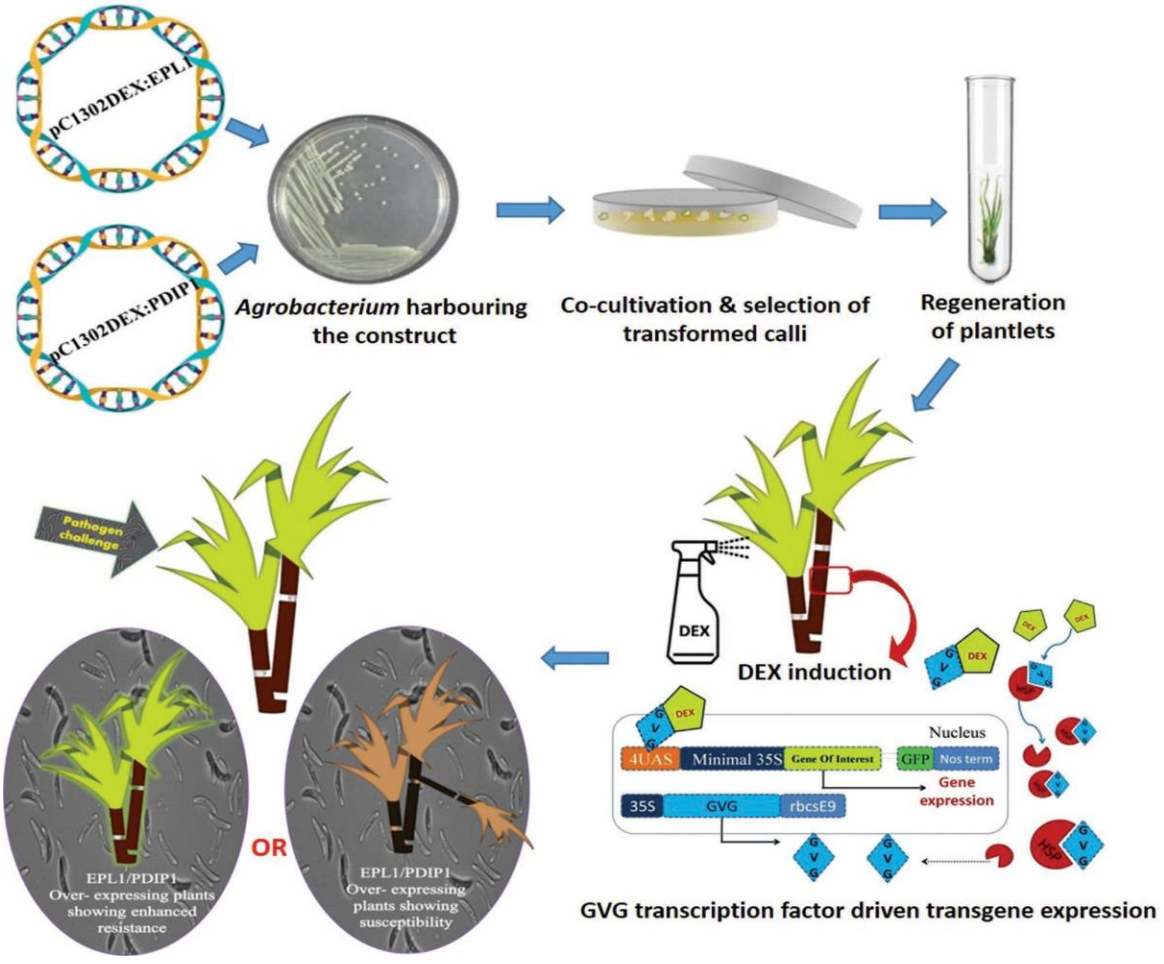


Fig. 87. Illustration of ectopic expression of CfEPL1 & CfPDIP1 in sugarcane using inducible expression vector system. Agrobacterium harbouring pC1302DEX:EPL1 & pC1302DEX:PDIP1 constructs will be used for co-cultivation of sugarcane embryogenic calli to generate transgenic lines. Successively, the transgene expression would be induced with dexamethasone spray (0.1-10µM) by transcriptional activation of GVG (Gal4 binding domain, VP16 activation domain, Glucocorticoid receptor) transcription factor. After which, the transgenic plants will be exposed to pathogen challenge to study PTI/ ETI mechanisms in sugarcane

Development of sugarcane bacilliform virus (SCBV) based VIGS vector for functional genomics in sugarcane (DST-SERB)

Sugarcane bacilliform virus (SCBV) (*Badnavirus*, *Caulimoviridae*), a plant pararetrovirus causes leaf fleck in sugarcane and is considered as an important limiting factor for exchange of germplasm worldwide. In general, badnavirus has high genomic variability and serological heterogeneity. During the period detailed studies were undertaken on genomic variability of SCBV and complete genome amplification of the virus by rolling circle amplification (RCA).

SCBV genetic variability: During the period around 100 leaf fleck suspected samples from germplasm at Kannur and Coimbatore and 233 leaf samples of cultivated varieties from different places of India viz. Tamil Nadu (Coimbatore, Avinashi and Sathyamangalam) Karnataka (Haliyal), Kerala (Agali), Maharashtra (Ajagaon, Pune) and Andaman and Nicobar islands were collected. Total DNA was extracted from all the samples and RT/RNase H coding region (ORF 3) was PCR amplified since, it is a common taxonomic marker for species demarcation within the genus *Badnavirus* and was sequenced by Sanger dideoxy sequencing method. The genomic variability was analyzed along with 16

other SCBV sequences submitted from different countries by maximum likelihood method with Tamura-Nei model. Most of the cultivated varieties had shown more than 70-89% identity to SCBV-BRU and SCBV-BT genomes reported earlier from India. Similarly, the germplasm samples had shown more than 85% identity to SCBV-BRU and SCBV-BO91 from India, SCBV-CHN2 from China, and SCBV-IM genome from Australia.

Construction of pSCBV-VIGS vector: Whole genome sequencing of SCBV isolatess BO 91 and GP24 Baragua were taken up by rolling circle amplification (RCA) method in order to develop the SCBV-VIGS vector construct for functional validation of sugarcane genes. RCA is a simple and efficient isothermal enzymatic process that utilizes unique Phi29 DNA polymerases to generate long single stranded DNA. Initially, several RCA methods like random primed RCA (RP-RCA) using exo resistant random hexamers, SCBV primer spiked RCA (SP-RCA) with only thio-modified SCBV specific primers, random primed SCBV primer spiked RCA (RP-SP-RCA) using exo resistant random hexamers and thio modified SCBV specific primers were attempted for optimization. Whole genomes of SCBV-BO 91 and GP24 Baragua were amplified by

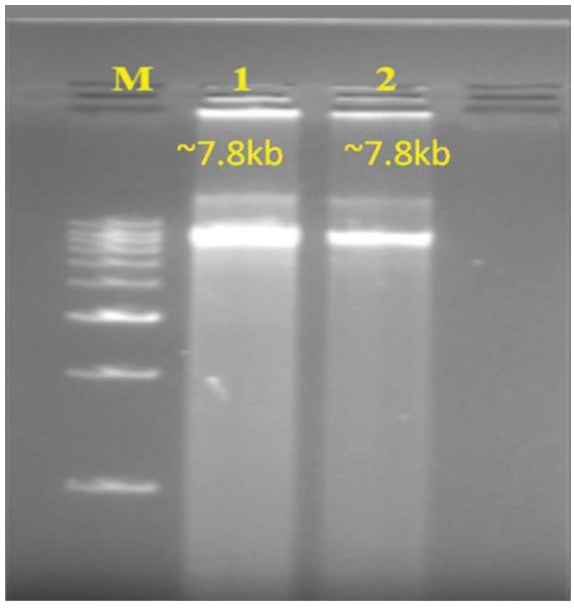


Fig. 88. Rolling cycle amplification (RCA) of Sugarcane bacilliform virus (SCBV) product: Lane M: 1 kb ladder; Lane 1&2: GP 24 Baragua, Hae II restriction enzyme digested

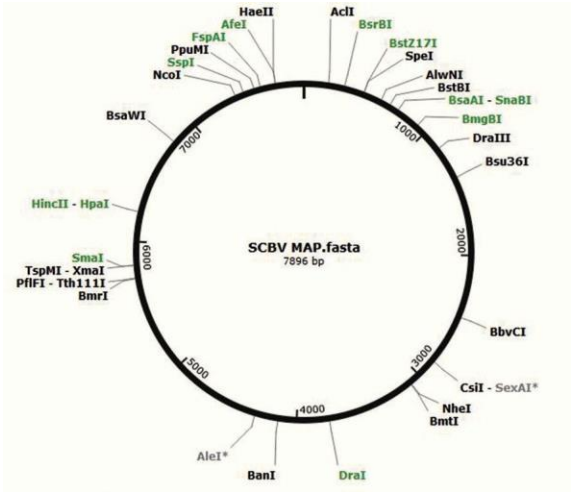


Fig. 89. WGS map of SCBV GP 24 Baragua with restriction enzyme profile

IllustraTempliPhi DNA Amplification kit (GE healthcare) with PUC19 as a positive control. Linear concatameric DNA obtained after RCA procedure was subjected to restriction digestion in order to get single SCBV genome (7.5-8kb). Several single cutting enzymes viz. *Eco*47III, *Cla* I, *Swa* I, *Hae* II, *Bst*BI, *Eam* 11051, *Nco*I, *Psh*AI, *Sna*BI, *Bam*HI, *Kpn*I, *Hpa*I, *Stu*I, *Nhe*I, *Eco*RV, *Xba*I and *Spe*I were selected based on the whole genome sequence of SCBV isolates and were used to get the single restriction enzyme digested RCA product. As a result, the expected ~7.8kb restricted product was observed in both the sample with *Hae* II restriction enzyme which was visualized on 1.2% agarose gel along with undigested RCA products (Fig. 88). Besides, an attempt was made to get the whole genome sequence of SCBV- GP 24 Baragua by MinION oxford Nanopore sequencing at ICAR-NRCB, Trichy using the whole RCA product. Sequences received consisted of 7896 nucleotides with 92.18% similarity to SCBV-BRU isolate (Fig. 89).

(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

Selection of Trichoderma sp. for biogenesis of nanoparticles: Available 27 isolates of *Trichoderma* isolated from sugarcane ecosystem belonging to four different species viz., *T. harzianum* and

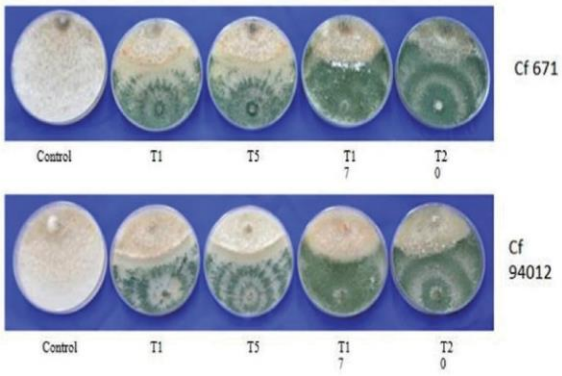


Fig. 90. Interaction between C. falcatum pathotypes varying in virulence and Trichoderma

T. aureoviride from Clade I and *T. asperullum* and *T. atroviride* from Clade II of ITS based grouping were screened against two virulent pathotypes viz., *Cf*671 and *Cf*94012 varying in their virulence. The pathotypes were grouped based on per cent inhibition as Class I (100%), Class II (75%) and Class III (50%) and compared their efficacy against two pathotypes. In all the categories, irrespective of mode of action (hyperparasitism, antibiosis), per cent inhibition was found to be low with respect to *Cf*94012, the highly virulent pathotype as compared to the reference pathotype *Cf*671 (Fig. 90). Finally two *Trichoderma* isolates *viz*., *T. harzianum* and *T. aureoviride* were selected for the extraction of intra-cellular and extra-cellular metabolites for biosynthesis of nano-particles.

(P. Malathi and V. Bhuvaneshwari, KASC, Coimbatore)

Virus indexing service

About 677 tissue culture raised plants from different tissue culture production units *viz.,* M/s EID Parry, Pugalur, M/s RSCL, Theni 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. 1,28,900/- was generated under virus indexing charges from the private tissue labs.

(R. Viswanathan)

Sugarcane quarantine

The following clones 2014 A 340, CoA 16321 (Anakapalle), CoS 14231, S. 301/87 (Shahjahanpur), CoPant 12221, CoPant 12226 (Pantnagar) and CoPb 18211 (Kapurthala) were handed over to NHG after quarantine. Similarly the following clones 2014 A 340, CoA 16321 (Anakapalle), 2011 T 70, 2012 T 58 (Perumalapalli), CoC 13339 (Cuddalore), CoH 06266, CoH 13263, CoH 14261 (Uchani) and CoLk 12209 (Lucknow) were handed over to NAG after quarantine. The following clones CoLk 14201, CoLk 14204 and CoPb 14185 (Lucknow) were received for NAG and are in quarantine.

(R. Viswanathan)

5.3.2. ENTOMOLOGY

Studies on Sugarcane Pests and Their Management

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

Assessment of shoot borer incidence on the progenies of red-fleshed Saccharum robustum: During 2019-20 cropping season, 20 progenies of red-fleshed *Saccharum robustum* clones were screened under field conditions for their relative degree of resistance against *Chilo infuscatellus* and the percent incidence ranged from 12.33 to 49.23 %. In the 20 entries screened, four genotypes namely GUK 14-722, GUK 14 -129, GUK 14-745 and GUK 14-130 were graded as least susceptible (LS); 10 genotypes as moderately susceptible (MS) and six genotypes as highly susceptible (HS) against shoot borer. In the artificial screening studies, all the genotypes were found to be susceptible against shoot borer.

Assessment of internode borer incidence on the progenies of red-fleshed Saccharum robustum: During 2019-20 cropping season, 20 progenies of red-fleshed *Saccharum robustum* clones were screened under field conditions for their relative degree of resistance against *Chilo sacchariphagus indicus* and the percent incidence ranged from 0.00 to 85 %. In the 20 entries, two genotypes namely GUK14-836 (14.81%) and GUK14-129 (15.15%) were graded as least susceptible (LS); three genotypes *viz*., GUK14-48, GUK 14-675 and

GUK 14-829 as moderately susceptible (MS) and fifteen genotypes as highly susceptible based on the percent incidence of INB at the harvesting stage. Intensity of the borer was the lowest in the genotypes GUK14-836, GUK14-129 and GUK14-48; and the highest in the genotypes GUK14-755, GUK14-69 and GUK14-732.

Observations of morphological characters on the red fleshed S. robustum progenies: Some of the morphological characters *viz*, apical meristem width, leaf spindle length, leaf sheath clasping, leaf sheath length and width, leaf sheath trichomes length and width, internode length and width and presence and absence of wax contents were observed at 3rd and 7th month after transplanting.

(M. Punithavalli and K.P. Salin)

Early detection of mechanism of resistance operating in sugarcane intergeneric hybrids against shoot borer and internode borer

Internode borer incidence on the intergeneric sugarcane hybrids derived from Erianthus arundinaceus: Eighteen intergeneric sugarcane hybrids derived from E. arundinaceus were screened under field conditions to study their relative degree of resistance against Chilo sacchariphagus indigus and the incidence ranged between 0 to 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 viz., CYM 09- 565, CYM 08-922, CYM 07-678 and CYM 07-678 recorded 10-20% incidence. Similarly, INB intensity of attack was minimum recorded 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 BC1 and 15 BC2 along with a cultivated variety Among the entries, selfed and BC1 progenies of E. arundinaceus were free from INB attack. Similarly, INB incidence on the BC2 progenies of E. arundinaceus ranged from 0.00 to 80% and the borer intensity varied from 0.00 to 4.35%. Among BC2 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: A total of 39 E. procerus progenies comprising selfed (2), BC_1 (31) and BC2 (6) were screened to study their degree of resistance against 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 CoC 671 were evaluated for their resistance against sugarcane internode borer (INB).

graded as LS, MS and 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 BC2 progenies of E. procerus than BC_1 progenies. In the BC_2 progenies, only one entry GU 15-4 was recorded as least susceptible to INB. With respect to the borer intensity, it was significantly higher in BC_2 progenies (2.08%) as compared BC1 progenies (0.72%).

Comparative observation of internode borer incidence on the progenies of E. arundinaceus *and* E. procerus: INB incidence and intensity was compared among three groups of intergeneric hybrids (IGHs) viz., E. arundinaceus (BC1 and BC2), E. procerus (BC1 and BC2) and CYM genotypes (Fig. 91). In the three groups, INB incidence and intensity was higher in the order of E. procerus (BC2) > CYM genotypes > E. arundinaceus (BC1)
> E. procerus (BC1) progenies. However, INB

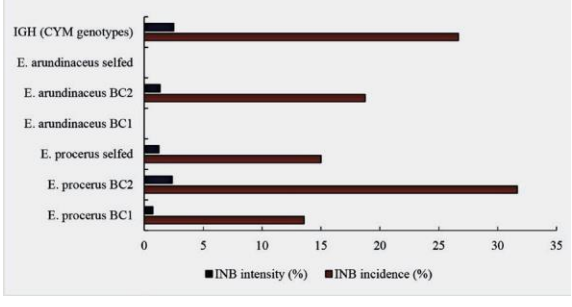


***Fig. 91. Comparative observation of internode borer incidence on the progenies of* E. arundinaceus *and* E. procerus**

infestation was absolutely nil in the selfed and BC1 progenies derived from E. arundinaceus.

(M. Punithavalli, K.P. Salin and K. Mohanraj)

Prospects for conjunctive use of *Telenomus dignus* and *Cotesia flavipes* against internode borer

Studies on *Telenomus*

Laboratory parasitization studies: In glass chimney method of multiplication, different host egg: parasitoid ratios of internode borer (INB) eggs and *Telenomus* adults were maintained. Parasitism rates ranged 80.8-100.0% within egg masses but with variable adult emergence (53.4-87.4) when 100 eggs were provided per chimney. In some egg masses, a few larvae emerged indicating incomplete parasitization.

Scaled-up multiplication method: In an improvised method devised to scale-up mass multiplication of *Telenomus* sp., INB egg masses on leaf bits totalling 400 were exposed to the parasitoid at 10:1 ratio in a plastic box enclosed in a polyvinyl cylindrical cage with cloth top. In this setup, 74.4-100.0% parasitization in different batches was obtained with adult emergence of 45.0-74.2%. In this method too, a few larvae hatched from some eggs possibly due to advanced age and insufficient fecundity of female parasitoids.

Studies on Cotesia flavipes: A laboratory culture of the braconid parasitoid *Cotesia flavipes* has been established on larvae of INB and sorghum, both multiplied on artificial diet. Higher output of the parasitoid was obtained from sorghum borer than INB when multiplied using the chimney method developed earlier.

Field evaluation of Telenomus: In an augmentative field trial with *Telenomus* sp., the parasitoid was released at about 4500 per ha after recording pre-release counts. Post-release counts were recorded 30 and 90 days after parasitoid release. Post-release observation recorded 30 days later indicated that INB incidence decreased in release whereas it increased in control plot.At 90 days after release, incidence in treatment showed a slight increase whereas in control plot, the incidence continued to increase.

Sentinel INB eggs for trapping Telenomus: INB egg masses were used as sentinel eggs to trap *Telenomus* in the field to be used as an aid to assess field efficacy of augmentative releases. In general, 10 laboratory obtained INB egg masses on leaf bits were placed in parasitoid release and control plots for 24 h and maintained later in the laboratory for parasitoid emergence. In both

Augmentative evaluation of *Telenomus* sp. against INB

Treatment	Pre-treatment INB		Post-treatment INB		Post-treatment INB	
	Incidence	Intensity	30 d		90 d	
			Incidence	Intensity	Incidence	Intensity
Release plot	9.8	4.7	8.0	3.2	13.8	3.1
Control plot	13.0	7.4	14.3	3.8	16.9	3.1

parasitoid and release plots, 22.2% egg masses trapped the parasitoid. In some egg masses, hatching was noticed. This indicated natural activity of the parasitoid in the habitat but loss of some eggs due to predation emphasized the need to further standardize the method.

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

Bio intensive management of white grubin sugarcane

To assess the efficacy of various microbials inthe laboratory against target hosts

Culture collection and maintenance: The isolates SBIMA-18, SBIMA-30, SBIMA-36, SBIMA-63 and SBIMA-82 isolated from136 soil samples from two locations in Tamil Nadu and two locations from Karnataka were found to be infective to H.*serrata* grubs.

Assessment of microbials and insecticides in pot culture against H. serrata *(II Instar):* Three

sets of experiments with two insecticides (lesenta (=Imidacloprid + Fipronil) and chlorantraniliprole), five microbials namely, *B. bassiana, B. brongniartii, M. anisopliae, H.indica, S. glaseri* were carried out to assess their efficacy against II instar white grub *H. serrata* in pot culture. The grubs retrieved after 25 days were incubated in the laboratory, if alive, for development of fungi or morbidity. Among the treatments, mortality ranged from 24.44% (*S. glaseri*) to 97.78% (chlorantraniliprole) with 13.3% mortality in control. Of the microbials, the highest mortality of 57.58% was due to *M. anisopliae* and the least in *S. glaseri* followed by *H. indica* (28.89%) and *B. bassiana*(33.33%) and *B. brongniartii* (44.44%) .

Pot culture experiments with microbials and insecticides against H. serrata *(I Instar):* In the studies against first instar three kinds of application with fresh inoculation, residual efficacy and cumulative efficacy of the agents were studied and compared against control. In continuation with the experiments against the first instar the third year data collected showed variations due to the application strategy. For example, in the third method (cumulative inoculation) showed that comparing the treatments comprising the combinations of *B. bassiana*, the highest mortality of 93.33% was observed in *B. bassiana* + chlorpyriphos, *B. bassiana*+ carbofuran and *B. bassiana*+ Lesenta while the lowest was in *B. bassiana*+ *H. indica*(60%) while in treatment set based on *B. brongniartii*, the highest mortality of 100% was observed in *B. brongniartii* + chlorantriprole, *B. brongniartii* + imidacloprid while the lowest was recorded in *B. brongniartii* + *H. indica* (46.7%) and in the case of combinations involving *M. anisopliae*, mortality of white grub was highest in *M. anisopliae* + imidacloprid as well as *M. anisopliae* + *B. brongniartii* (93.33%) and the lowest was in pots with *M. anisopliae* + *S. glaseri*(53.33%). In the treatment combinations involving *H. indica*, the mortality was highest in treatments involving the nematode with either lesenta or chlorantraniliprole 93.33%) and the lowest was in treatments with *H. indica* alone or in combination with either *B. brongniartii* or fipronil or carbofuran (46.67%). Of the treatment combinations involving *S.glaseri* , the most effective combination was with either chlorantraniliprole (100%) or imidacloprid or lesenta (93.33%) and the least effective was when the EPN was applied alone (40.0%). Among the insecticides, when applied alone, the most effective ones were Lesenta and chlorantraniliprole with 93.3% while the least effective was fipronil (33.33%). Similar trend for majority of treatments was observed for the fresh inoculation but not necessarily for the residual efficacy of agents.

Evaluation of EPF + Insecticide in the laboratory: Against IV instar model host *Galleria mellonella*, the three EPF *i.e.*, *B. bassiana*, *B. brongniartii* and *M. anisopliae* were tested either alone (as direct dipping) or in combination with lesenta in three different methods (Direct dipping, Filter paper walking and Granular exposure). Lesenta alone was also applied in three different methods. Three replications with 15 larvae each, of the 16 treatments with control were maintained. Mortality rates showed that in all three methods the efficacy of lesenta ranged between 86.67 to 88.9%.While *B. brongniartii* could bring about 93.33% mortality when applied singly, it could not be retrieved from more than 10% cadavers when treated in combination with Lesenta , the latter bringing about 90-93.33% mortality in all the three methods of combination treatments. Similarly, *B. bassiana* could kill 86.67% when alone but could be recovered from a maximum of 13.13% cadavers in combination treatments with Lesenta, though the total mortality ranged from 86.67-100%. Direct dipping caused no recovery of *B. bassiana* from the combination treatment. In the case of *M. anisopliae*, the mortality due to the fungus was 90% when applied alone. The efficacy of combination treatments was 100% in all three methods but the death due to fungus being the highest at 56.67% in filter paper walking method and the lowest at 0.0% in granular exposure method. Hence, simultaneous application of Lesenta and any of the three EPF tested is more effective but harmful for the recovery or horizontal spread of the respective fungi irrespective of method of application.

Assessment the impact of soil temperature on viability and virulence of entomopathogenic fungi:

The microbials *B. bassiana*, *B. brongniartii* and *S. glaseri* were incubated either alone or in combination as two batches in which one of the batches was maintained inside the incubator at constant temperature of 15°C and another batch at ambient temperature. Bioassays with *G. mellonella* indicated that all the microbials could cause mortality even after 60 days at 15°C, with the lowest of 27.78% in *S. glaseri* and the highest (69.44%) in the combination of *B. bassiana* + *B. brongniartii*. Ambient temperature, however led to no activity of *S. glaseri* at 60days after inoculation and the highest efficacy was observed in the combination of *B. brongniartii* + *S. glaseri* (72.22%).

To assess the persistence of the microbials applied in pot culture: As a part of three years study, soil samples at 30, 60, 90, 180 and 360 days were collected in order to assess the persistence EPF, EPN, insecticides and their combined efficacy over the period of a year from respective treatment pots and assayed against *G. mellonella*. The observations on mortality showed degradation of EPF after 60days but a revival at 90 days and beyond was observed. However, at 360 days no activity could be observed.

Field evaluation: In the two field trials under the aegis of Bannari Amman Sugars (Thalavadi) were conducted for the evaluation of the EPFs against the white grub *H. serrata*. The treatments replicated thrice were *B. bassiana, B. bassiana +Lesenta, B. Brongniartii, B. brongniartii + Lesenta, M. anisopliae, M. anisopliae + Lesenta, B. bassiana + B. brongniartii+ M. anisopliae*, and the insecticide check Lesenta and a control, the white grub population reduction from the pretreatment levels was 65% and 58.4% due to *M. anisopliae* (SBIMA-16) application while the combination of *M . ansiopliae* + Lesenta gave 80% (the highest) and 72.2% reduction respectively. Combination of all the EPFs provided 71.43% protection in the first trial while in the second trial it was 59.4% grub reduction. In the plots applied with Lesenta 72.22% reduction and 78.9% reduction were observed respectively. Recovery data showed only *M. anisopliae* could be recovered in combination treatments either with fungi or insecticide. In the treatments of fungus alone, 0.7% and 1.3% of *B. bassiana*, 1.6% and 4.7% of *B. brongniartii*, 17.8%, 42.2% of *M. anisopliae* were recovered respectively. In combination treatments, *M. anisopliae* was recovered in the range of 11.3- 46.2% either in the combination with other fungi or with Lesenta. Persistence data showed survival of *M. ansiopliae* for more than 6 months after application.

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

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 in shaken flasks: Five different agro-based by-products media material, namely jaggery, sugarcane juice, molasses, sugarcane trash and groundnut, found to be suitable in earlier studies, were evaluated for confirmation at two different concentrations, i.e. 3 and 6%. The bacterial population produced was considerably different among the treatments, the highest spore count of 5.54×10^{10} CFU/ml was being in jaggery 3%. Sugarcane juice 40% produced the second-highest spore count (3.07×10^{10} CFU/ ml) followed by groundnut cake 3% (2.34×10^{10} CFU/ml). Jaggery 6% also had a moderate spore count (1.92 $x10^{10}$ CFU/ml). Sugarcane juice 60% (1.10×10^{10} CFU/ml) and molasses 3% (1.11×10^{10} CFU/ml) produced more or less similar output. Sugarcane trash media produced a spore count of 1.85×10^{10} CFU/ml at 6% and 1.08×10^{10} CFU/ ml at 3% concentrations. The lowest spore count was obtained in molasses 6% (0.45 $x10^{10}$ CFU/ml) medium, which was on par with the standard T3 (0.53 $x10^{10}$ CFU/ml) medium (Fig.92).

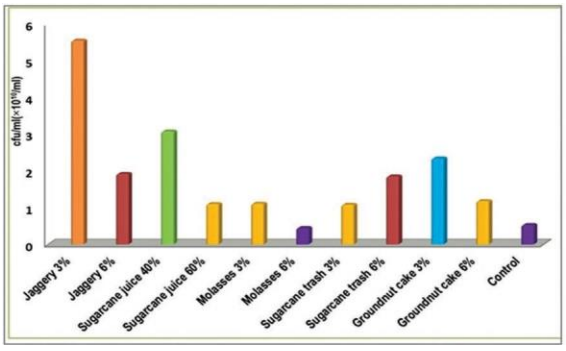


Fig. 92. Evaluation of agro-based by-products for production of Bt-62 in shaken flasks

Pilot scale fermenter production

Standardization of seed inoculum level: Three different volumes of bacterial inoculations, namely 1, 5, and 10% of fermenter medium were used to evaluate the effect of preculture volume on the growth of Bt-62. It was found that by increasing the percentage of inoculation, the lag phase decreased and the growth rate increased. By increasing the volume of preculture from 1.0 to 10.0%, the quantity of spore and crystals increased significantly, whereas increasing from 1.0 to 5.0% did not show a significant effect on spore and crystal production. However, 1.0% inoculum was selected as preculture volume considering the cost factor.

Optimization of growth conditions for pilot scale production: A pilot scale fermentor of 20 l capacity was devised at ICAR-SBI for this experiment in which Bt 62 was seeded at 1% volume of the medium. Sterilized air was supplied @ 5.4 l/lit of media/hr. The fermentation was carried out at 30°C and 100 rpm/min (Fig. 93). Highest growth was observed at 72 h (7.0 $x10^8$ CFU/ml). When Bt 62 was seeded at 5% volume of the medium the lowest growth was observed at 24h (0.32 $x10^8$ CFU/ml) and the highest at 72 h (4.54 $x10^8$ CFU/ ml); there was a decline in bacterial growth by 96 h (2.0 $x10^8$ CFU/ml).

Bt 62 was cultured in 50 l fermentor at M/s T. Stanes for pilot scale production. Optimized conditions for fermentation process, i.e. tip speed, aeration etc. were adopted and samples were collected at different intervals for checking the quality. Lowest growth was observed at 24h and highest was observed at 48 h. Output was more or less similar at 72 h and 96 h. When Bt 62 was seeded at 5% volume of the medium the lowest growth was observed at 24h (2.92 $x10^7$ CFU/ml) and highest was at 48 h (12.9 $x10^7$ CFU/ml) followed by 72 h (4.39 $x10^7$ CFU/ml).

Fig. 93. Optimization of growth conditions for pilot scale production

Fermentor production in different media: In 20 l fermentor, three different sugarcane-based byproduct media material, namely jaggery 3%, jaggery 6% and sugarcane juice 40% were evaluated along with the standard T3 medium at ICAR-SBI. Among all treatments, the highest spore count of 5.01 x 10^{10} CFU/ml was observed in jaggery 3% followed by sugarcane juice 40% (2.93 x 10^{10} CFU/ml) and jaiggery 6% (0.40×10^{10} CFU/ml). The standard media T3 produced 0.45 x 10^{10} CFU/ml on par with jaiggery 6%.

Evaluation in pot culture: Bt 62 culture multiplied on the standard T3 media in 20 l fermenter was evaluated against first instar white grubs in a pot culture experiment with four dosages, i.e. 1.0 x 10^7, 1.0 x 10^8, 1.0 x 10^9, 1.0 x 10^{10} CFU/pot and control replicated four times. In each pot, 10 grubs were inoculated in the root zone. Post-treatment white grub incidence was assessed 15 days after imposing the treatments. Results showed that highest mortality (64.37%) was observed at 1.0 x 10^{10}CFU/ pot followed by 61.25% mortality at 1.0 x 10^9CFU/ pot, 60.62% at 1.0 x 10^8CFU/ pot and 58.75 % at 1.0 x 10^8CFU/ pot with no significant differences among treatments. The lowest mortality (17.49%) was observed in control plot.

Field evaluation: Bt 62 culture multiplied on the standard T3 media and molasse 3% in seed fermentor was evaluated in white grub endemic Thalavady area under M/s Bannari Amman Sugars in two different trials. In trial-1, three plots of 200 sq m each with 7-month old sugarcane crop were demarcated in a highly grub-infested grower's farm. In each plot, soil was excavated for about 1 m length in the root zone at randomly selected spots and grub number counted to represent pre-treatment assessment of white grub. Bt 62 multiplied on T3 (5.0 x 10^{12} CFUs) and molasses (4.6 x 10^{12} CFUs) was applied in one plot each and an untreated plot was maintained as control. The 20 l fermenter product with pre-

determined dosage was diluted with 20 l of water and dispensed uniformly in the furrows of the standing crop with a rose can. Post-treatment white grub incidence was assessed 15 days after imposing the treatments following the procedure described above. Results showed a 46.9% decrease in grub number in T3 plot and 20.0% decline in molasses plot. However, comparable reduction was observed in control plot also. In trial-2, Bt multiplied on molasses medium alone was tested as per the procedure followed for trial-1. Post treatment observations indicated 44.4% decrease in molasses whereas 11.8% increase was observed in the control plot. In addition, diseased grubs and soil samples collected from treated plots indicated the presence of Bt-62.

(P. Mahesh, B. Singaravelu, J. Srikanth and K. Hari)

Temperature driven phenology modelling to assess the impact of climate change on population dynamics of internode borer, *Chilo sacchariphagus indicus* in sugarcane

Stock culture of internode borer, *Chilo sacchariphagus indicus* was established in the laboratory, from the larvae and pupae collected in sugarcane fields located in Coimbatore District, Tamil Nadu and were maintained on sugarcane shoot bits (variety Co 86032) and in semi synthetic diet for conducting experiments.

Two experiments were carried out at 35 ± 0.5°C and 20 ± 0.5 °C constant temperatures in Biological Oxygen Demand incubator. The eggs were collected from captive adults in the insect stock culture maintained in the laboratory and transferred to incubator until they hatched. The newly hatched larvae were carefully placed individually on tender sugarcane sheath kept in transparent jars initially. Later, they were provided with fresh split shoots regularly until the larvae reached pupal stage. Survival, duration of larvae and pupae were determined. The daily observation was continued even after pupation until adult emergence. Newly emerged adults were sexed and were paired. Pairs were individually confined to transparent plastic jars having sugarcane leaf bits immersed in water at bottom end to maintain turgidity, which served as substrate for egg laying Adult moths were fed with 50.0% honey solution fortified with multivitamins using absorbent cotton. The observations on fecundity, duration of oviposition for fecund females and longevity of adults were recorded daily until the death of both the adults. At 35 ± 0.5 °C temperature, some female laid eggs but they were not fertile and did not hatch. Larval stage lasted for about 32.0 days and pupal stage for about 3.5 days for male and 6.5 days for female. Larval survival was about 16.0 per cent. Adults lived for about 2-3 days. At 20 ± 0.5 °C temperature, female moths did not lay eggs. Larval stage lasted for about 46.0 days and pupal stage for about 7.5 days for male and 8.5 days for female. Larval survival was about 14.0 per cent. Adults lived for about 3-5 days.

(L. Saravanan and T. Ramasubramanian)

Isolation of novel Bt isolates from biodiversity hot spots and functional validation of indigenous crystal toxin genes against sugarcane insect pests

Soil samples collected in western ghats from Karnataka various places *viz.,* Mudubidri, Karkala, Bajegoli and Kudremukh National Park, Kundadiri Hills, Srimane falls, Kalasa, Horamadu, Balehole, Balehonnur, Khandya, Kannathi Vastare, Dhramsthala, Shiradi ghats forest, Sakleshpur, Kodlipet and Shanivarasanthe were subjected for *Bacillus thuringiensis* (*Bt*) isolation. From 396 samples collected for the period under report, 200 soil samples were screened for occurrence of Bt resulting in isolation of 18 isolates. So far 11 *Bt* isolates isolated from Karnataka Western ghats having distinct genomic profiles have been identified. PCR screening of these isolates for *cry1* gene revealed some positive isolates but however the sequencing chromatogram showed overlapping peaks indicating presence of multiple crystal toxin genes. The genomic profiles of other Bt's isolated and maintained in our collection were also studied, and we could identify 18 more distinct profiles. Whole

genome sequencing of these Bt isolates with distinct genomic sequence would be taken up for deducing their toxin gene content. Two *cry8* gene family identified from Bt 62 isolate, toxic to white grub *H. serrata* was cloned individually in *Bt* shuttle vector and successfully expressed in acrystalliferous Bt strain. The individual toxicity of these two Cry8 toxins from Bt 62 isolate would be bioassayed against *H. serrata* in the ensuing season. Similarly cloning of the two novel *cry1* gene from SBI-KK 27 which was reported from our previous study was also undertaken in *Bt* shuttle vector. The expression and bioassay of these novel toxins is to be undertaken against sugarcane borers.

(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

Instar-wise transcriptomes of sugarcane early shoot borer (ESB), *Chilo infuscatellus* Swinhoe were established through this project. The raw reads were in the range of 41.54-43.31 million. Since the raw reads across the instars were almost equal to one another (around 42 million), there was no need for normalization of the raw reads. After trimming, the clean reads were in the range of 40.78-42.05 million, which account for 95.80-98.89% of the raw reads. The average lengths of the clean reads were in the range of 143-146.7bp. There were no ambiguous bases in the reads. The PHRED score of >35 clearly indicated that the sequences were good enough to proceed further for constructing the *de novo* assembly. Instar-wise *de novo* assembly for the first biological replicate had also been completed during the period under report. The number of contigs across the larval transcriptomes was in the range of 40, 160-46, 215. The average lengths of the contigs were in the range of 776-866. The N_{50} values of the larval transcriptomes were about 1000 bp (952-1110 bp), indicating good coverage of contigs in the ESB transcriptome.

(T. Ramasubramanian and S. Mohankumar (TNAU)

Formulation and field application of *Metarhizium anisopliae* (Metchnikoff) Sorokin (1883) as a mycoinsecticide

Multiplication of the *M. anisopliae* strain (SBIMA-16) was done through liquid fermentation. Standardization of inoculum, temperature, volume of medium with the resultant spore output and virulence are in the process. On several grains, husks, brans,oil cakes with and without fortification of yeast, peptone and salts, the multiplication is being studied. Persistence of the mass produced SBIMA-16 at different temperatures and ambient temperature as well as at different crop stages of sugarcane is under study.

(N. Geetha, K.P. Salin and T. Ramasubramanian)

5.3.3 NEMATOLOGY

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

Liquid culturing of EPN and its bioassay against Galleria larvae: Mass production of four *Steinernema* spp. (*Steinernema surkhetense* SBIP3, *S. thermophilum* SBIH1, *S. siamkayai* SBITNT1, *Steinernema* spp. SBIUP96) was attempted in monoxenic liquid culturing and successful nematode mass production was observed in the liquid media. The multiplication of EPN in liquid culture was differed with EPN species. *S. surkhetense* SBIP3 and *Steinernema* spp. SBIUP96 obtained maximum yield at 8th day. *S. thermophilum* SBIH1obtained maximum yield at 15days and *S. siamkayai* SBITNT1 obtained maximum yield at 21 days. Under bioassay studies, all the EPN isolates caused 100 percent mortality of *Galleria* larvae at 72h.

Formulation of subtropical EPN: Shelf life of novel talc formulation of fifteen EPN (seven *Heterorhabditis* spp and eight *Steinernema* spp) isolates stored at 22-25°C was observed. The shelf life of 12 months old talc formulation of EPN was evaluated against *Galleria* larvae. It was observed that About 60 to 100 mortality of *Galleria* larvae observed with the talc based EPN

formulations. All EPN caused 100% mortality of *Galleria* larvae at 8th month storage and at 10th month 10 EPN recorded 100 % mortality of *Galleria* larvae. At 12th month, three EPN recorded maximum shelf life of 100%.

Maintenance of EPN and symbiotic bacterial cultures: Seventy eight EPN isolates belongs to Tropical (49) and subtropical (29) isolates were maintained by regular culturing in *Galleria mellonella* larvae and are being maintained in the culture collection. Totally 45 symbiotic bacteria belongs to *Photorhabdus* spp. (26 Nos.) and *Xenorhabdus* spp (19 Nos) are being regularly sub cultured on NBTA media 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

Survey was conducted in fall Army worm (FAW) infested fields of maize and sugarcane from different districts of Tamil Nadu and fourteen numbers of entomopathogenic nematode (EPN) naturally occurring in maize fields were isolated. Based on the Sequence analysis of the 18srDNA 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. Newly isolated populations were subjected to the series of bioassays such as bio-efficacy tests, mortality tests (LC_{50} values), heat tolerance assay, desiccation tolerance assays (both rapid desiccation tolerance assay and slow desiccation tolerance assay) and reproduction potential, for selection of a superior isolate for biological control of fall army worm, *Spodeoptera frugeperda*. Based on the above screening procedures, the isolates of 5 (*S. siamkayai*), 7 (*H. indica*), 13 (*H. bacteriophora*) and *S. glaseri* were identified as superior and could be deployed for the management of FAW.

(C. Sankaranarayanan, N. Seenivasan (TNAU, CBE) and B. Singaravelu)

5.4 ECONOMICS AND STATISTICS SECTION

An economic analysis on sugar recovery in different states in India

Adoption of the sugarcane varieties and sugar recovery improvement in Uttar Pradesh state which shares about 40 % of the total cane area in the country was studied since 1950-51. The sugar recovery was depicting decelerating trend and never be equal with national average. The sugar recovery also not crossed 10 % up to introduction of the variety Co 0238 in the state. After introduction of the variety Co 0238, the recovery significantly improved in correspondence with adoption rate. The overall sugar recovery was 9.54 % during 2014-15 and has attained 11.56 % in the current sugar season (2019-20). The three-unit sugar recovery improvement was recorded in the Uttar Pradesh is a historical achievement in the domain of sugar recovery research and development. The sugar recovery improvement has additionally produced 5.39 lakh tonnes of sugar which worth Rs. 1725 crores in the state. Similarly, to study the sugar recovery at micro level, survey was conducted at Haryana, Punjab and Uttar Pradesh. The results have shown that the sugar recovery improvement varied with states and agro climatic regions of the sub-tropical states. The maximum sugar recovery of 11.77 % in Haryana was recorded during 2019-20 and 12.5 % improvement of sugar recovery was recorded at Uttam sugars, Barghatpur, Bijnore, Uttar Pradesh in 281-19. It is expected to record more than 13 % sugar recovery in many sugar mills in the state in the current season (2019-20). The sugar recovery improvement in the sub-tropical India has significantly helped to offset poor sugar recovery recorded in the tropical states due to drought and untimely rainfall. The better sugar recovery in the sub-tropical states is helping for overall sugar recovery improvement of the country despite fluctuating sugar recovery pattern.

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

Table 25. Objectives and outcome of the project

Objectives	Outcome/knowledge/Technologies developed
Selection of appropriate Technologies: Two potential technologies of ICAR-SBI (SMI and Set- tling Transplanter), and one promising allied enterprise like production of Bio fertilizer were selected based on their income generation poten- tial and starting an enterprise	Stepwise methodology developed to identify various entrepreneurial qualities present in an individual who is aspiring to be an entrepreneur. Test battery developed by the study to measure the entrepreneurial qualities will help to understand the level of preparedness of an individual in terms of his psychological qualities. The attitude scale developed in the study helps to measure the attitude of an individual with aspect to starting an enterprise and starting a business. A knowledge test for recognition of pre learning level of the potential entrepreneur selected for capacity development programme. Skill Development and Capacity Development template for entrepreneurial promotion will help to eliminate the subjective influence in designing a capacity development programme. Capacity Development Programme module for imparting entrepreneurial knowledge and skills helps to organize capacity development programmes on the selected technologies namely, SMI, Bio Fertiliser and Settling transplanter. Business plans for starting entrepreneurship in SMI, Bio Fertiliser manufacturing unit and Settling transplanter were developed and validated by experts.
Analysis of Men and Material, Manufacturing process, Knowledge, skill and financial requirements etc and preparing a Business plan/project report on three selected enterprises (SMI, Settling Transplanter and Biofertiliser)	
Analysis of entrepreneurial qualities and needs of potential rural youth for providing technological and methodology support related to starting an enterprise and developing a CD module for developing entrepreneurship.	

A Feasibility Study of Recommended Sugarcane Production and Protection Technologies for Promoting Rural Entrepreneurship

Farmers Commission report emphasized the promotion of agri-preneurship through income generation activities in the rural areas through appropriate technologies. NAIP also envisaged the promotion of entrepreneurship through the establishment of BPD units. NARP-NATP- NAIP-NAEP continuum of ICAR for technology for income generation and livelihood security started ITMU –BPD units and ZTM.

Based on the recommendations during the project start presentation at IRC held in 2017 the following technologies namely, Soil Moisture Indicator (SMI), Sett Treatment Device and Production of Organic farm yard manure enterprises were finalized for study of the entrepreneurship potential and included in the objectives. Accordingly, the project objectives were revised. The results were depicted in the table. 25.

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

Socio-economic impact of ICAR-SBI varieties and production technologies in different agro-climatic zones of India

The varieties and technologies which had a significant impact on cane production system were delineated with different agro climatic zones in the country and abroad. The socio-economic impact of technological time line was assessed. The dynamics of yield and sugar recovery improvement were attributed

with respective technologies/varieties. The production and protection technologies which had an impact was an compiled for drawing technology timeline. The study has found that varieties and technologies developed at ICAR-SBI and its centres had a greater impact on sugarcane and sugar system in the county as well as cane growing countries abroad.

(P. Murali, V. Venkatasubramanian, Ravinder Kumar and K. Elayaraja)

Economic impact and climate smartness of variety Co 0238 in sub-tropical India

The variety Co 0238 is widely cultivated in the sub-tropical India. The area cultivated by this variety increased from 2.70 (2014-15) to 25.88 (2019-20) lakh hectares in sub-tropical region, which accounts about 86.09 % of the total area in sub-tropical India during 2019-20, which is the highest ever area (53.2 per cent) occupied by a single variety in the country in a very short span of time. Co 0238 has greatly contributed towards achieving the highest ever sugar production (33.16 million tonnes) in the country during 2018-19 that in turn led to a Governments' Policy decision on permitting direct conversion of sugarcane juice into ethanol.

During this period, Co 0238 has fetched an additional return of Rs. 28,033 crores to the farmers (from sugarcane and fodder) inUttar Pradesh, Punjab, Haryana, Bihar and Uttarakhand. As a result, the profit of farmers increased by about Rs 51,239 per hectare. The additional benefit to the sugar mills was Rs. 18,027 crores due to more sugar and by-product production as result of higher sugar recovery of variety Co 0238. The Economic Surplus model was fitted to estimate the total gain to society/economy due to adoption of Co 0238. Accordingly, the total annual economic gain (surpluses) was Rs. 13,107.1 crores which was distributed in the share of 37:63 between consumers and producers, respectively.

The surplus sugar and Jaggery production have immensely contributed towards supply of white sugar and jaggery to the domestic and international markets. Export of sugar was the minimum (0.46 lakh tonnes) during 2016-17 has attained new record of 57 lakh tonnes during 2019-20 was depicted in the Fig. 94. Co 0238 has mainly contributed for exporting white sugar through its high sugar recovery in the sub-tropical India.

(P. Murali, V. Venkatasubramanian, D. Puthira Prathap and Ravinder Kumar)

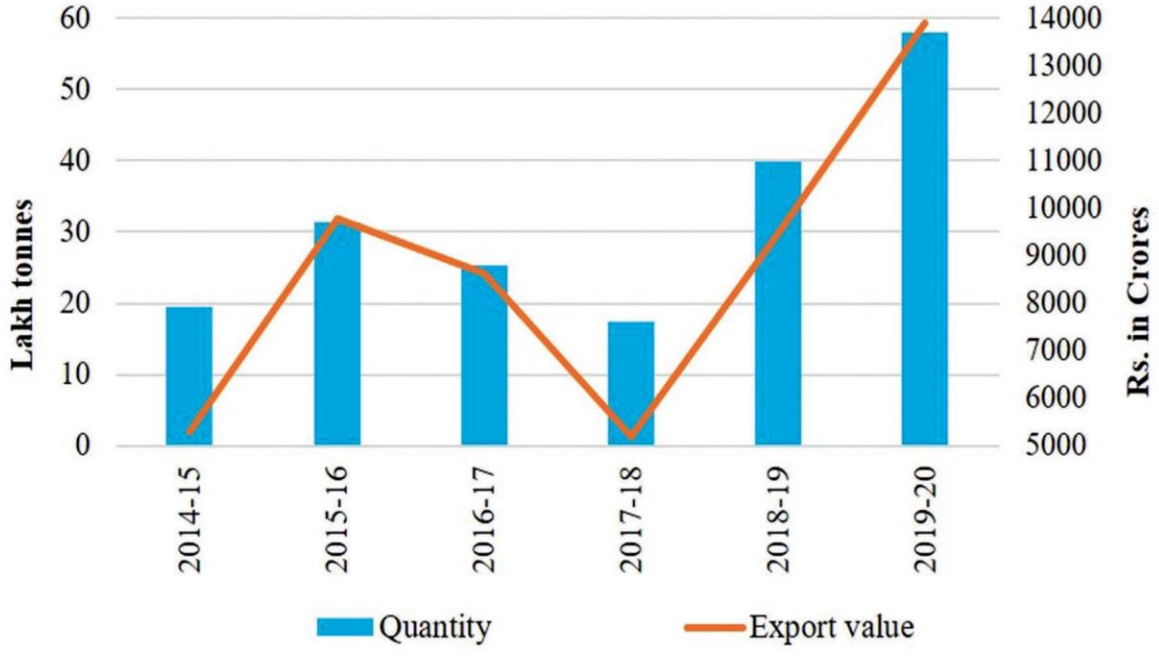


Fig. 94. Contribution of Co 0238

Sugarcane based Agri-Business Incubator (SBI-ABI) (NAIF funded project)

ICAR-SBI-ABI is newly established business incubator under establishment stage. Incubator space was established with existing building. Display area for technologies, six cubicles for incubator and one discussion room were created for entrepreneurs, start-ups and innovators. Entrepreneurship guide was published for the technologies such as soil moisture indicator and settling transplanter. The guide has complete information for agri startups and technology commercialization. Cane jam technologies was standardized for commercial scale production. The different flavours jam was produced for consumers preferences was depicted in Fig.95.

The cane jam was tested for consumer's preferences among different categories of staffs working in the institute. Organoleptic tests have confirmed that there was high consumer preference for cane jam which was tested for taste, aroma and quality. The ginger flavour was most preferred by adults similarly mango flavour was numero uno for children and adolescents. Technical supports were provided new FPC's and entrepreneurs for initiation of sugarcane-based value chain production.

Fig. 95. ABI driven product development and sale

(P. Murali, V. Venkatasubramanian, K. Hari, A.J. Prabakaran, G. Suresha and D. Puthira Prathap)

5.5 EXTENSION SECTION

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

State level training programs

Eight State Level Training programs on 'Scientific Sugarcane Cultivation' sponsored by the Department of Agriculture, Tamil Nadu under NFSM were organized (Fig. 96) as detailed below:

- I program: 7-8 January 2020 with 20 cane officials from Sugar mills of Tamil Nadu.
- II program: 4-5 February 2020 with 20 cane officials from Sugar mills of Tamil Nadu.
- III program: 11-12 February 2020 with 20 officials from TN state government.
- IV program: 18-19 February 2020 with 20 officials from TN state government.
- V program: 25-26 February 2020 with 20 officials from TN state government.
- VI program: 3-4 March 2020 with 20 officials from TN state government.
- VII program: 10 March 2020 for 20 farmers from Dharmapuri district.
- VIII program: 17 March 2020 for 20 farmers from Erode district.

The training comprised theory classes, visit to Institute Museum, laboratories and technology park. A training manual on 'Scientific sugarcane cultivation' was printed in Tamil and distributed to the participants. Knowledge evaluation studies were conducted pre and post training using a teacher-made knowledge test (Table 26). The average pre-evaluation score was 55.41 (range being 45.53 to 65.21) and average post-evaluation score was 90.62 (range 86.52 to 94.94) with an average knowledge gain of 35.21.

Feedback obtained from the participants indicated that they were satisfied with the overall course content. However, they had asked for more information on climate smart sugarcane technologies, organic farming, on-farm practical classes on pest and disease identification and increase in duration of the training to at least three days.

7-8 January 2020

4-5 February 2020

11-12 February 2020

18-19 February 2020

25-26 February 2020

3-4 March 2020

10 March 2020

17 March 2020

Fig. 96. Participants of the state level training program

Table 26. Pre and post evaluation of knowledge level

Training	No. of participants	Knowledge level (%)		Difference
		Pre-training	Post-training	
7-8 January 2020	20	65.21	91.30	26.09
4-5 February 2020	20	56.52	86.52	30.00
11-12 February 2020	20	52.82	94.94	42.12
18-19 February 2020	20	45.53	87.86	42.33
25-26 February 2020	20	50.86	91.30	40.44
3-4 March 2020	20	61.52	92.17	30.65
Average		55.41	90.62	35.21

DSD sponsored training

Conducted a state level one-day training sponsored by Directorate of Sugarcane Development (DSD), Lucknow on 'Scientific sugarcane cultivation' for 80 farmers from Coimbatore, Erode, Dharmapuri and Tirupur districts, Tamil Nadu on 27 February 2020 (Fig. 97). The program comprised theory classes, visit to Institute Museum, laboratories apart from demonstration on sugarcane settling transplanter. A training manual on 'Scientific

Fig. 97. Participants of the training (27 February 2020)

sugarcane cultivation' was printed in Tamil and distributed to the participants.

One-day training programs

Conducted the following 15 one-day training program (Fig. 98):

- For 43 farmers from Kodumudi block on 'SSI planting and drip fertigation in sugarcane' on 22 January 2020.
- For 50 farmers from Erode on 'SSI planting and drip fertigation in sugarcane' on 23 January 2020.
- For 18 Farm Tele-advisors from IFFCO Kisan Sanchar Ltd., Coimbatore on 28 January 2020.
- For 42 farmers from Tirupur district on 25 November 2020.
- For 40 farmers and one staff from Madathukulam block, Tirupur district on 25 November 2020.
- For 40 farmers and one staff from Veppanthattai block, Perambalur district on 25 November 2020.
- For 21 farmers and two staff from Annagramam, Cuddalore district on 16 December 2020.
- For 35 farmers and two staff from Bhavani, Erode district on 17 December 2020.
- For 38 farmers and two staff from Kodumudi, Erode district on 21 December 2020.
- For 39 farmers and two staff from Sathyamangalam, Erode district on 21 December 2020.
- For 40 farmers and two staff from Kallakurichi district on 22 December 2020.
- For 41 farmers and one staff from Thiruvannamalai district on 28 December 2020.

3 December 2020

16 December 2020

21 December 2020

21 December 2020

22 December 2020

28 December 2020

29 December 2020

29 December 2020

Fig. 98. Participants of the one-day training programs

- For 40 farmers and one staff from Thiruvannamalai district on 28 December 2020.
- For 40 farmers and two staff from Thiruvannamalai district on 29 December 2020.
- For 49 farmers and two staff from Sathyamangalam, Erode district on 29 December 2020.

Researchable issues: *Sugarcane* varieties specifically for juice purpose, Silage making, *in situ* trash composting.

Participation in Exhibition: Participated in the International Conference at VSI Pune during 31 January to 2 February 2020 by putting up a stall depicting package of practices, live specimens of new sugarcane varieties and distributed pamphlets on sugarcane cultivation (Fig. 99).

Frontline demonstrations on sugarcane

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 (Fig. 100).

Factors limiting sugarcane cultivation in Tamil Nadu

For the past few years, there is a decline in sugarcane cropped area in Tamil Nadu, as low as 1.65 lakh hectare during 2018-19 and it has slowly increased to 2.06 lakh hectares during 2019-20. However, many of the sugar mills in Tamil Nadu stopped crushing for want of adequate quantity of sugarcane.

In this context, a study was conducted to identify the reasons for reduction in sugarcane area in Tamil Nadu. To start with, a request was sent to all the sugar mills in the state to get details about the cane growers who had registered less than 50% area during 2018-19. Survey was conducted in five districts viz., Kallakurichi, Sivaganga, Tiruvannamalai, Salem and Namakkal among 65 sugarcane farmers chosen from five sugar mills, namely Dharani Sugars & Chemicals Ltd., Polur, Sakthi Sugars, Sivaganga, Salem Cooperative Sugar Mills, Cheyyar Cooperative Sugar Mills and Kallakurichi Cooperative Sugar Mills unit II.

Preliminary analysis of the responses indicated that more than 85% of the respondents have discontinued sugarcane cultivation completely and the rest have hardly 10% of the area under sugarcane now compared to previous years. However, a few farmers maintain limited area for seed production.

The major reasons attributed by the respondents for reduced area under sugarcane include non-settlement of payment for cane by sugar mills, exorbitant labour cost specially for harvesting, acute water shortage and not interested in taking up sugarcane farming anymore in their order of importance. The other reasons are low procurement price for sugarcane, lowly income from sugarcane, shifting to other allied enterprises / non-farming sector, erratic rainfall, varietal degeneration leading to reduced yield,

Fig. 99. ICAR-SBI stall in the International Conference at VSI, Pune

Fig. 100. Frontline demonstration on the variety Co 11015

non-remunerative jaggery prices and difficulty in procuring inputs.

The alternate crops opted by the respondent farmers include tapioca, paddy, coconut, vegetables, maize and pulses. Minimum price suggested by farmers is at least Rs 4000 per tonne of cane supplied.

The factors to make sugarcane farming more attractive as suggested by farmers are timely payment by the sugar mills, reduced labour charges, custom hiring centres for machines in villages, younger generation not willing to take up farming and to make some means to attract then towards farming.

Publications

- Printed ICAR-SBI Annual Report 2019 (English and Hindi)
- Printed ICAR-SBI News January 2020.
- Three Training Manuals, four pamphlets.

Technology Park: Technology Park 2019 was maintained with 17 sugarcane varieties (Co 86032, Co 06027, Co 06030, Co 99004, Co 2001-13, Co 92005, Co 06022, Co 99006, Co 2001-15, Co 0118, Co 0212, Co 0232, Co 0233, Co 0237, Co 0238, Co 05011, Co 11015) & tissue culture plants in 100 rows (Fig. 101).

Fig. 101. A view of Technology Park

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

National Science Day

National Science Day was celebrated at the Institute on 28 February 2020 as an 'open day' with the participation of 1180 students from 12 schools and two colleges in Coimbatore district (Fig. 102). The students were taken around the institute's museum and the exhibits with live specimens were explained by Scientists and Technicians apart from video shows.

Fig. 102. National Science Day celebration (28 February 2020)

Visitors program

Entertained 2780 visitors to the institute comprising students (2058), farmers (591) & cane development staff (131).

(T. Rajula Shanthy and D. Puthira Pratap)

Farmer support programme for sustainable sugarcane production

This project was sponsored by Solidaridad through Prakruthi with the objective to train progressive cane growers representing eight sugar mills of Tamil Nadu on sustainable agricultural practices to improve their knowledge base and thereby cane productivity and profitability of cane farming. A total of 755 cane growers from 481 villages across 10 districts were trained and designated as Sugarcane Lead Farmers (SLF) to serve as change agents to enable fellow farmers take up sustainable farming at village level.

A schedule was developed to get feedback from the participants on the usefulness of the capacity building program and the extent to which the messages are being utilized by them and being shared to fellow farmers. The schedule included details on technologies learnt during the training and adopted as a consequence of the training by Sugarcane Lead Farmers, opinion about the technologies adopted (performance, constraints,

relative advantage etc.), technologies shared with fellow cane growers, frequency to discuss the technologies learnt with fellow growers, opinion of the fellow farmers with whom they had shared the technologies and growers motivated by the SLF to adopt new sugarcane technologies so far.

To start with, survey was conducted among 31 women lead farmers who had participated in the last training program whichwassolely for women farmers. Preliminary analysis indicated that all the women contacted still had a vivid memory of their maiden visit to Coimbatore; Among the technologies popularized, intercropping with blackgram / greengram was the technology well received and adopted by almost all the respondents and they had motivated fellow farmers also to take up intercropping. This was followed by application of biofertilizers like *Azospirillum* and Phosphobacteria and they had reported that biofertilizer application made their crop turn lush green resulting in a good harvest.

(T. Rajula Shanthy)

Cane Adviser- A mobile app on sugarcane

We had developed an android mobile app 'Cane Adviser' in trilingual (English, Tamil and Hindi) and is available in google playstore for free download. The app contains information on state-wise sugarcane varieties, crop production technologies, crop protection technologies. Total downloads are 11013 from 61 countries and the number of hits are 156,010 with 59399 (38%) on crop production, 49078 (31%) on crop protection, 32397 (21%) on sugarcane varieties, 11734 (8%) on fertilizer schedule and 3402 (2%) on Saccharum species. On an average, 35-40 queries from farmers are being answered.

(T. Rajula Shanthy, S. Alarmelu, C. Jayabose and P. Malathi)

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.

New Beneficiary villages and interventions

Surveys were conducted in Sirumugai and Karamadai hill ranges to identify new tribal villages for implementation of Tribal Sub Plan during 2019-20. Accordingly, Kaanthavayal and Uliyur tribal villages in Sirumugai range with 60 tribal families were selected as beneficiary villages. Focus group discussions were held with the Tribal Head and other tribal people in the respective villages. Discussions were also held with the Headmaster of a tribal school in the village. Transect analysis in Kanthavayal helped us to get first-hand information about the local resources, ongoing agriculture and related activities, livelihood pattern and their felt needs. Based on the observations made, technological interventions were identified for the two villages.

Subsequently, surveys were conducted in Karamadai range and Domanur and Sembukkarai tribal villages with over 130 tribal families were identified as beneficiary villages. Based on the discussions held with the Tribal Head and other tribal people in the respective villages and observations made, technological interventions were identified for the two villages and a tribal school.

A 'Tribal Farmers Meet' was organized at at Domanur and Sembukkarai tribal villages on 16 October 2020 (Fig. 103). The following inputs: sewing machine (17), 190 each of induction stove, induction utensils, blankets, torch lights, led tube & bulb, umbrellas, bicycles, storage drum, rain coat, pick axe, gum boot, sickle, battery sprayer, coconut dehusker, tarpaulin sheet 200 gsm, emergency light, irrigation green

Fig. 103. Distribution of items during Tribal Farmers Meet on 16 October 2020

Fig. 104. Distribution of items during Tribal Farmers Meet on 28 October 2020

hose, rose can 5 litres, crow bar-5 feet, digging fork, spade, hand hoe, measurement tape (30m), plastic pan, plastic shears, chairs, bill hook, tiffin box, thick bed spread; and school items namely swing, slide, white boards, plastic chairs, tables, utensils, sport items, toys, mats, which were procured in March and withheld due to covid were supplied to the tribal villagers. Six sewing machines were supplied for tribal women from six tribal villages on 27 October 2020 at the Institute.

'Tribal Farmers Meet' at Kandhavayal and Uliyur tribal villages on 28 October 2020 (Fig. 104) and supplied the following items to 60 tribal families and school – Bicycles (25), Induction Stove, Blankets, Torch lights, LED Tube & Bulb, Storage drum, Rain Coat, Pick Axe, Gum Boot, Sickle, Battery Sprayer, Coconut Dehusker, Tarpaulin Sheet 200 gsm, Emergency Light, Plastic Chair, Irrigation Green Hose, Rose can 5 l, Crow Bar-5 feet, Digging Fork, Spade, Hand hoe, Measurement Tape (30m), plastic pan, Plastic Shears, Bill Hook, Tiffin box, Umbrellas, Thick bed spread, Induction Utensils.

Interventions during 2020-21

Based on surveys conducted, four villages viz., Neelampathi, Ookaiyanoor, Ookapatti and Mottiyoor in Periyanaickenpalayam range with over 140 acres of cultivated area were selected (Fig. 105). Most of the areas are rainfed and the crops grown include ragi, castor, beans, cowpea, horsegram, toovar, blackgram. Kudhiraivaali, saamai, thinai and in limited areas paddy, vegetables, banana and coconut are grown. Based on discussions with the tribal villagers and their demands for seeds, visits were made to TNAU and discussed with Dean, College of Horticulture, Head, Department of Vegetables, Head, Department of Pulses, Head, Department of Millets, Manager, Central Farm, Manager, Orchard and enquiries were made with Head, KVK, Santhiyur and Head, Centre for Excellence in Minor Millets, Bhavani. Visits were also made to various private firms, plant nurseries and SPIC unit in Coimbatore.

Subsequently, 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), DAP (350 kg), bone meal (35 kg), 360 coconut (TxD), banana (Quintal nendran - 820 & G naine - 1525), lemon Balaji variety (285), mango seedlings (25), and annual moringa were supplied. A portion of the seeds procured were also supplied to earlier beneficiary villages in Palamalai hills as well. Apart from this, the

Fig. 105. Scientists of ICAR-SBI interacting with tribal people of Neelampathi

following items were distributed: Field operation kit (tata spade with handle, crowbar five feet, 5 litre rose can, bill hook, plastic pan, hand hoe, FHS666 scissors, 15 m fibre measuring tape - 70 nos), power sprayer (12 nos), bullock drawn steel country plough (20), coconut dehusker (80), mini-flour mill, ICAR-SBI jaggery (250 kg) and liquid jaggery (250 bottles), tiffin carrier (55), water tank (1000 litres). 5 125 health & hygiene kit for tribal children of the four villages.

Training / awareness programs organized in tribal villages

- Conducted a training program on 'Nutrient management in coconut cultivation' for 108 tribal people of Neelampathi, Ookaiyanoor, Ookapatti and Mottiyoor tribal villages on 30 September 2020. They were supplied with coconut seedlings and vegetable seeds (Fig. 106-107).
- Conducted an awareness program on 'Healthy seeds for a better crop' for 51 tribal people of Neelampathi, Ookaiyanoor, Ookapatti and Mottiyoor tribal villages on08 October 2020 and supplied seeds of minor millets and vegetables.
- Conducted a training program on 'Healthy seeds for a good crop' for 89 tribal people in Palamalai on 15 October 2020 (Fig 108).
- Conducted 'Mahila Kisan Diwas' in Palamalai tribal village with the participation of 46 tribal women from eight nearby villages on 15 October 2020 (Fig. 109).
- Conducted an Awareness Campaign on health and hygiene for 40 tribal children of the age group 2-14 years in Ookaiyanoor tribal village on 10 November 2020 (Fig. 110-111). They were educated about basic hygiene and were given Health and Hygiene kit comprising 21 items. A chart displaying 'Basic hygiene practices' in Tamil were pasted on a vantage place in the village.

Fig. 106. Distribution of vegetable seeds (30 September 2020)

Fig 107. Distribution of coconut seedlings (30 September 2020)

Fig.108. Distribution of seeds in Palamalai tribal villages (15 October 2020)

Fig. 109. Mahila Kisan Diwas celebrated in Palamalai (10 November 2020)

Fig. 110. Awareness Campaign on Health and Hygiene in tribal village (10 November 2020)

Fig. 111.Tribal children receiving Health & Hygiene kit from ICAR-Sugarcane Breeding

Fig. 112. Tribal villagers being explained about lime cultivation (10 November 2020)

Fig. 113. Distribution of lime air layered plants to tribal villagers (10 November 2020)

Fig. 114. Overhead tank for community hall in tribal village being given (10 November 2020)

Fig. 115a Awareness Campaign on Health and Hygiene in tribal village (25 November 2020)

Fig. 116. Transect walk in tribal villages

- Conducted a training program on 'Scientific cultivation of lime' for 47 tribal villagers in Neelapathi, Oookaiyanoor, Motiyur and Ookapatti tribal villages on 10 November 2020 (Fig. 112) and were supplied 200 Balaji lime air layered saplings and bone meal mixture (Fig. 113). The villagers were supplied with a 1000 litres water tank for the community hall (Fig. 114).
- Conducted an Awareness Campaign on health and hygiene for 25 tribal children of the age group 2-14 years in Motiyoor tribal village on 27 November 2020 (Fig. 115). They were educated about basic hygiene and were given Health and Hygiene kit.

Fig. 115b. Distribution of Health and hygiene kits (27 November 2020)

- Focus group discussion with tribal head and tribal villagers and transect analysis in seven villages namely kunjapana, Kunjapanapudhur, Mantharai, Thuthikarai, 10 line, 23 line, 40 line on 2 December 2020 (Fig. 116).
- Conducted an Awareness Campaign on health and hygiene for 30 tribal children of the age group 2-14 years in Ookapatti tribal village on 9 December 2020 (Fig. 117). They were educated about basic hygiene and were given Health and Hygiene kit.
- Conducted Awareness campaign on health and hygiene for 51 tribal children of the age group of 2-17 years of Neelampathi tribal village on 23 December 2020. They were educated about basic hygiene and were given Health and Hygiene kit comprising 18 items (Fig. 118).
- Conducted a Swachchhta Awareness program at Neelampathi on 23 December 2020 with the participation of 43 tribal people (Fig. 119).
- Distributed 70 field operation kits (tata spade with handle, crowbar 5', rose can 5

Fig. 117 Awareness Campaign on health and hygiene in tribal village (09 December 2020)

Fig. 118. Awareness Campaign on health and hygiene in Neelampathi (23 December 2020)

Fig. 119. Cleanliness Campaign in Neelampathi tribal village on 23 December 2020

Fig. 120. Distribution of field operation kits to tribal villagers (23 December 2020)

Fig. 121. Distribution of ICAR-SBI jaggery to tribal villagers (23 December 2020)

litres, billhook, plastic pan 2 nos., handhoe, FHS scissor, measuring tape fibre 15 m), 250 kg ICAR-SBI jaggery and 250 bottles of liquid jaggery in four tribal villagers on 23 December 2020 (Fig. 20-21).

(T. Rajula Shanthy, C. Jayabose, R. Arunkumar C. Sankaranarayanan, R. Karuppaiyan)

Evaluating the effectiveness of state-level sugarcane R & D workshops – A cross state assessment

The project was initiated to evaluate the effectiveness of sugarcane Research and Development workshops in Tamil Nadu/ Puducherry and Karnataka with the following objectives: to ascertain the profile of the respondents who have participated in R&D workshops, to determine their perceptions of the overall organization of the workshop, to analyze the effects of the workshop on the participants, to ascertain the factors which influenced their decision to attend this workshop and to obtain suggestions and provide concrete recommendations for the future conduct of Sugarcane R&D workshops.

The refined questionnaire consisted of three parts: face-sheet information, evaluating the impact and suggestions. The questionnaire was evaluated against aspects such as validity, appropriateness for the sample, understandability, comprehensiveness and unambiguity.

A questionnaire was designed and refined with the help of experts using Google Forms.

5.6. ICAR- SBI, REGIONAL CENTRE, KARNAL

Breeding elite clones suitable for NWZ

Sugarcane variety notified for commercial cultivation

Co 13035, a mid-late maturing sugarcane variety was gazette notified (No 3482 dt 07.10.2020) by Govt. of India for commercial cultivation in North Western Zone (central and western UP, Utrakhand, Haryana, Punjab, Delhi and Rajasthan) (Fig. 122).

Performance of Co 13035 in North West Zone: The variety Co 13035 was evaluated in AICRP(S) trials at nine locations in North West Zone during 2016-2019. The comparative performance of the variety with the standards is given in Table 27.

Table 27. Comparative performance of Co 13035 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 13035	11.17	87.86	18.30	14.17
Standards				
CoPant 97222	10.00	80.11	17.97	13.91
CoS 767	9.61	78.44	17.71	13.39
CoS 8436	8.86	70.20	18.19	13.94
Percent improvement over standards				
CoPant 97222	11.70	9.67	1.84	1.96
CoS 767	16.23	12.01	3.33	5.88
CoS 8436	26.07	25.16	0.60	1.71

Variety identified by VIC release and notification proposal accepted by CVRC: Co 15023, an early maturing variety was identified in the 33rd biennual workshop of AICRP(S), virtually organized by IISR, Lucknow during 19–20 Oct 2020. The release and notification proposal of the variety was accepted in the 85th meeting of the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops held through Video Conferencing on 09th November 2020 (minutes of 95 meeting, S.No 90 at page No 10). The performance of Co 15023 with the standards is given in Table 28 (Fig. 123).

Co canes accepted for inclusion in ZVT: Three Co canes *viz*. Co 20016 under early, Co 20017 and Co 20018 under midlate were accepted for inclusion in ZVT trails for NWZ. Similarly, Co 15023 was accepted for inclusion in ZVT trail of NE and NC Zone in the 33rd biennial workshop of AICRP(S), organized virtually by IISR, Lucknow during 19 – 20 Oct. 2020.

Hybridization, progeny evaluation and selection

Fluff raising: Fluff consist of a total of 68 bi-parental crosses, 33 GC, and 11 PC were raised in the green shade net house during 17- 23 April 2020.

Seedling selection in ratoon ground nursery 2019-20: A total of 90 better 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 K18-01 to K18- 90 and were field transplanted in augmented design under C1 evaluation stage along with four standards (Co 0238, CoJ 64, Co 05011 and CoS 767).

Seedling ground nursery 2020-21: A total of 4960 seedlings transplanted into the field conditions during the month of July 2020, were ratooned during the peak winter period (3rd week of Dec. 2020). A total of 640 seedlings from 29 cross combinations were field transplanted during October 2020

Fig. 122. Field view of Co 13035

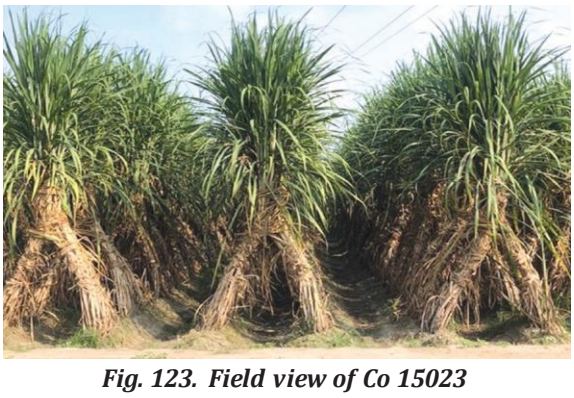


Fig. 123. Field view of Co 15023

Table 28. 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

First clonal trial 2019-20: The experiment consisting of 494 C1 selections of K16 series were evaluated for cane yield and quality traits. A total of 108 best performing clones were advanced to preliminary trial.

First clonal trial 2020-21: A total of 124 clones of K17 series were evaluated for cane quality at 8th month. The clone Co 0238 was best among the standard with 19.1% HR brix and three entries; K17-001 (20.2%), K17-037 (19.7%), and K17-038 (19.4%) were numerically superior to Co 0238 whereas, another six entries namely; K17-003 (18.9%), K17-008 (18.8%), K17-089 (18.8%), K17-082 (18.6%), K17-109 (18.6%), and K17-006 (18.5%) had numerically higher HR brix than CoJ 64 (18.5%).

Red rot: A total of 128 C1 trial clones were screened for red rot resistance and four exhibited resistant, 27 moderately resistant, 16 moderately susceptible, 56 susceptible and 25 showed highly susceptible reaction.

Preliminary trial 2019-20: Based on cane yield, juice quality parameters, red rot reaction and performance as compared to best standards a total of 55 K15 series entries out of 227 were selected for next stage evaluation under PZVT.

Preliminary trial 2020-21: Among the 108 test entries of the trial, 13 entries have higher NMC over best standard CoS 767 (105.56 thousands) among them K16-348 (144.44), K16-490 (132.41), K16-185 (118.52) & K16-464 (118.52) were top performers. For sucrose% at 8 month crop stage entries K16-144 (19.65), K16-01 (18.34), K16-43 (17.91), K16-99 (17.86) and K16-475 (17.79) found promising over the best standard CoJ 64 (17.56).

Red rot: Of the 96 clones evaluated, four found to be resistant, 43 moderately resistant, 25 moderately susceptible, 24 susceptible/ highly susceptible to red rot.

Pre-Zonal Varietal Trial

The experiment consisting of 54 elite clones along with four standards (Co 0238, CoJ 64 and Co 05011, CoS 767) was evaluated for cane and juice quality traits. Considering cane yield, juice quality and red rot reaction, two early K14- 219 (Co 20015), K14-425 (Co 20016) and three midlate clones K14-352 (Co 20017), K14-410 (Co 20018) and K14-501 (Co 20019) were assigned Co status. (Tables 29 and 30).

PZVT trial 2020-21: The general mean of the trial for HR brix at 7th month recorded was 14.3% and CoJ 64 (16.1%) was the best among the standards. The top ranking entries for high quality HR brix were, K15-386 (17.8%), K15-526 (17.3%), K15-401(17.0%), K15-112 (16.6%), K15-588 (16.5%), K15-361 (16.2%).The overall mean of the trial for pol% in juice at 8th month was 15.09% and CoJ 64 was the best among the standard (18.06%) and five test entries; K15-066, K15-088, K15-521, K15-639, K15-609 were at par with the best standard CoJ 64.

Red rot: Among the 54 clones evaluated, 10 were resistant, 27 moderately resistant, 09 moderately susceptible and 8 susceptible / highly susceptible with CF08 pathotype, while

Table 29. Performance of early maturing clones selected for awarding 'Co' status at ICAR-SBIRC, Karnal during 2019-20

Clone Number	Parentage	CCS (t/ ha)	Yield (t/ ha)	Sucrose (%)		Red rot rating	
				8m	10m	CF08	CF09
Co 20015 (K14-219)	CoS 8436 x Co 89003	19.57*	144.66*	18.28	19.34	MR	MR
Co 20016 (K14-425)	Co 0240 x Co 62198	19.13*	136.09	18.92*	19.64	MR	MR
Standards							
CoJ 64		11.04	99.05	17.60	16.44		
Co 0238		16.34	117.71	17.49	19.66		
CD		2.77	21.54	1.12	0.55		
CV		12.89	12.37	4.33	1.92		

Table 30. Performance of midlate maturing clones selected for awarding 'Co' status at ICAR-SBIRC, Karnal during 2019-20

Clone Number	Parentage	CCS (t/ ha)	Yield (t/ha)	Sucrose (%)		Red Rot Rating	
				10m	12m	CF08	CF09
Co 20017 (K14-352)	Co 7219 x CoV 92102	17.79	126.01	19.97*	20.07*	MR	MR
Co 20018 (K14-410)	Co 86032 x 85R186	19.52*	137.29*	19.45*	20.36*	MR	MR
Co 20019 (K14-501)	Co 0240 x Co 06037	16.86	115.82	19.39*	20.84*	MR	MR
CoS 767		10.10	79.95	17.54	18.20		
Co 05011		15.71	115.62	17.77	19.36		
CD		2.92	21.54	0.55	0.65		
CV		12.21	12.37	1.92	2.04		

with CF09 pathotype, one clones exhibited resistant, 35 moderately resistant, 12 moderately susceptible and six susceptible/ highly susceptible reaction to red rot. However, four clones viz. K15-292, K15-312, K15-596 and K15-622 showed susceptibility to both the isolates.

(Ravinder Kumar, M.R. Meena, M.L. Chhabra and B. Parameswari)

Evaluation at sugar factory locations in subtropical India

DCM Shriram Sugars Ltd unit, Ajabapur: Nine elite Co canes *viz.*, Co 12029, Co 13034, Co 13035, Co 14034, Co 15023, Co 15024, Co 15026, Co 15027 and Co 16029 along with two standards *viz.,* Co 0118 and Co 0238 were evaluated for cane yield and juice quality traits. At harvest (10th month) Co 15023 (14.8 t/ha) was the better performing entry over best standard Co 0238 (14.1 t/ha) for CCS t/ha. As compared to Co 0238 (103.7 t/ha), four test entries viz. Co 12029 (118.3 t/ha), Co 15027 (110.6 t/ha), Co 15026 (108.5 t/ha) and Co 15023 (108.1 t/ha) performed well for cane yield t/ha. Co 15023 was the best performing entry for juice sucrose % at 8th (18.3%), 10th (19.7%) and 12th (20.7%) month of crop stage, Co 0238 was best standard at 8th (16.5%) and 10th (19.4%) month while Co 0118 (20.1%) was best standard at 12th month of crop stage.

DCM Shriram Sugars Ltd unit, Rupapur: Among the nine test entries viz., Co 12029, Co 13034, Co 13035, Co 14034, Co 15023, Co 15024, Co 15026, Co 15027 and Co 16029 along with standard Co 0238 evaluated in RBD layout, Co 15023 (10.1 t/ha) was the best performing test entry for CCS t/ha over Co 0238 (8.4 t/ha). The cane yield of Co 15023 (76.5 t/ha) and Co 15027 (75.5 t/ha) were also on par with Co 0238 (73.3 t/ha).

DCM Shriram Sugars Ltd unit, Hariyawan: Among the nine test entries viz., Co 12029, Co 13034, Co 13035, Co 14034, Co 15023, Co 15024, Co 15026, Co 15027 and Co 16029 along with standard Co 0238 evaluated in RBD layout, Co 15023 (14.7 t/ha) followed by Co 13035 (14.5 t/ha) were the best performing test entries for CCS t/ha over Co 0238 (11.3 t/ha). The cane yield of Co 13035 (111.4 t/ha), Co 15024 (108.7 t/ha), Co 16029 (108.6 t/ha), Co 15023 (107.4 t/ha), Co 15027 (107.3 t/ha) were better over Co 0238 (97.3 t/ha).

DCM Shriram Sugars Ltd unit Loni: Among the nine test entries viz., Co 12029, Co 13034, Co 13035, Co 14034, Co 15023, Co 15024, Co 15026, Co 15027 and Co 16029 along with standard Co 0238 evaluated in RBD layout, Co 15023 (13.98 t/ha) followed by Co 15027 (13.60 t/ha) and Co 14034 (13.08 t/ha) were the best performing test entries for CCS t/ha over Co 0238 (11.51 t/ha). The cane yield of Co 15027 (116.6 t/ha), Co 15023 (107.23 t/ha) and Co 14034 (105.37 t/ha) was better over Co 0238 (94.07 t/ha).

Balrampur Sugar Mill unit, Balrampur: At Balrampur Sugar Mill, the performance of seven test entries viz., Co 12029, Co 13035, Co 14034, Co 15023, Co 15024, Co 15026 and Co 15027along with standards Co 0118 and Co 0238 was evaluated in two plant and one ratoon crop. The pooled data (2P+1R) indicates that for sugar and cane yield Co 0238 (12.94 t/ha CCS; 97.22 t/ha cane yield) was the best standard, and entry Co 15023 (14.05 t/ha CCS; 102.0 t/ha cane yield) found superior over it. The juice sucrose% of Co 15023 (19.79%) was also higher over Co 0238 (19.11%).

Dalmia Sugar Mill unit, Ramgarh: The performance of seven test entries viz., Co 14034, Co 14035, Co 15023, Co 15024, Co 15025, Co 15026 and Co 15027 along with standard Co 0238 was assessed for cane yield and juice quality parameters from two plant and one ratoon crop. The mean performance for CCS t/ha of test entries Co 15023 (16.48 t/ha) and Co 15027 (15.26 t/ha) was significantly higher over Co 0238 (14.42 t/ha). The cane yield of Co 15027 (124.4 t/ha), followed by Co 15023 (117.15 t/ha) and Co 15025 (114 t/ha) was comparable with Co 0238 (115.2 t/ha). The juice sucrose % was highest in entry Co 15023 (20.2%), which depicted 9.96% improvement over Co 0238 (18.37%).

Saraswati Sugar Mill, Yamunanagar: The trial consisting of 8 test entries viz., Co 12029, Co 13034, Co 13035, Co 14034, Co 14035, Co 15023, Co 15024, Co 15026 and Co 15027 along with two standards Co 0118 and Co 0238 was evaluated for cane yield and juice quality traits. Among the standards, Co 0118 (16.56 t/ha) had higher CCS t/ha, and test entries Co 15023 (18.33 t/ha) and Co 15027 (18.30 t/ha) performed better over it. Co 0238 (117.64 t/ha) was the better standard for cane yield and test entries Co 13035 (125.28 t/ha), Co 15027 (124.42 t/ha), Co 15023 (115.11 t/ha), Co 12029 (115.08 t/ha) and Co 13034 (111.62 t/ha) had on par performance with it. The sucrose% in juice at 8th, 10th and 12th month of crop stage was higher in standard Co 0118 (17.42%, 18.19% &20.55%), entries Co 15023 (19.14%, 19.96% & 22.32%) and Co 14034 (18.01, 19.60 & 21.47%) found promising over it.Similarly in ratoon trial at SSM, Yamunanagar, Co 0118 (20.56%) was the best in quality and entry Co 14034 (18.52%), Co 15026 (18.57%) Co 15023 (18.46%), Co 15027 (18.42%) had numerical higher value for pol% in juice than Co 0238 (18.33%) at 9th month ratoon crop.

Daurala Sugar Mill: The mean pol% in juice ofthe ratoon trial at Daurala Sugar mill at the 9th month was 16.68% and entry Co 15023 (18.53%) and Co 14034 (17.93%) had recorded better quality.

(M.R. Meena, Ravinder Kumar, M.L. Chhabra and S.K. Pandey)

'Co' canes maintenance

Sixty eight 'Co' canes were planted in ABD layout with four standards (Co 0118, Co 0238, Co 05011, Co 12029) replicated in six blocks. At 10th and 12th month of crop stage, the experimental average for pol% was 18.53 and 19.94%, respectively. Co 15023 (21.37%), Co 17016 (21.21%), Co 14034 (20.84%), Co 0118 (20.44%), Co 0116 (20.22%), Co 12029 (20.20%) and Co 0237 (20.0%) were the top performing entries at 10th month, whereas at 12th month Co 15023 (22.56%), Co 14034 (21.95%), Co 17015 (21.74%), Co 12029 (21.66%), Co 0116 (21.43%), Co 17016 (21.42%), Co 15027

(21.38%), Co 15025 (21.37%), Co 0118 (21.27%) and Co 0237 (21.22%), were the top performing entries for pol%. The experimental mean for cane yield was 103.9 t/ha, and Co 18022 (158.15 t/ha), Co 18020 (155.86 t/ha), Co 15027 (155.81 t/ha), Co 0238 (153.7 t/ha), Co 17018 (152.79 t/ha), Co 15023 (146.46 t/ha), Co 94008 (145.96 t/ha), Co 11026 (144.19 t/ha), Co 15025 (140.71 t/ha) and Co 15026 (140.12 t/ha) were the best performer entries.

(Ravinder Kumar and M.R. Meena)

Enhancement of sugarcane germplasm and development of pre-breeding material

Evaluation of sugarcane germplasm, ISH and IGH Clones under sub-tropical conditions: The experiment in 2019-20 was evaluated for cane yield and quality parameters at 12 month crop stage. The mean cane yield reduction percent in the trial observed was 41% and Co 0238 was best among the standards with least reduction of 21% under drought conditions. Highest cane yield reduction (>50%) was observed in entries viz., PRB, B43-380, B37-161 and PR 1047. Whereas, entry Cavangerie, 14-50, 12 CBE and CL 41- 141 had least reduction (<10%) for cane yield at harvest. However, there was no significant reduction for cane quality at harvest. Based on the performance of the clones for different growth parameter under the drought condition, clones; 14-50, Cavangerie, SP 80-185, 51 NG163, H 49-104 and GU00-139 were considered for further evaluation into salinity stress under the pot conditions.

New experiment of the season 2020-21: ISH trial consisting of 27 new entries along with 4 standards (Co 0238, Co 0118, Co 12029 and Co 05011) were planted with two replications (each under normal and drought conditions). The experiment was evaluated for physiological, morphological and periodic growth parameters at different crop intervals. At 60 DAP, the average plant height till top visual dewlap (TVD) recorded was 70.7 cm, 53.7 cm under the normal and drought stress, respectively. The overall mean reduction in the trial for cane height under drought was 22.39%. The mean reduction in SPAD value for chlorophyll content under the drought was 11.36%. The normal conditions recorded more chlorophyll (43.21) than of the drought stress (37.84). At 90 DAP, mean reduction for cane height recorded was 21.9% and early standard Co 0238 had minimum reduction of 13% whereas, clones namely; 14-49, 14-171, 14-43, 14-189 and 14-147 recorded were at par with the best standard Co 0238.

Cane yield and quality parameters: A total of 27 ISH clones were evaluated along with four standards for cane yield and quality parameters at 8th month crop stage. The mean cane height in normal and drought trial was 242 cm, 198 cm, respectively. While there was 18.44% reduction under the drought for cane height. The NMC population of trial under normal and drought conditions was 1.07 lakhs/ha and 0.91 lakhs/ha respectively. Mean single cane weight of overall trial under normal conditions was 0.98 kg where it was 0.80 kg under drought conditions and a reduction of 17.62% was observed for SCW under the drought. The mean HR Brix recorded was higher under drought conditions (17.12%) compared to normal conditions (15.5%) at 8th month. Similarly, pol % in juice at 8th month crop stage of the trial recorded was slight higher under drought (13.10) conditions as compared to the normal (12.62) conditions. Clones SA14-147, SA14-52, SA 14-49 produced higher number of millable canes (NMC) as well higher sucrose% under drought at 8th month.

Screening of ISH clones under salinity stress: Six inter specific hybrid (ISH) namely SP 80-185, GU00-139, Cavangerie, H 49-104, 14-50 and 51 NG-163 and two standard viz., Co 0238 and Co 05011 were planted during second fortnight of April, 2020, in pots to screen them under different salinity level. After 60 days of planting (DAP), chloride dominated saline irrigation of different concentration i.e. 4, 8 and 10 dSm-1 were applied. At 120 DAP, average no. of tillers were 8/pot in control and reduced up to 13.75%, 27.5% and 43.75% in 4dSm-1, 8dSm-1 and 10dSm-1, respectively. At 150 days of salinity stress, average plant height reduced by 14.43% in 4 dSm-1, 25.29% in 8 dSm-1 and 34.87% in10 dSm-1as compared to normal irrigated control (189.70 cm). ISH clones showed less reduction

in plant height than standard Co 0238 (21.71, 31.81 and 39.80% reduction at 4, 8 and 10 dSm- 1, respectively). Under applied salinity levels, least reduction was recorded in 14-50 (17.25%) followed by H 49-104 (17.85%), 51 NG-163 (18.22%) and Cavangerie (18.89%) on mean basis. Average plant population reduced up to 17.12, 34.98 and 47.94% under 4 dSm-1, 8 dSm-1 and 10 dSm-1, respectively. Minimum reduction was recorded in H 49-104 (23.3%) followed by 14-50 (24.4%), GU00-139 (25.8%) and Cavangerie (29.3%) while maximum reduction was recorded in Co 0238 (37.3%) and 51NG-163 (33.3%).

Red rot: Out of 27 ISH clones, four exhibited resistant, 12 moderately resistant, six moderately susceptible, one susceptible and four highly susceptible reactions to red rot.

Insect Pests: A total of 26 sugarcane germplasms/ species clones (ISH & IGH) viz. 14-19, 14-42, 14-43, 14-44, 14-049, 14-52, 14-56, 14-61,14-63, 14-71, 14-80, 14-82, 14-88A, 14-99, 14-100, 14-105, 14-125, 14-127, 14-144, 14-145, 14-147, 14-170, 14-188, 14-189, 14-192, and 14-198 were evaluated against early shoot borer (ESB) and top borer (TB). Incidence of ESB and TB was varied from 0.0 to 9.1 % and 0.0 to 7.3 %, respectively. Hence, all the test clones were least susceptible to early shoot borer and top borer.

(M.R. Meena, Ravinder Kumar, S.K. Pandey M.L. Chhabra, B. Parameswari and Pooja)

All India Coordinated Research Project (Sugarcane)

Subtropical zone – Breeding (19-20)

IVT Early: Experiment consisting of nine test entries and three standards *viz*., CoJ 64, Co0238 and Co 05009 was evaluated for various cane yield and juice quality traits. In general the experiment was very good in terms of phenotypic expression of agronomic traits. At harvest the experimental average for sugar (CCS) yield, cane yield, CCS%, Pol%, pol in cane, fibre% and single cane weight (kg) was 15.25 t/ha, 124.17 t/ha, 12.26%, 17.65%, 13.48%,
13.67% and 1.31 kg respectively. For sugar yield (16.79 t/ha), cane yield (126.76 t/ha) and pol% (19.02%), Co 0238 was the best entry among standards. Co 15025 (19.53 t/ha) followed by CoPb 16211 (18.59 t/ha), CoLk 16201 (17.95 t/ha) and CoPant 16222 (17.6 t/ha) for CCS t/ha; CoPb 16211 (169.7 t/ha), CoLk 16201 (147.11 t/ha), Co 15025 (145.85 t/ha), CoS 16231 (143.64 t/h) and CoPant 16222 (138.27 t/ha) for cane yield; Co 15025 (19.29%) for pol%, were the promising test entries of the experiment which performed either superior or on par with the best standard Co 0238. Entries Co 15025 (1.42 Kg), followedby CoS 16231(1.37 Kg) and CoPant 16221(1.36 Kg) produced significantly heavier single cane weight (SCW) over Co 0238 (1.22 kg), the best standard. Test entries CoPb 16181 (1.33 kg), Co 16029 (1.30 Kg), CoLk 16201 (1.28 Kg), CoPant 16222 (1.17 Kg) and CoPb 16211 (1.11 Kg) had on par performance with Co 0238 for SCW.

AVT Early I Plant: The experiment consisting six test entries and three standards was evaluated for various cane yield and juice quality traits. At eighth month of crop stage CoJ 64 (17.52%) was the best standard for pol%. Test entries Co 15023 (20.43%) and CoLk 15205 (18.15%) were significantly superior over it. At harvest, the sugar yield of entry Co 15023 (20.13 t/ha) was significantly higher, while of Co 15027 (17.14 t/ha), was numerically higher over the best standard Co 0238 (14.98 t/ha). Entries Co 15027 (132.25 t/ha), Co 15023 (129.32 t/ha) had numerically higher cane yield over the best standard variety Co 0238 (116.4 t/ha). Atharvest, the sucrose% of test entry Co 15023 (21.88%) was significantly higher over Co 0238 (18.54%), the best standard, whereas of entries Co 15027 (18.56%), CoLk 15205 (18.19%), Co 15024 (18.06%) and CoLk 15201 (18.02%) had on par performance with Co 0238.

AVT Early II Plant: The experiment consisting four test entries and three standards was evaluated for various cane yield and juice quality traits. At 8th month of crop stage, Co 0238 (18.08%) was the best standard for pol%, and test entries CoPb 14181 (17.83%) and Co 14034 (17.41%) had at par performance with it. At harvest Co 0238 with 17.71 t/ha CCS yield and 132.45 t/ha cane yield, was the best standard, whereas Co 14034 with 19.02 t/ha CCS yield and 139.43 t/ha cane yield was the promising test entry. For pol% also, Co 14034 (19.39%) had numerically higher performance as compare to Co 0238 (19.12%).

AVT Early Ratoon: The experiment was evaluated for various cane yield and juice quality parameters at harvest (9th month of crop stage). Co 0238 was the best standard for SCW (1.32 kg), sucrose content (19.79%), CCS% (13.8), cane yield (115.43 t/ha) and CCS yield (15.89 t/ha). Test entry Co 14034 was on par with Co 0238 for SCW (1.44 kg), sucrose% (20.03%), CCS% (14.15), Cane yield (117.84 t/ha) and CCS yield (16.68 t/ha).

IVT Midlate: The experiment consisting seven test entries and three standards was evaluated for various cane yield and juice quality traits. At harvest, CoPant 97222 (17.38 t/ha) was the best standard for sugar yield. Test entries CoS 16232 (18.34 t/ha), Co 16030 (18.02 t/ha) and CoS 16233 (17.4 t/ha) found promising over it. Co 05011 (129.16 t/ha), was the best standard for cane yield and test entries viz., CoS 16232 (134.7 t/ha), Co 16030 (131.95 t/ha), CoPant 16223 (126.59 t/ha), CoS 16233 (124.73 t/ha) and CoLk 16204 (114.06 t/ha) performed at par with it. At harvest (12 month) CoS 16233 with 19.87% pol in juice was the best test entry, as compare to best standard CoPant 97222 (19.05%) it was statistically superior. Co 16030 (19.47%) and CoS 16232 (19.33%) were the other promising test entries.

Breeding (2020-21)

IVT (Early): The experiment consisting seven test entries and three standards was evaluated for cane yield and juice quality traits. At 240 days, for NMC (000/ha), test entries CoLk 17203 (131.17) performed better whereas CoS 17231 (105.09) and CoLk 17201 (97.38) had on par performance with it. During 8th month, the overall mean of the trial for sucrose% in juice recorded was 15.53% and CoJ 64 (18.39%) was best among the standards and none of the clones were even at par with it.

AVT (Early) IPlant: In AVT I P (early), CoJ 64 (107.95 thousands) was the best standard for NMC; entries CoLk 16202 (104.78), CoLk 16201 (99.31) & Co 15025 (95.29) were on par with it. The overall mean of the trial for pol% in juice at 8th month was 16.94%. CoJ 64 (17.34%) was the best standards and entries Co 15025 (17.94%), Co 16029 (17.63%) and CoLk 16202 (17.46%) had on par performance with it.

AVT (Early) II Plant: NMC (000/ha), of test entry CoLk 15205 (113.04) was higher over best standard CoJ 64 (102.31). At 8 month of crop stage CoJ 64 (18.15) was the best standard for sucrose%; test entries Co 15023 (20.29) and CoLk 15205 (18.95) performed better over it.

AVT (Early) Ratoon: The experiment was evaluated for cane yield and juice quality traits at harvest (9 month). The average cane yield of the experiment was 117.8 t/ha. Co 0238 with 124.24 t/ha cane yield was the best standard. Test entries Co 15027 (139.92 t/ha) and Co 15023 (133.07 t/ha) performed better over it. For sucrose% Co 0238 (19.29) was the best standard, and test entries Co 15023 (20.09) and CoLk 15205 (19.83) had better performance whereas Co 15027 (18.50%) performed at par with Co 0238.

AVT (Midlate) IP: The, experiment was evaluated for NMC population (000/ha). Co 05011 (103.55 thousands) was the best standard for NMC, test entry CoLk 16204 (122.61) was superior, whereas CoS 16232 (106.71), CoLk 16203 (106.1) and Co 16030 (102.78) had on par performance with it.

(Ravinder Kumar and M.R. Meena)

Identification of pathotypes /races of red rot pathogen

Fourteen red rot isolates comprising seven reference pathotypes and seven isolates collected from Co 0238 (4), Co 89003(1), CoS 8436(1) and CoLk 94184(1) were inoculated independently on a set of twenty one 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, Co 86032, CoC 671, Co 7805 and SES 594 by plug method of inoculation. The overall disease reactions indicated that there was a clear pathogenic variation on test host differentials. The pathogenic reaction on differential hosts shown that reference pathotype CF11 found to be most virulent followed by CF01, CF02, CF08, CF07, CF09 and CF03. The four new isolates collected from variety Co 0238 (UP) expressed susceptibility on eight to ten

host differentials. Isolate Cf8436 (Karnal) caused susceptibility on the differential CoS 8436 with intermediate to susceptible reactions, whereas, isolate Cf89003 (Co 89003) was too virulent and showed susceptible reactions on 12 host differentials, suggests the possible emergence of new pathotype in the subtropics. Further, isolate CfLk94184 of variety CoLk 94184(UP) was also showed susceptibility to eight host differentials. The host differential SES 594 exhibited complete resistance to all the isolates (Table 31).

(B. Parameswari and M.L. Chhabra)

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

Red rot incidence was observed up to 30.0% in samples of variety Co 89003 of five sugar mills viz. Assandh, Sonipat, Gohana (Haryana), Khatauli and Bajaj Hindustan Sugar Ltd. Bhaisana (UP) and trace incidence on variety CoJ 85 in Shahabad area. Mild to severe incidence of pokkah boeng was reported by many sugar mills on cultivated varieties in the zone. Trace incidence of smut was found in variety CoH 160 and Co 0238 in Karnal area, whereas, wilt by traces to 10.0% in diseased samples of variety CoH 160 from village Dhakwala Rodan (Karnal), Sonipat and Gohana (Haryana) and Bhaisana (UP). SCBV incidence (1 to 5%) was also noticed in CoPb 17213, CoPant 17221, CoLk 16202, CoLk 15201, CoS 16233, CoPb 17212 and CoLk 16202 entries in ZVT trial.

(M.L. Chhabra and B. Parameswari)

Evaluation of IET/Zonal varieties for resistance to red rot

Forty five IVT entries along with eight standard varieties were evaluated for red rot resistance by plug and cotton swab methods of inoculation with CF08 and CF09 isolates. One IVT(E) entry CoPb17212 and two IVT(ML) entries CoPant 17224 and CoS 17237 expressed susceptibility with CF08 and CF09 pathotypes by both plug and cotton swab methods. Five entries viz. CoPant 17221, CoLk 15201, CoPb 15212, CoPb 17214 and CoS 17234 showed moderately susceptible reaction with Cf08 and Cf09 pathotypes by plug method only. However, remaining entries exhibited resistant or moderately resistant reactions with both the inocula and methods (Table 6). Trace incidence of wilt was also recorded in three entries namely CoPb 17211, CoPb 17214 and CoS 17231.

(M.L. Chhabra)

Yellow Leaf Disease (YLD)

Natural incidence of yellow leaf disease (YLD) was recorded in 53 entries planted in the zonal varietal trial based on the YLD severity (0-5) scale. Among the different IVT and AVT clones screened, 26 were apparently free from the yellow leaf disease symptoms and probably resistance to YLD. Fourteen clones exhibited moderately resistant (MR) reaction, whereas eleven clones showed moderately susceptible (MR) reaction. Two IVT (ML) clones viz. CoPb 17214 and CoS 17233 expressed severity scores >3 and shown susceptible reaction to YLD.

(B. Parameswari and M.L. Chhabra)

Evaluation of zonal varieties for their reaction against major insect pests

AVT Ratoon: A total of thirteen genotypes along with two check varieties were evaluated against major insect pests namely; black bug (BB), early shoot borer (ESB), top borer (TB), root borer (RB) and stalk borer (SB). Early shoot borer and top borer incidence ranged from 0.0 to 2.0 and 0.3 to 2.6 per cent, respectively. Black bug population varied from 1.1 to 2.4 bugs/leaf. Hence all the 13 genotypes; Co 15023, Co 15024, Co 15027, CoLk 15201, CoLk 15205, CoPb 15212, Co 15026, CoLk 15206, CoLk 15207, CoLk 15209, CoPb 15213, CoS 15232 and CoS 15233 showed least susceptible (LS) reaction to BB (<25.0 individual/20 leaves), ESB (<15.0%) and top borer (<10.0%). Root borer incidence varied from 16.1 to 34.0 per cent. Eleven genotypes; Co 15023,Co 15024,Co 15027,CoLk 15201,CoLk 15205,CoPb 15212,Co 15026,CoLk 15206,CoLk 15207,CoLk 15209 and CoPb 15213 were moderately susceptible (15.1 to 30 %) whereas, Two genotypes (CoS 15232 and CoS 15233) were Highly susceptible (>30) to root borer. Stalk borer incidence ranged from 2.0-16.0 per cent and infestation index varied from 0.2 to 1.7. All the eleven genotypes were least susceptible (infestation index < 2.0) to stalk borer.

Table 31. 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	C0 1148	S	R	S	S	S	S	R	I	R	S	S	R	I	R	S	S	I	R	S	I	R
CF02	Co 7717	I	R	S	S	S	S	I	I	I	S	S	R	R	R	S	R	R	I	S	R	R
CF03	CoJ 64	R	R	S	S	R	R	R	R	R	S	R	R	R	R	S	R	R	R	S	R	R
CF07	CoJ 64	R	R	S	R	R	I	R	R	R	S	R	R	R	R	S	S	R	R	S	S	R
CF08	CoJ 64	R	R	S	S	R	S	R	R	R	S	R	R	R	R	S	I	R	R	I	S	R
CF09	CoS 767	R	R	I	I	I	R	R	R	I	R	R	R	R	R	S	R	R	R	S	S	R
CF11	CoJ 64	R	S	S	R	S	S	S	I	I	S	S	R	R	R	S	I	I	S	S	I	R
Co 0238(LK)	Co 0238	S	S	S	R	R	S	R	R	R	I	R	R	R	R	R	R	R	S	S	S	R
Co 0238 (Afjalgarh)	Co 0238	S	I	S	R	I	S	I	I	R	R	R	R	R	R	R	R	R	S	S	R	R
Co 0238 (Ajbapur	Co 0238	S	S	S	R	I	S	I	I	R	S	R	R	R	R	I	R	R	S	S	S	R
Co 0238 (Faridpur)	Co 0238	S	R	S	R	R	S	R	R	R	R	R	R	R	R	R	I	R	S	S	R	R
Cf89003	Co 89003	S	S	S	R	R	S	R	R	S	R	S	R	R	S	S	R	R	S	S	S	R
Cf8436 (Karnal)	CoS 8436	S	I	R	R	R	I	R	R	I	S	S	R	R	S	S	R	R	R	S	S	R
CfLk 94184	CoLk 94184	I	R	R	I	R	S	R	R	R	S	I	R	R	R	R	R	R	R	S	S	R

R-Resistant; X- Intermediate; S- Susceptible

AVT I plant: A total of ten genotypes along with two check varieties were evaluated against early shoot borer (ESB), top borer (TB). Early shoot borer and top borer incidence ranged from 0.0 to 1.5 and 0.3 to 2.7 per cent, respectively. All the 10 genotypes viz. Co 15025, Co 16029, CoLk 16201, CoLk 16202, CoPb 16181, CoLk 16203, CoLk 16204, CoS 16232, CoS 16233 and Co 16030 were showed least susceptible reaction to early shoot borer and top borer.

AVT II Plant: A total of thirteen genotypes along with two check varieties were evaluated against early shoot borer (ESB), top borer (TB). Early shoot borer and top borer incidence ranged from 0.0 to 1.9 and 0.2 to 1.8 per cent, respectively. All the test genotypes namely CoPb 15213, CoLk 15209, CoLk 15207, CoS 15232, CoS 15233, Co15023, Co 15024, Co 15027, CoLk 15201, CoLk 15206, Co 15026, CoLk 15205 and CoPb 15212 showed least susceptible reaction to ESB and top borer.

Survey and surveillance of sugarcane insect- pests

To identify the key insect pests' of sugarcane under North Western Zone, insect pests' survey could not be carried out due to Covid19. Some of the information gathered telephonically. Incidence of top borer 3rd and 4th brood was traces to 44.0 and 80.0 per cent, respectively. Pink borer incidence was traces to 17.5 per cent. Black bug incidence was traces to 07 and 24 black bug/leaf in plant and ratoon crops, respectively. Grasshopper and pyrilla incidence was recorded in traces. Blister mite incidence varied from traces to 80.0 per cent in leaf sheaths. Incidence of web mite was in some of the field up to 60.0%. Received feedback from the farmers as well cane development personnel that the efficacy of Chlorantraniliprole was found not effective in controlling top borer satisfactory as earlier.

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 bio agents of sugarcane at regular interval. The cumulative incidence of early shoot borer and top borer varied from 2.3 to 4.3 and 5.7 to 7.9 % respectively. Pink borer incidence was 7.3 per cent. Incidence of root borer and stalk borer was 23.5 and 24.3 per cent respectively. Termite and pyrilla incidence was in traces. The mean population of black bug was 2.0/leaf. Parasitization of top borer larvae *was* 2.0 per cent by *Isotima javensis*.

(S.K. Pandey)

Genotypic behavior of sugarcane under moisture stress in sub-tropical India

Evaluation of plant crop of Co clones under moisture stress conditions: An experiment was conducted to study the effect of drought stress in plant crop of ten Co-canes namely Co 98014, Co 0118, Co 0124, Co 0238, Co 05011, Co 07023, Co 11027, Co 12029, Co 15023 and Co 15027 during crop season of 2019-20. Drought stress was imposed during formative phase of the crop by withholding irrigation and later on i.e. post monsoon period (from July, 2019) crop was irrigated for stress revival as per the requirement.

Effect of drought stress on quality parameters, yield and yield attributing traits: Mean single cane weight (SCW) reduced by 31.78% under drought stress as compared to normal irrigated control. In Co 98014 (22.86%), Co 05011 (23.68%), Co 07023 (27.12%), Co 0118 (27.94%), Co 12029 (27.97%), Co 0238 (28.28%) and Co 15023 (28.69%) reduction in SCW was less than the average reduction. Co 15027 and Co 0238 had highest SCW of 1.74 and 1.45 Kg and 1.13 and 1.04 kg both under control and water stress conditions, respectively. Drought stress reduced number of millable canes (NMC) by 24.34% as compared to control. Co 98014, Co 05011, Co 12029, Co 0238 and Co 15023 had higher NMC (000/ha) than mean value (79.98) under water stress (Table 7). Cane length (cm) reduced with a range of 15.79% (Co 0238) – to 36.38% (Co 0124) and maximum cane length was recorded in Co 98014 (290 & 202cm) followed by Co 11027 (273 & 184 cm), Co 07023 (269 & 209 cm), Co 12029 (265 & 202cm) and Co 0238 (247 & 208 cm) under control and water stress conditions, respectively. Statistical non-significant effect of drought stress was noticed for cane diameter but numerically cane diameter increased under

water stress. Mean cane diameter was increased by 6.26% under water stress condition (27.21 mm) in comparison to control (25.64 mm). Cane yield reduced by 48.10% under drought stress treatment as compared to control. Co 0238, Co 05011, Co 12029, Co 98014 and Co 15023 had higher cane yield both under control as wellas drought stress conditions (Table 32). Under juice quality parameters overall experimental average of pol% was 18.50% at 10th month and no significant difference was recorded in normal irrigated and drought stress treatments. Clones, Co 15023 (21.16), Co 0118 (19.97), Co 0238 (19.21), produced significantly higher sucrose over the experimental average.

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 condition in two row plots of 6m length x 0.9 m row to row spacing at ICAR- SBI-RC, Karnal. (Co-nodal centre for testing of sub-tropical sugarcane varieties). 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 were further verified /re-characterized and the database of all the verified DUS reference varieties will be submitted to the PPV&FR Authority Digital photographs of these clones depicting major morphological features were taken during 240 DAP.

Cane yield and quality traits: The experiment consisting 167 entries was evaluated cane yield and quality traits in augmented block design at harvest stage. The mean pol% in juice recorded was 18.23% and clones Co 15023 (21.75%), Co 0118 (20.8%), CoSe 01424 (20.63%), Co 0238 (20.6%), CoPant 84211 (20.51%), Co 14034 (20.20%), Co 1148 (20.2%) and Co 12029 (20.0%) were top raking and 27 reference clones shoed more than >19.5% pol% in juice at 12th month crop stage (crop season 2019-20). For cane yield,

Table 32. Effect of water stress on and NMC and cane yield

Traits/Treatments / Co-clones Control	NMC (000/ha)		Cane yield(t ha^{-1})	
	Drought	Control	Drought	Control
Co 98014	116.9	98.6	123.1	79.8
Co 0118	106.1	72.6	144.0	70.9
Co 0124	115.5	87.3	139.2	51.5
Co 0238	107.6	88.3	155.7	91.9
Co 05011	122.4	98.3	138.9	85.5
Co 07023	90.7	64.5	106.7	55.5
Co 11027	84.9	56.5	113.2	46.0
Co 12029	126.1	92.1	149.2	78.7
Co 15023	100.9	82.9	122.7	71.8
Co 15027	86.8	58.7	150.7	66.1
General Mean	**105.8**	**79.9**	**134.3**	**69.8**
SD @ 5 % Co-clones (C) Treatment (T) C× T	2.08 8.75 11.91		4.90 9.32 13.39	

(Pooja and Ravinder Kumar)

Co 0118 (177.8 t/ha), CoPb 9181 (166.6 t/ha), CoPant 97222 (152.33 t/ha), Co 0238 (148.14 t/ha), Co 15027 (143.11 t/ha), CoBln 9102 (134.65 t/ha) were top ranking clones and 23 clones had > 100 t/ha cane yield at harvest. NMC at 240 days after planting was recorded from 2020-21 season trial. The overall mean number of millable canes (NMC) estimated was 1.0 lakh/ ha and top raking clones for number of millable canes were CoS 797 (1.48 lakh/ha), BO 129 (1.44 lakh/ha), BO 147 (1.34 lakh/ha), BO 99 (1.31 lakh/ha), CoSe 96436 (1.31 lakh/ha), and CoPant 97222 (1.29 lakh/ha).

DUS testing of candidate variety: The single budded setts of candidate variety Co 12029 along with reference varieties were raised in portray and 30days old settling of candidate variety Co 12029 along with reference variety (Co 05011 and CoS 97264) were field transplanted in randomized block design with two replications. The plot size of 6 m length x 4 rows x 0.9m row to row spacing was maintained. DUS descriptors were recorded from the candidate and reference varieties at 240 DAP and remaining descriptors will be verified at 300 and 360 DAP.

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

ICAR seed project – Seed production in agricultural crops and fisheries – sugarcane

During the crop year 2019-20, a total of 34301.71 quintals seed cane of varieties Co 0118, Co 0238, and Co 12029 was supplied. From the sale of seed revenue worth Rs 21, 91, 387/- was generated.

On farm seed production: A total of 3267.16 quintals of breeder seed was produced and sold.

Farmer's participatory seed production: A total of 31034.55 quintals of quality sugarcane seed from seed farmer's field was supplied to various stake holders.

Settling production and sale: A total of 180,240 settlings of varieties Co 0118, Co 0238, Co 12029 were produced and sold to various stakeholders.

Fungicide treated single budded setts: A total of 19075 single bud setts were detached using QSSBC and treated with fungicide (Carbendazim) using STD were sold to various stake holders.

Royalty from the sale of QSSBC: The licensing rights of Quatro Sugarcane Single Sett Cutter (QSSSC) machine was given to M/s Hanzra Engg Works, vill- Bansa, Karnal. A royalty of Rs 40,000/- @8.0 was received from the firm. During the year the firm manufactured and sold nearly 30 QSSBC machines.

Promotion of quality seed production technologies: For the promotion of quality seed production activities in the region the settling transplanting activity using tractor drawn two row settling planter was demonstrated to the farmers and sugar mill personals of the region. Trainings on Settling Transplanting Techniques were organized for Saraswati Sugar Mill, Yamunanagar, Haryana, Balrampur Sugar Mill Group UP, DCM Shiram Sugar unit Ajbapur, UP, Karnal Cooperative Sugar Mill, Karnal, Haryana at the Centre.

To promote STT, the entire area under sugarcane seed crop at ICAR-SBIRC, Karnal was transplanted with the settlings of varieties Co 0118, Co 0238, Co 12029 and Co 13035 using settling transplanter.

MoU for healthy seed production: For the production of quality seed material using STT, the MoU were signed between Director, ICAR-SBI, Coimbatore and following sugar mills/ groups (Table 33).

Autumn season 2020

On farm seed production: A total of 751.47 quintals of breeder seed worth Rs. 2,55,500/- was produced and sold to the various stakeholders.

On farm Settling production: A total of 1,23,145 settlings were produced at on farm out of which 25000 were self-utilized for transplanting 4 acres of breeder seed crop, while rest were sold to various stakeholders mainly mills of Sugarfed, Haryana

FPSP seed production: During the quarter a total of 9324.22 quintals worth Rs 31,70,233/-was produced and sold to various stakeholders from FPSP farmers field.

FPSP settling production: A total of 84,250 settlings were produced and sold to various stakeholders of Haryana state.

(Ravinder Kumar)

Table 33. MOU Signed with different sugar mills and ICAR - SBI for quality sead production

Name of Firm	Date	Place
M/s Uttam Sugar Mill, unit Barkatpur	13.01.2020	ICAR-SBIRC, Karnal
M/s Rana Sugar Mill, unit Butter Seviyan, Amritsar, Punjab	13.01.2020	ICAR-SBIRC, Karnal
M/s Superior Food Grains Pvt Ltd, Unn, Shamli, UP	13.01.2020	ICAR-SBIRC, Karnal
M/s Rana Ranjeet Singh Seed Farm, Bikrampur, Bazpur, Uttrakhand	13.01.2020	ICAR-SBIRC, Karnal
M/s Haryana Sugar Federation, Panchkula, Haryana (10 units)	18.03.2020	ICAR-SBI, Coimbatore
M/s DCM Shriram Sugar Ltd (4 units)	22.01.2020	ICAR-SBI, Coimbatore
M/s Punjab Sugar Federation, Mohali, Punjab (9 units)	03.08.2020	ICAR-SBI, Coimbatore
Ms Mawana Sugar Mills, Naglamal, Meerut, UP	20.10.2020	ICAR-SBI, Coimbatore
M/s BCML, Kumbhi Chini Mill, Kumbhi, UP	26.11.2020	ICAR-SBI, Coimbatore
Ms BCML, Gularia Chini Mill, Gularia, UP	26.11.2020	ICAR-SBI, Coimbatore

Healthy seed production and mechanization of sugarcane agriculture - A farmer's participatory initiative (RKVY Haryana)

A total of 15,000 quintals of healthy seed of sugarcane varieties Co 0238 and Co 0118 was produced under participatory mode at farmers field and the visiting farmers were advised for purchasing the healthy seed from these farmers field.

Nearly 10 farmer ICAR-SBIRC, Karnal trained & motivated entrepreneurs produced around 8, 80,000 settlings and which were either self-utilized or supplied to other fellow farmers for planting in nearly 110 acres of area. Cane staff of all the Cooperative sugar mills of Haryana were trained for settling transplanting technology.

The farmers of the Karnal region were allowed to use implements purchased under RKVY viz., Reverse rotary Rotavator, Sugarcane Trash Mulcher, Ratoon management device and two tyne reversible MB plough towards management of sugarcane trash, ratoon crop etc. The farmers of the state were promoted to adopt wider spaced planting along with intercropping during autumn and spring seasons.

At ICAR-SBI Regional Centre, Karnal variety Co 0238 and Co 0118 replaced with 100% tissue culture virus indexed material. Nearly 2000 quintals of high quality breeder seed of varieties Co 0118, Co 0238 and Co 12029 and nearly 35,000 settlings of these varieties was supplied to the various sugarcane farmers and sugar mills of Haryana state for production of healthy seed.

Quatro Sugarcane Single Bud Cutters (11 Nos) were purchased and in the presence of MD, Sugarfed, Haryana were distributed to all the cooperative sugar mills of the state. The seed plots at all the Co-operative sugar mills and farmers field were monitored. Necessary crop management practices were suggested to them for raising healthy crop.

Autumn season 2020

Seed supply: A total of 630.78 quintals of breeder seed of varieties Co 0118 (271.45 quintals), Co 13035 (2.4 quintals) & Co 15023 (332.98 quintals) was supplied to 21 stakeholders of Haryana.

Settlings sale: A total of 180,645 settlings of varieties Co 0118 (55,361) and Co 15023 (125,284) were supplied to 61 stakeholders of Haryana.

Utilizing the plant growth chamber installed under RKVY seed project, nearly 70000 settlings of variety Co 15023 were raised and shifted in the mist chamber and poly tunnels. The temperature and relative humidity of Plant Growth Chamber for settling raising was standardized at 30^{0}C and 90%, respectively. At these conditions the germination happened within 72 hrs and the settlings attained ready to transplanting

stage within 7-8 days. It was observed that the sett roots showed negative geotropism under darkness whereas positive geotropism under light condition in the plant growth chamber.

(Ravinder Kumar, M.R. Meena, M.L. Chhabra, S.K. Pandey, B. Parameswari and Pooja)

Sugarcane breeder seed production and demonstration of intercropping (NFSM-CC)

During 2019-20 crop season 120.8 quintals of cane seed, 1,13,500 settlings and 10200 treated single budded setts were utilized for on farm and off farm production of breeder seed crop. Various intercrops viz., wheat, mustard, chickpea, seasonal vegetables, papaya, banana, onion, garlic etc were promoted in breeder seed production. Around 12000 quintals of high quality breeder seed was produced at on farm and off farm, which was utilized for planting new seed crop, sold to the sugar mills and fellow farmers of the region. As a result, seed health of the region has improved. The farmers were advised to take various intercrops viz., chickpea, carrot, garlic, raddish, wheat, mustard, cabbage, potato etc. in autumn planted seed crop. The seed fields of village Kahangarh, Khudda Kalan, Kharkali, Barsalu, Budhanpur, Titavi, Santri, Rindal and Bal Pawana were monitored.

(Ravinder Kumar and M.R. Meena)

Unraveling the molecular mechanismof early maturing responsive genes in sugarcane through transcriptome analysis

Experiment of season 2019-20: The experiment was evaluated for juice quality at 10th and 12th month crop stage and the mean value for pol% in juice of the trial recorded was 19.98% and 20.89%, respectively. The highest pol% in juice recorded in early clones Co 15023 was 21.16% at 10th month and 21.67% at 12th month. Whereas, midlate entry Co 0124 had 18.89% and 19.4% pol in juice at 10 and 12th month stage.

New experiment of season 2020-21: The experiment was laid out in a randomized block design with four replications. The crop growth parameters were recorded at different intervals of the crop. The mean germination at 30 DAP in the early clone Co 15023 and midlate entry Co 0124 was 37.2% and 35.5%, respectively. Whereas, germination percent at 45 DAP in Co 15023 and Co 0124 was 44.31% and 42.34% respectively. The plant height at 60 days after planting (DAP) in Co 15023 and Co 0124 was 24.67cm, 17.76 cm respectively, whereas, it was 65.5 cm, 44.58 cm respectively in Co 15023 and Co 0124 at 90 days after planting. At 120 DAP, cane height in Co 15023 and Co 0124 recorded was 151.25 cm, 115.25 cm respectively. Canopy coverage in early maturing clone Co 15023 was 43.47 % whereas, it was 32.44% in midlate entry Co 0124. Leaf area was recorded by Li-cor leaf area meter and LAI was estimated per unit area. Leaf area index (LAI) in early clone Co 15023 was 2.85 as compared to 1.39 in midlate variety Co 0124. At 90 days, Co 15023 had 42.12 spad value for chlorophyll content as compared to spad value of 37.36 in Co 0124. Similarly, at 120 days, Co 15023 had 44.37 SPAD value, whereas, midlate maturing entry had 47.82 spad value. Tillers count at 60 DAP in Co 15023 (97.19/row) and Co 0124 (78.5/row), at 90 DAP in Co 15023 (2.19 lakhs/ha) and Co 0124 (2.42 lakhs/ha), at 120 DAP in Co 15023 and Co 0124 recorded were 1.52 lakh/ha, 1.72 lakh/ha tillers population respectively. The crop growth rate was estimated by following formula of Watson (1952) and work out in gm per m^2 day^{-1}. The crop growth rate (CGR) between 60 DAP & 90 DAP in early clones Co 15023 was 21 gm/m^2 day^{-1} whereas it was 19 gm/m^2 day^{-1} Similarly, CGR between 90 DAP & 120 DAP in Co 15023 was higher (72 gm/m^2 day^{-1}) than Co 0124 (64 gm/m^2 day^{-1}). The mean cane height at 8th month crop in Co 15023 was 226 cm whereas, it was 188 cm in Co 0124. Single cane weight and cane dia in Co 15023 (1.27kg; 2.7cm) recorded was higher than the Co 0124 (0.9kg; 2.4cm). HR Brix was recorded at 7th month crop stage and early clones Co 15023 (21.44%) had higher HR brix level than that of Co 0124 (17.70%). At 8th month juice analysis, early clone Co 15023 (20.75%) had higher pol% in juice as compared to the midlate maturing variety Co 0124 (18.46%). Leaves and stem samples of early maturing clones Co 15023 and midlate maturing variety Co 0124 were collected at 8th month crop stage with three biological replicate and total RNA was isolated from Trizol method. Sample purification and

QC check was done using Agilent Bio-Analyzer and samples with RIN value more than 7 will be used for library preparation using Tru-seq RNA sample preparation kit.

(M.R. Meena)

Physiological approaches for winter ratooning management in Sugarcane under subtropical conditions (RKVY, Haryana)

Evaluation of effect of exogenous application of ethrel on winter sprouting in sugarcane stubble: Different doses of ethrel i.e. 100, 200, 500 and 1000 ppm, were applied as foliar spray on stubbles of three varieties *i.e.* Co 0118, C0 0238 and Co 05011 during second fortnight of December, 2020 to analyze their effect on winter sprouting. Same treatments were applied at farmer's field (Tilak Raj, Village Bada Gaoun, Distt. Karnal). After 50 days of treatment (DAT) non-significant effect of different concentration of etheral was recorded in enhancement of winter sprouting in stubbles as compared to control. At 50 days after treatment, 0.289, 0.291, 0.260, 0.269 and 0.306 shoot/clump were recorded in control, 100, 200, 500 and 1000 ppm ethrel treatment, respectively.

Evaluation of effect of ethrel on germination during winter: Single budded setts of three varieties viz. Co 0118, C0 0238 and Co 05011 were soaked overnight with ethrel solution @ 100, 200, 500 and 1000 ppm and planted in cavity trays during first fortnight of January. Germination (%), morphological and physico-chemical parameters were recorded. Ethrel treatment of 200 and 500 ppm showed significantly higher germination as compared to untreated control and other treatment up to second fortnight of February (Fig. 124). Among all the treatments,

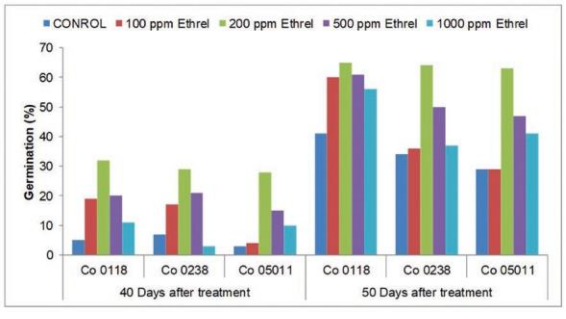


Fig. 124. Effect of ethrel traetment on germination percent

maximum reducing sugar and acid invertase activity was recorded in 200 and 500 ppm etheral treated buds in Co 0238, Co 05011 and Co 0118. Sett treatment with 200 and 500 ppm ethrel increased reducing sugar content up to 43.33% and 52%, respectively as compared to control value (1.50 mg/g FW). Acid invertase activity increased from 0.11 (µmol/mg of proteins/min) to 0.38 and 0.44 (µmol/mg of proteins/min).

Distribution of soil health card: Soil health card (39 No.) were distributed to farmers of District Karnal villages i.e. Rindel, Landera, Bada Gaon, Budhanpur, Mahmadpur, Gagseena and Makhu Majra.

(Pooja and Ravinder Kumar)

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 was conducted with fourteen WL 16 series clones and Co 86032, Co 62175 and Co 99006 as standards in three replications of two rows (10 feet each). The traits studied include 30th day germination count, 90th day tiller count, NMC, HR brix of top, middle and bottom of the cane at 8th month, cane thickness, cane length, SCW, juice extraction %, brix% at 11th month and sucrose % at 11th month. Yield and CCS yield per plot were calculated. The genotypic differences among the clones were significant at 5 % level for all the traits except for the Juice Extraction %. Highest NMC was recorded for Co 62175 (62) and lowest for WL 16-410 (30). The clones *viz.*, WL 16-457, WL 16-75, WL 16-416, WL 16-498, WL 16-475 and WL 16-469 along with check variety Co 62175 formed the homogenous subset for higher NMC. HR brix middle at 8th month of the clones ranged from 17.2 to 23.4 %. The clone WL 16-785 had the highest % HR brix at 8th month. HR brix at 8th month of WL 16-245, WL 16-209,Co 86032, WL 16-498, WL 16-410, WL 16-271, WL 16-463 and WL 16-785 were not significantly different

and thy formed the top performing group for HR brix. Cane length ranged from 199 cm (WL 16-245) to 257 cm (WL 16-462). Cane thickness of nine clones including standards Co 99006 and Co 86032 were below 2.5 cm. Eight clones including the standard Co 62175 had thickness above 2.5 cm. Clone WL 16-498 had thickness of 2.7cm. SCW ranged from 0.8 to 1.3 kg. The clones WL 16-462,WL 16-410, WL 16-498,WL 16-469,WL 16-785,WL 16- having high SCW mainly contributed by cane thickness and cane length. The juice extraction % of the clones ranged from 32.4 % (WL 16-475) to 48.5% (WL 16-271). The Brix % at 11th month ranged from 15.3 (WL16-469) to 21.3 (WL 16-463). The sucrose % at 11th month ranged from 12.5 (WL16-469) to 20.1(WL 16-463). The high brix clones were WL 16-271, WL 16-498, WL 16-209, Co 99006 and WL 16-463. Among the high brix clones WL 16-498 and WL 16-463 topped for sucrose % and they can be utilised as source of high sucrose. The cane yield ranged from 34.1 kg to 70.5 kg. The high yielding clones were WL-16-475, WL-16-457, WL-16-498 and WL-16-469. The CCS yield per plot of the clones ranged from 3.9 (WL 16-435) to 8.4 (WL 16-498). The clones WL-16-457 and WL-16-498 with significantly higher CCS yield per plot were identified for PZVT.

In the second clonal trial 35, WL 17 series clones and two standard varieties (Co 62175 and Co 86032) were evaluated for various yield and quality traits. Clones showed significant difference for all the trait analysed except the juice extraction %. NMC ranged from 9 (WL 17-940) to 37 (WL 17-1427). The clone WL 17-785 had the highest HR brix 24.3 % at 8th month and Co 62175 had the lowest brix % of 18.1%. The cane length varied from 153 to 261 cm and cane thickness varied from 1.6 to 2.7 cm. The SCW for the clone WL 17-1161 was 0.5kg and for the clone WL 17-1344 was 1.1 kg. Both standards had SCW more than that of test entries. The brix at 11th month was lowest for Co 62175 (16.2%) and was highest for WL 17-691 and WL 17-1040 (22.6%). The clones WL 17-806, WL 17-1828, WL 17-760, WL 17-1460, WL 17-823, WL 17-1434, WL 17-1366, WL 17-1804, WL 17-1040 and WL 17-691 were the top performing group with more than 20.5 % brix at 11th month . The sucrose content ranged from 14.2% (Co 62175) to 21.8% (WL 17-1040). The high sucrose clones include WL 17-806, WL 17-1460, WL 17-1434, WL 17-691, WL 17-1804, WL 17-1040 with more that 20% sucrose. The yield ranged from 6.6 (WL 17-940) to 41.8 kg (Co 62175). The clones WL 17-884, WL 17-720, WL 17-1427, WL 17-1434 and WL 17-1344 had numerically higher CCS yield per plot compared to the standard Co 62175. Based on the performance 15 clones were selected for final evaluation trial.

In the first clonal trial 95 clones of WL 18 series were evaluated for NMC, Cane thickness and HR brix % (Top, middle and bottom). The NMC ranged from 1 to 30. The highest NMC was recorded for the clone WL 18-689. The cane thickness ranged from 1 to 2.5cm. The HR brix ranged from 17.8 to 23.5 (WL 18-596) with an average of 20.8. Based on the overall performance 35 clones were advanced to the second clonal trial.

Thousand two hundred and seventy progenies from 12 crosses were evaluated for NMC, cane thickness and HR Brix at 8th month. The NMC ranged from 1-11, thickness 0.8 to 3.3cm and HR brix from 10 to 25.4. Progenies of WL 15-1179 x WL13-456 were having high brix (>20%) and were thick canes. From the progenies, 116 were selected for first clonal trial. During the 2020-21 flowering season 16 new crosses were made using Co canes and various WL series clones.

(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 10 clones of different back cross progenies of inter specific crosses. One clone GUK 16-967 was found significant superior for CCS yield over check varieties and was resistant to red rot. Three clones GUK 16-975, GUK 16-801 and GUK 16-917were on par with the check variety Co 86032 and are moderately resistant to red rot. In GUK 16-967 and GUK 16-975 the *Erianthus arundinaceus* clone IK 76-10 was involved and

in other two Exotic hybrid clones F 49-11 and CP 89-1762 respectively was involved. These four clones were identified as genetic stock with diverse genetic background.

In the second clonal trail 21 clones were evaluated with two checks. Six clones were found promising for CCS yield. Most of the clone are form back progenies involving *S.robustum var.sanguineum*. cane yield was superior to Co 99006 in many clones but brix and pol% were much lower than both check varieties. 11 clones were advanced to final clonal trial.

Sixty one clones of various interspecific crosses were evaluated in first clonal trial for cane thickness, brix at bottom, middle and top and NMC and tillering. About 70% of the clones were having HR birx above 20% and 22 clones were selected for further evaluation. 556 seedlings form 5 crosses were evaluated in ground nursery 72 progenies were selected for further evaluation. 17 crosses incluing back crosses using diverse parental clones were attempted and fluff was harvested.

(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 is maintained in field gene bank by annual re-planting. The flowering of the clones was monitored. The flowering ranged from 6.0% (*S.officinarum* to 89.2% (IA clones). The flowering percentage of different set of clones were *S.spontaneum* (Exotic collection) 74.6%, Allied genera (IND) 67.05%, Exotic hybrids 38.7%, Allied genera (exotic collection) 34.8%. *S.robustum* 29.6%, Indian hybrids 23.9%., *S, barberi* 23.8%, *S.sinense* 10% and *S.spontaneum* (IND) 9.18%,

Characterization: Forty two clones of *S. barberi* and 30 clones of *S.sinense* were characterized for 31 morphological and yield and quality traits to understand the variability in the collection for different traits and to find duplicate collection if any by combining with molecular profiling.

(K. Chandran and M. Nisha)

Monitoring of diseases and quarantine

Diseases recorded during 2020 were ring spot, rust, smut, Pokka boeng, YLD etc. Ring spot incidence was severe with maximum disease score five in 28 NG 20, 28 NG 260, 28 NG 262 and 28 NG 285 of *S. officinarum*, Co 819 and Co 854, Q 42, Q 44, B 45-151, CP 44-154, CP 57-614, and CP 73-351 of foreign hybrids. Maximum disease score of 3 was recorded in Chin, Dhaulu of *S. barberi*. In Agaul and Archi of *S. sinense* recorded maximum disease score (4). Smut was recorded in 21 NG 21, NG 77-26 of S. officinarum, H-45369, H-39-7028 of foreign hybrids, also in 17 Indian hybrids viz., Co 464, Co 654, Co 705, Co 745, Co 792, Co 813, Co 884, Co 989, Co 1018, Co 1197, Co 1301 Co 1318, Co 1042, Co 62143, Co 62145, Co 62168, Co 62175 and IND 85-497and IND 85-522 of *S. spontaneum* and also Maneria IMP- 1552 of *S. barberi*. Rust was recorded in Sylvia, 28NG 211 of *S. officinarum*, POJ 279, Co 300, Co 302, Co 986 of hybrid clones and IND 81-20, IND 81-74, IND 81-82, and IND 81-83 clones of *S. spontaneum*. YLD symptoms was noticed in 57 NG 56, IJ 76 494 and NG 77 61 of *S. robustum*. Stalk rot was recorded in S. officinarum clones such as 57 NG 140 and 28 NG 10. Prophylactic and curative measures were undertaken using fungicides like Carbendazim (0.1%), mancozeb (0.2%) for the management of various diseases. 200 clones (28 NG 260 to 57 NG 223)of *S. officinarum* were treated with Hot water 52 ^{0}C for 30 min along with Carbendazim 0.1%. 250clones (Argentina-1 to L 61-43) of foreign hybrids were treated with Hot water 52 ^{0}C for 30 min and along with Carbendazim 0.1% in sett treatment device. Treated plants established well and the clones treated with sett treatment device showed improve growth.

(R. Gopi)

Monitoring for pests incidence, biological control of the pests

Sugarcane germplasm maintained at SBIRC, Kannur was monitored for occurrence of insects and their natural enemies. Insect pests viz., Internode borer (INB), *Chilo sacchariphagus indicus*; Pink borer, *Sesamia inferens*; Pyrilla, *Pyrilla perpusilla*; 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 during monitoring period. During the month of December, sugarcane wooly aphid *Ceratovacuna lanigera* colonies were noticed on 4 accessions of *Saccharum officinarum viz*., 28 NG 34; 28 NG 35; 28 NG 36; 28 NG 37. The spraying of soap solution was carried out along with clipping and destruction of aphid infested leaves in order to eradicate the aphid population completely from the field. INB incidence was noticed less than 5% of the accessions across all crop assemblages with percent infestation ranged from 0-10% on cane basis. In respect to symptoms of INB, mostly bore hole in top most internodes with dead heart and side shoots were observed. The soil based application of insecticide Fipronil 0.3% GR was undertaken at the time of sett planting for the management of pink borer in crop assemblages of *S. officinarum,* Hybrids of Indian and Foreign origin. Pyrilla population was effectively suppressed by natural epizootics of entomopathogenic fungi, *Hirsutella sp.* and *Metarhizium anisopliae* along with other natural enemies viz., egg parasitoid, *Parachrysocharis javensis* and nymphal parasitoid, *Dryinuspyrillae.*

(B.Mahendran)

In vitro conservation of germplasm

Around 110 *Saccharum officinarum* clones are *in vitro* cultured using shoot tip and are maintained through sub culturing.

(K. Chandran and M. Nisha)

Harnessing antagonistic microbes for the management of wilt and rot diseases in sugarcane

In the field study, sugarcane setts of Co 86032 were treated with four PGPR cultures *i.e* BC 23, PF 4, PF 60, BC 36 and bacterial consortia showed improved growth of sugarcane over control. Disease incidence was not observed on the treated plants. Among the cultures BC 36 followed by PF 60 improved the plant growth over other treatments. BC 36 @ 5% recorded maximum height (230.6 cm), girth (4.6), NMC (9) over control (height (199 cm), girth (4.1), NMC(5)) and other treatments. Clones showing stalk rot was treated with PGPR planted.

(R. Gopi and K. Nithya)

Evaluation of seasonal dynamics and biological control of sugarcane pyrilla, *Pyrilla perpusilla*, in crop island scenario

Observations recorded on population dynamics of pyrilla and its natural enemies on sugarcane germplasm across different crop assemblages from June to December 2020. Overall seasonal activity of pyrilla was less compared to previous three years. Pyrilla population abundance, comprising nymphs and adults showed a resource concentration pattern with most abundant on *S. officinarum* and hybrids of Indian and foreign origin that are in high density crop patches, and least abundant on other crop assemblages viz., *S. robustum*; *S. sinense*, *S. barberi* that are in low density patches in the ecosystem. *P. perpusilla* has shown less host preference towards other wild sugarcane, *S. spontaneum* and sugarcane allied genera. The peak population of pyrilla was recorded in the starting of the season during the month of June followed by gradual decrease in the population during the month of August-October and then population became negligible from November onwards (Fig. 125).

It is found that the survival rate of pyrilla population of the previous season would determine the current seasons' population. Since, the remarkable epizootics exhibited by entomopathogenic fungi during previous season led to very negligible population survived for the current season which were eventually suppressed by the action of egg

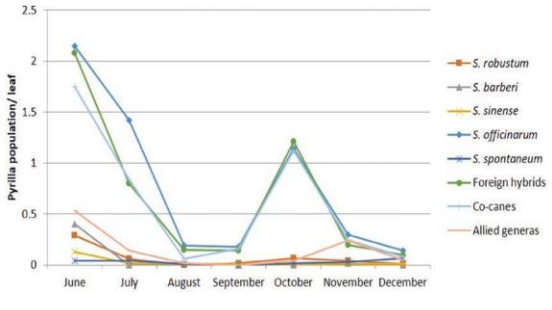


Fig. 125. Pyrilla population on different crop assemblages during cropping season 2020

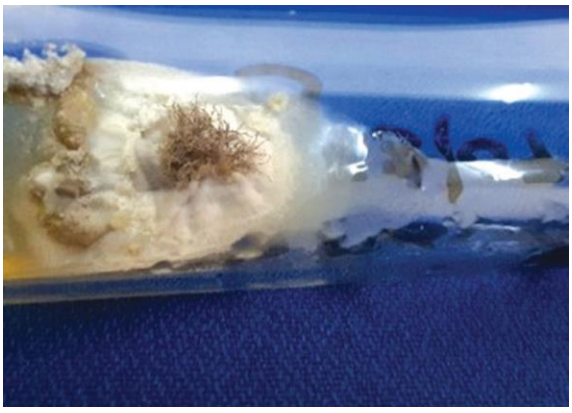


Fig. 126. Hirsutella sp.mucilaginous colony on SDAY media

parasitoid, *Parachrysocharis javensis*, nymphal parasitoid, *Dryinuspyrillae* and pathogenicity of entomopathogenic fungi, *Metarhizium anisopliae* and *Hirsutella* sp. The attempt of isolating highly fastidious entomopathogenic fungus. *Hirsutella* sp. infecting pyrilla was made at the laboratory using Sabouraud dextrose agar with 5% yeast extract (SDAY) culture media. Production of mucilaginous colonies *by Hirsutella sp.* on SDAY with numerous synnemata containing group of erect conidiophores was observed (Fig. 126).

(B. Mahendran, R. Gopi and P. Mahesh)

5.8 ICAR-SBI, RESEARCH CENTRE, AGALI

Enhancement of sugarcane germplasm and development of pre-breeding material

Germplasm maintenance, hybridization and Off-season nursery (Agali)

Germplasm maintenance: A total of 1380 germplasm including Co canes, Co allied clones, exotic clones, inter-specific and inter-generic hybrids, core collection of *Saccharum officinarum,* species clones of *S. barberi, S. sinense, S. robustum, Erianthus* spp, *Sclerostachya* and *Narenga* are clonally maintained in field.

Flowering during 2020 season: Out of 1380 germplasm, 635 accessions came to flowering in 2020. Hence, the intensity of flowering was worked out to be 46.01%, which was slightly higher than the flowering intensity (44.28%) recorded in the previous season. During 2020, nearly 65 clones of *S. officinarum* flowered, which was three times higher than previous season flowering (26). Six clones of *S. robustum,* Six in each of *S. sinense* and *S. barberi* flowered in 2020 season. Intensity of flowering in Co cane, Co allied clones and exotic clones were higher in current season in comparison to 2019 flowering season. Flowers (opening of spikelets) began from 16th Sep 2020 and lasted up to 7th Dec 2020. 57 NG 174, Monget gayam, Naz, Otaheiti, LS 89-2064, Suphan-50, Sugar doctor, White transparent, are the early flowering clones (flowered during last week of September 2020).

Hybridization: At Agali center, a total of 150 crosses were made during 2020 flowering season. This season due to nationwide Covid-19 lockdown restrictions, none of the AICRP(S) centers visited the National Distant Hybridization Facility (NDHF) at Agali center. As a contingent plan, we have effected crosses for Cuddalore, Locknow, Navsari, Pune, Padegeon, Pantnagar, Sankeshwar, and Seorahi centres as per their choice of cross combinations sent to the Director, ICAR SBI, Coimbatore. Due to unseasonal rains at Agali during December and January 2020 fluff harvesting and fluff cleaning is underway.

Ground nursery: 28 clones having >22% brix at 300 days were selected from the 564 BC3 progenies, derived crosses involving cold tolerant *S. spontaneum* (SES 114) as one of a parent, in ground nursery.

(V. Sreenivasa, R. Karuppaiyan and A. Annadurai)

DUS Testing of Sugarcane (Agali Centre)

Maintenance of reference varieties: A total of 233 reference varieties are being maintained clonally at Agali Centre.

Conduct of DUS test: DUS test for two farmers' varieties (FV) namely, Sugam Katari and Jeet Katari and one new variety, Co 09004 was conducted during 2020-21 crop season. The two FV belongs to the species *S. officinarum*. Settlings from single bud setts of these FV and its closely resembling reference varieties namely, IJ 76-317, Tahiti-3, NG 77-137, 57 NG 192 and NG 77-015 were raised in polybag during 1st week of Feb 2020. The Co-operating Centre received the new

variety, Co 09004 for DUS testing. Settlings of this variety along with its closely resembling RV namely, CoV 89101, CoN 95132, Co 7717 and zonal standards Co 86032 and CoC 671 were raised during February 2020. Forty settlings of these varieties were transplanted in the main field on 23 March 2020 (4 row /entry x 6 m x 0.90 m). Each variety was planted in two replications. Stage-specific observations are recorded from these varieties following the PPV&FRA's guidelines. Field observations indicated that the farmers' varieties Sugam Katari and Jeet Katari and new variety Co 09004 were different from existing reference varieties. Report is being prepared to submit to the PPV& FR Authority, New Delhi

Multiplication of FV: We have received two new varieties namely Co 10026 and Co 11015 during December 2020 for multiplication and conduct of DUS test at Agali Centre. These New varieties are multiplied for conduct of DUS testing during 2021-22 cropping season at Agali centre.

(R. Karuppaiyan and V. Sreenivasa)

6. EDUCATION AND TRAINING

6.1 EDUCATION - M.Phil / Ph.D.Programme

- Mr. S. Senthilkumar (Guide: Dr. P. Govindaraj) was awarded Ph.D. degree by Bharathiar University w.e.f. 7.3.2020 for the thesis entitled 'Genome-wide association mapping and comparative genomic study of QTLs for sucrose and other important agronomic traits in Saccharum hybrids'.
- Mrs. E. Karpagam (Guide: Dr. S. Alarmelu) was awarded Ph.D. degree by Bharathiar University w.e.f. 17.12.2020 for the thesis entitled 'Introgression breeding in sugarcane (Saccharum spp.).
- Mr.T.S. Sarath Padmanabhan (Guide: Dr. G. Hemaprabha) was awarded Ph.D. degree by Bharathiyar University w.e.f 17.10.2020 for the thesis entitled 'Understanding the genetic architecture of commercial gene pool and characterisation of drought responsive genes from sugarcane and an intergeneric hybrid'.

6.2 TRAINING PROGRAMS ORGANIZED

At Coimbatore

- Organized eight State level training programs on 'Scientific sugarcane cultivation' sponsored by the Department of Agriculture, Tamil Nadu under National Food Security Mission during January to March 2020 for 40 cane officials, 80 agricultural officers and 40 sugarcane growers.

- Conducted a state level one-day training sponsored by DSD, Lucknow on 'Scientific sugarcane cultivation' for 80 farmers from Coimbatore, Erode, Dharmapuri and Tirupur districts, Tamil Nadu on 27 February 2020.
- Organized 15 one-day training programs for sugarcane farmers sponsored by ATMA, State department of Agriculture, Tamil Nadu state.
- Advanced National Training Programme (ANTP 2020) on 'Recent scientific interventions and practices of sugarcane breeding, production, protection and utilization for doubling farmer's income' was organized by ICAR-Sugarcane Breeding Institute, Coimbatore and National Agriculture Development Cooperative Limited, Baramulla, Jammu and Kashmir in virtual mode during 1-21 December 2020.

At Karnal

- One-day training program cum brainstorming session on seed production and varietal planning was organized for one hundred fifty farmers, Sugar Federation Haryana officials and cane development staff of all the cooperative sugar mills of Haryana on 17 January 2020 (Fig. 127).
- Two days training program for Haryana State Agricultural Officers under NFSM during 06-07 February 2020 (Fig. 128).

Fig. 127. Participants of the training (17 January 2020)

Fig. 128.Participants of the two-days training (6-7 February 2020)

Fig. 129. Participants of the six-days training (10-15 February 2020)

Fig. 130. Participants of the two-days training (14-15 February 2020)

- Six days farmers training program on Smart Ganna Kheti funded by LBS Ganna Kisan Sansthan was organized during 10-15 February 2020 (Fig. 129).
- Two days training for the cane Development officials and Farmers of Punjab state on Feb 14-15, 2020 (Fig. 130).

6.3 INTERNATIONAL VISIT

- Dr. K. Lakshmi was awarded bioenergy award for cutting edge research (b-acer) fellowship for a period of seven months from 27.01.2020 to 21.08.2020 at University of Florida, Institute of food and Agricultural Sciences, USA.

6.4 TRAINING AND CAPACITY BUILDING

Participation in training program by officials (online)

- Dr. T. Rajula Shanthy: Training on Personality development, effective communication skills and stress management conducted by MPKVV, Rahuri during 14-18 April 2020.
- Dr. K. Hari: Workshop on Approaches of public funded research organizations in agri-technology generation and its transfer in new normal situation on 28 May 2020.
- Dr. C. Palaniswami & DR. K. Hari: MDP on Implementation of Access and Benefit sharing regulations in Agriculture Research: Awareness cum sensitization workshop during 7-10 July 2020.
- Dr. S. Alarmelu: Training programme on Stress Management during 7-10 July 2020.
- Dr. P. Malathi: Training programme on Design thinking in research project formulation and implementation during 25-29 August 2020.
- Dr. P. Murali: Webinar on IPR in Agricultural Research & Education in India during 12-28 September 2020.
- Dr. Krishnapriya: International webinar on Translating physiology into techniques for abiotic stress tolerance in crops on 09 October 2020 organised by ICAR-National Institute of Abiotic Stress Management, Baramati.
- Dr. S. Anusha: Training programme on Analysis of experimental data using SAS during 9-14 November 2020.
- Dr. H.K. Mahadevaswamy: Training programme on Analysis of experimental data using SAS for five days from 9-14 November 2020.

- Dr.V.P Sobhakumari, Dr. P Malathi & Smt R. Nirmala: Training programme on Enhancing Capacity in Preventing Sexual Harassment at the workplace conducted by V.V Giri National Labour Institute, Noida during 25-27 November 2020.
- Dr. S. Anusha, Dr. Krishnapriya, Dr. Vinu, Dr. R. Valarmathi, Dr. C. Mahadeviah, Dr. H.K. Mahadevaswamy, Dr. Sheelamary, Dr. Sreenivasa, Dr. Lakshmipathy, Dr, Elayaraja: 21 days Advanced National Training Programme on Recent scientific interventions and practices of sugarcane breeding, production, protection and utilization for doubling farmers' income during 1-21 December 2020.
- Dr. G. Hemaprabha, Dr. C. Sankaranarayanan & Dr. R. Gomathi: Training programme on Management Development Programme on Leadership Development' organized by ICAR –NAARM during 8-19 December 2020.
- Shri. S. Karuppasamy: Generic online training in Cyber security for Central Government Ministries & Departments on 16 December 2020.
- Dr. Mayalekshmi & Shri. P.P. Gireesan: Off-campus training programme on Motivation, Positive Thinking and Communication skills for Technical Officers of ICAR during 17-22 December 2020.

7. AWARDS AND RECOGNITIONS

- Dr. Bakshi Ram was conferred with Lifetime Achievement Award from Society for Sugarcane Research and Development (SSRD), Coimbatore.
- Dr. Bakshi Ram, received the Swaraj Award in the category of Agriculture Scientist by OUTLOOK for his outstanding contribution in agriculture.
- Dr. G. Hemaprabha was awarded Noel Deerr Gold Medal for the research paper presented in 77th Annual convention of STAI held during 17-19 July 2019 at Kolkata.
- Dr. Mintu Ram Meena was conferred with Young Researcher Award of Society by Sugarcane Research and Development (SSRD), Coimbatore.
- Fellow Award of Society for Sugarcane Research and Development (SSRD), Coimbatore was given to Dr. Bakshi Ram.
- Fellow Award of Society for Sugarcane Research and Development (SSRD), Coimbatore was given to Dr G. Hemaprabha.
- Fellow Award of Society for Sugarcane Research and Development (SSRD), Coimbatore was given to Dr. R. Viswanathan.
- Fellow Award of Society for Sugarcane Research and Development (SSRD), Coimbatore was given to Dr. P. Govindaraj.
- Fellowship of Agricultural Scientific Tamil Society (SciTSA) was conferred to Dr. R. Gomathi.
- First Prize in the National Water Awards-2019 for 'Soil Moisture Indicator and its application in irrigation water management' in the Best Research/ Innovation/ adaptation of New Technology for Water Conservation category by Ministry of Jal Shakti, Department of Water Resources, river development & Ganga rejuvenation, Government of India.
- Twenty-one research articles of the institute got Best Research Paper Award of SSRD for Articles published in Journal of Sugarcane Research.

Title of the Article	Year, Volume & Issue	Authors
Evaluation of sugarcane tops of co clones for fodder quality traits	2011:1(1)	Bakshi Ram, S.K. Tomar and R. Karuppaiyan
Evaluation of wild sugarcane *Erianthus arundinaceus* (Retz) Jesw. germplasm	2011:1(2)	V.Amalraj, P. Rakkiyappan and A.K. Rema Devi
Standardization of a staining methodology for sugarcane proteins towards better mass spectrometry compliance	2012:2(1)	E. Leonard Barnabas, M. Muthumeena, A. Ramesh Sundar, P. Malathi and R. Viswanathan
Microsporogenesis in a fertile *Saccharum officinarum x Erianthus arundinaceus* hybrid with floral abnormalities	2012:2(1)	M.N. Premachandran and R. Lalitha
Sulphur status of sugarcane growing soils of Tamil Nadu	2012:2(2)	A.Bhaskaran, P. Rakkiappan and C. Palaniswami
An assessment of high temperature tolerance potential of elite genotypes of sugarcane *(Saccharum* spp.) evaluated in the peninsular zone of India	2013:3(1)	G. Hemaprabha, S.P. Adhini, T.S. Sarath, S. Alarmelu and R.M. Shanthi
Production and characterization of sugarcane juice powder	2013:3(1)	K. Hari, S. Reginold Jebitta and K. Sivaraman
Sustainability of sugarcane productivity in a long-term organic production system vis-à-vis conventional system	2013:3(1)	K. Sivaraman, J. Srikanth, K. Hari, P. Rakkiyappan, C. Sankaranarayanan, A. Ramesh Sundar, N. Somasekhar, B. Sundara, S. Asokan and S.D. Chandrasekhar
Development and evaluation of backcross progenies of improved Saccharum spp. for yield and quality traits	2014: 4(1)	S. Alarmelu, R. Nagarajan, R.M. Shanthi, G. Hemaprabha and N.V. Nair
Cloning and characterization of a differentially regulated invertase inhibitor gene during sucrose accumulation in sugarcane	2014:4(2)	P.T. Prathima, T.V. Suparna, S. Anishma, R. Punnya and K. Ramalakshmi
Predators as natural and applied biocontrol agents of sugarcane woolly aphid *Ceratovacuna lanigera* in India: an appraisal	2015: 5(2)	J. Srikanth, B. Singaravelu, N.K. Kurup, N. Mukunthan, G. Santhalakshmi and R. Nirmala
Saccharum and Erianthus specific markers based on drought and sucrose specific candidate genes for hybrid identification	2015:5(1)	T.S. Sarath Padmanabhan, M.N. Premachandran and G. Hemaprabha
Study of genetic diversity and evaluation of interspecific hybrids of *Saccharum* spp. using SSR markers	2016: 6(1)	E. Karpagam and S. Alarmelu
Exploration and genetic diversity analysis of Saccharum spontaneum in Maharashtra State, India	2016:6(2)	P. Govindaraj, S. Karthigeyan and Adhini S. Pazhany
Heterosis and combining ability of sugarcane inbreds for early stage selection traits	2016:6(1)	A. Anna Durai and G. Hemaprabha

Title of the Article	Year, Volume & Issue	Authors
Effect of green cane trash blanketing and microbial consortia application on soil compaction and productivity of mechanically harvested sugarcane ratoon crops	2017:7(2)	A.S. Tayade, P. Geetha, S. Anusha, R. Dhanapal and K. Hari
Sugarcane root growth and development in hydroponics system	2017:7(2)	K. Hari , S. Vasantha, A. Anna Durai, Rajeshkumar, C. Brinda and P. Shruthi
Molecular cytogenetic characterization of sorghum chromosomes in *Saccharum* background and vice versa using genomic in situ hybridization	2018:8(1)	V.P. Sobhakumari, N.V. Nair, K. Mohanraj and Maya Lekshmi
Prospects of commercial hybrids of sugarcane *(Saccharum* spp.) for biomass and bioenergy production potential	2018:8(1)	S. Vasantha, S. Venkataramana, K. Hari and R. Arun kumar
Colletotrichum falcatum causing red rot in sugarcane: Genomic and proteomic approaches to characterize the pathogenic variation	2019: 9(2)	P. Malathi, K. Kaverinathan, M. Scindiya, E. Elamathi, A. Ramesh Sundar and R. Viswanathan
Identification of single nucleotide polymorphisms (SNPs) in the transcriptome of sugarcane variety Co 86032 exposed to oxidative stress	2019:9(1)	S. Gayathri, M. Arockiyajainmary, R. Shalini, M. Ram Vannish, A. Selvi and R. Manimekalai

8. LINKAGES AND COLLABORATIONS IN INDIA INCULDING 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 scientist involved	Source of funding	Total outlay (Rs. in lakhs)
Identification, characterisation 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 - Bakshi Ram and G. Hemaprabha	Dept. of Sugar, Govt. of TN	7.00

Project title and scientist 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 *Erianthus arundinaceus* 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	TRANALAB	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. Rajula Shanthy, C. Palaniswami, A.S. Tayade and L. Saravanan	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 planta secretome of *Sporisorium scitamineum* x sugarcane interaction - A. Ramesh Sundar, R. Viswanathan and G. S. Suresha	DST-SERB	24.55

Project title and scientist 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 Dr. 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
State level training on 'Advances in sugarcane cultivation' – T. Rajula Shanthy	Min. of Agri, Govt. of India	3.20
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
Need based technological interventions under Tribal Sub Plan in selected tribal villages - T. Rajula Shanthy, C. Sankaranarayanan, R. Karuppaiyan, C. Jayabose and R. Arunkumar	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 programmes (Fig. 131). The following are the research areas under this project:

- Fluff supply to various sugarcane research institutes / centres.
- Evaluation of 'Co' canes for different sugarcane growing regions and acting as the coordinating unit for the identification of 'Co' and other Co- regional selections.
- To gather information on general and specific combining ability of biparental crosses.
- Collaboration for development of national varieties.
- Collaborative research on Agronomy, Soil science, Plant Physiology, Entomology and Plant Pathology.

Dr. Bakshi Ram, Director is the Principal Investigator of Crop Improvement and Dr. R. Viswanathan, Head I/c, Division of Crop Protection is the Principal Investigator of Plant Pathology.

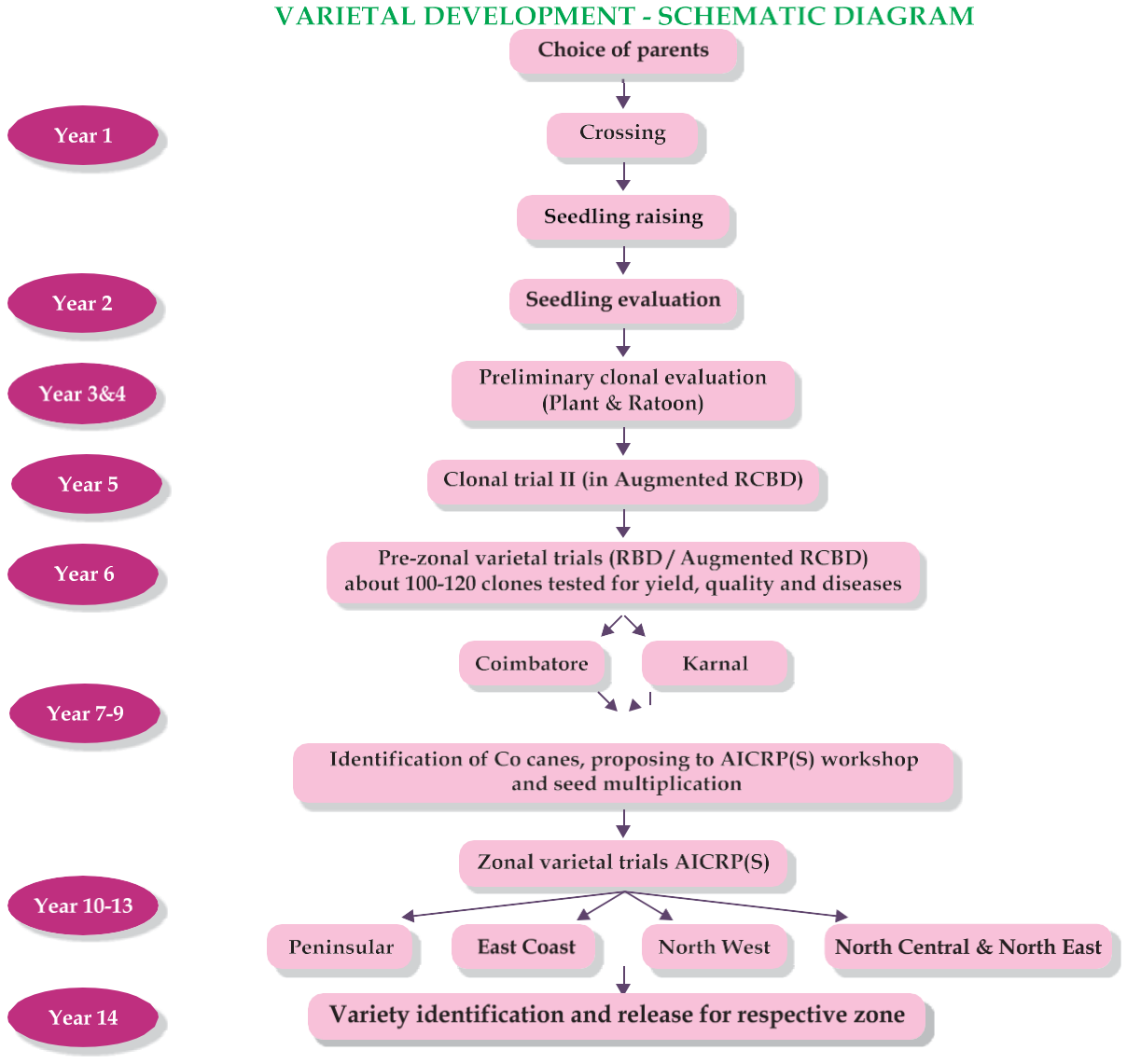


Fig. 131. Varietal Development - Schematic Diagram

10. PUBLICATIONS

Research papers

1. Aiswarya, D., R.K. Raja, C. Kamaraj, G. Balasubramani, P. Deepak, D. Arul, V. Amutha, C. Sankaranarayanan, S. Hazir and P. Perumal. 2019. Biosynthesis of gold and silver nanoparticles from the symbiotic bacterium, *Photorhabdus luminescens* of Entomopathogenic Nematode: larvicidal properties against three mosquitoes and *Galleria mellonella larvae. Journal of Cluster Science* 30 (4): 1051–1063 https://doi.org/10.1007/s10876-019-01564-1.
2. Anandakumar, L., K. Bagyalakshmi, T.Raja Muthuramalingam, K. Nithya, B. Parameswari and R. Viswanathan. 2020. Reverse Transcription Loop-mediated Isothermal Amplification based rapid detection of *Sugarcane mosaic virus* and *Sugarcane streak mosaic virus* associated with mosaic disease of sugarcane. *Indian Phytopathology* 73: 349-358 DOI: 10.1007/s42360-020-00219-w.
3. Anna Durai, A., C. Mahadevaiah and K. Gopinath. 2020. Identification of early and mid-late maturing sugarcane varieties for western region of Tamil Nadu. *Journal of Sugarcane Research* 10 (1): 32-42.
4. Appunu, C., J. Ashwin Narayan, H.K. Mahadeva swamy, S. Karthigeyan, R. Valarmathi, C. Mahadevaiah, Ravinder Kumar, M.R. Meena and Bakshi Ram. 2020. Variability and molecular diversity of wild sugarcane germplasm collected from low temperature regions Lohit and Changlang of Arunachal Pradesh. *Indian Journal of Biotechnology* 19. July 2020.
5. Arun kumar, R., S. Vasantha, A.S. Tayade, Anusha, P. Geetha and G. Hemaprabha. 2020. Physiological efficiency of sugarcane clones under water limited conditions. *Transactions of the ASABE (American Society of Agricultural and Biological Engineers)* 63: 133-140.
6. Ashwin, N.M.R., L. Barnabas, D. Amalamol, K.V. Lakshana, A.Ramesh Sundar, P. Malathi and R. Viswanathan. 2020. Transcriptional reprogramming of major defense-signaling pathways during defense priming and sugarcane-*Colletotrichum falcatum* interaction. *Molecular Biology Reports* 47: 8911–8923 https://doi.org/10.1007/s11033-020-05944-z.
7. Bagyalakshmi, K. and R. Viswanathan. 2020. Identification of the RNA Silencing Suppressor Activity of *Sugarcane streak mosaic virus* P1 gene. *Virus Disease* 31 (3): 333–340 DOI: 10.1007/s13337-020-00618-7.
8. Bakshi Ram and G. Hemaprabha. 2020. The sugarcane variety Co 0238 – a reward to farmers and elixir to India's sugar sector. *Current Science* 118 (11): 1643-1646.
9. Balan, S., R. Viswanathan and K. Anita Cherian. 2020. Status of leaf fleck caused by Sugarcane bacilliform virus incidence and severity in different sugarcane growing areas of Kerala and Tamil Nadu. *Journal ofSugarcane Research* 10: 74-86 https://doi.org/10.37580/JSR.2020.1.10.74-86.
10. Balasubramaniyan, M., P. Mahesh, J. Srikanth, B. Singaravelu, D. Puthira Prathap and N. Pothiraja. 2020. Infestation levels of sugarcane shoot borer in Cauvery delta zone of Tamil Nadu, India. *Journal of Sugarcane Research* 10 (1): 94-99.
11. Bharathi, S., M.R. Manikantan, T. Arumuganathan and K.A. Athmaselvi. 2020. Development, nutritional and functional evaluation of mixed millet and mixed millet soy based cookies. *International Journal of Agriculture Sciences.* 12 (9): 9837-9842.
12. Brinda, C., S.Vasantha, R. Arun Kumar and A.S. Tayade. 2020. Characterization of the salt overly sensitive pathway genes in sugarcane under salinity stress. *Physiology Plantaurum (special issue article,* Oct,2020). DOI/10.1111/ppl.13245.
13. Brindha, C., S. Vasantha and R. Arun Kumar. 2019. The response of sugarcane genotypes subjected to salinity stress at different growth phases. *Journal of Plant Stress Physiology* 5: 28-33.

14. Brindha, C., S. Vasantha, R. Arun Kumar and A.S. Tayade. 2020. Characterization of Salt Overly Sensitive (SOS) pathway genes involved in Na+ ions trafficking in sugarcane under salinity stress. *Physiologia Plantarum.* https://doi.org/10.1111/ppl.13245.

15. Chandran, K., M. Nisha and P.P. Gireesan. 2020. Characterization of Progenies from Polycrosses of *S.robustum Clones.f.sanguineum. Sugar Tech* 22 (3): 379–388.

16. Dharshini, S., N.V. Hoang, C. Mahadevaiah, T.S. Sarath Padmanabhan, G. Alagarasan, G.S. Suresha, Ravinder Kumar, M.R. Meena, Bakshi Ram and C. Appunu. 2020. Root transcriptome analysis of *Saccharum spontaneum* uncovers key genes and pathways in response to low-temperature stress. *Environmental and Experimental Botany* 171:103935

17. Dharshini, S., V.M. Manoj, G.S. Suresha, J. Ashwin Narayan, T.S. Sarath Padmanabhan, Ravinder Kumar, M.R. Meena, M. Manickavasagam, Bakshi Ram and C. Appunu. 2020. Isolation and characterization of nuclear localized abiotic stress responsive cold regulated gene 413 (SsCor413) from *Saccharum spontaneum. Plant Molecular Biology Reporte*r (online).

18. Ganesh Kumar, V., R. Viswanathan, P. Malathi, A. Ramesh Sundar, C.N. Prasanth and M. Nandakumar. 2020. Identification of differential expressed proteins and establishing a defense proteome of sugarcane in response to *Colletotrichum falcatum infection. Journal of Plant Pathology* DOI: 10.1007/s42161-020-00577-4.

19. Gomathi, R., S. Kohila and K. Lakshmi. 2020. High-throughput sequencing reveals genes associated with high temperature stress tolerance in sugarcane. *Biotech* 3.10.198. https://doi.org/10.1007/s13205-020-02170-z.

20. Gomathi, R., V. Krishnapriya, R. Arunkumar, P. Govindaraj and Bakshi Ram. 2020. Physiological traits imparting drought stress tolerance to promising sugarcane (*Saccharum* spp.) Clones. *Plant Physiology Report* 25: 509-515.

21. Gopi, R., B. Mahendran, K. Chandran, M. Nisha and R. Viswanathan. 2020. Plant and weather factors on resistance of saccharum officinarum germplasm against ring spot disease. *Sugar Tech* https://doi.org/10.1007/s12355-020-00943-7.

22. Govindaraj, P. 2020. SBIEC 14006 – A high biomass energycane for power, alcohol and paper industries. *Journal of Sugarcane Research* 10 (1): 100-106.

23. Hemaprabha, G., K. Mohanraj, S. Alarmelu and Bakshi Ram. 2020. Assessment of breeding methods and parental value of Co canes developed during 1918 to 2017. *Journal of Sugarcane Research* 10 (1): 24-31.

24. Holkar, S.K., B. Parameswari, A. Kumar, K.Nithya, P.R. Shingote, M.L. Chhabra, S. Kumar, P. Kumar, R. Viswanathan, R.K. Jain and A.D. Pathak. 2020. Present status and future management strategies for sugarcane yellow leaf virus: A major constraint to the global sugarcane production: An overview. *Plant Pathology Journal* 36 (6): 1-22.

25. Jayakumar, V., A. Ramesh Sundar and R. Viswanathan. 2020. Biocontrol of *Colletotrichum falcatum* with volatile metabolites produced by endophytic bacteria and profiling VOCs by headspace SPME coupled with GC–MS. *Sugar Tech* https://doi.org/10.1007/s12355-020-00891- 2.

26. Krishnapriya, V., R. Arunkumar, R. Gomathi and S. Vasantha. 2019. Prediction models for non-destructive estimation of total chlorophyll content in sugarcane. *Journal of Sugarcane Research* 9 (2): 150-163.

27. Karuppaiyan, R., N.V. Nair, Bakshi Ram, K. Mohanraj, A. Anna Durai, and P. Amudha. 2020. Evaluation of intra-specific hybrids of *Saccharum robustum* for yield, quality and yellow leaf disease incidence. *Indian Journal of Sugarcane Technology* 35 (1): 28-32.

28. Lakshmi K., R. Valiyaparambth, A. Kubandiran and J. Velu. 2020. Isolation, cloning and expression analysis of cinnamyl

alcohol dehydrogenase (CAD) involved in phenylpropanoid pathway of Erianthus arundinaceus, a wild relative of sugarcane. *3 Biotech* 10 (1).

29. Lakshmi, K. and J.A. Maupin-Furlow. 2020. Halophilic archaea and their potential to generate renewable fuels and chemicals. *Biotechnol Bioeng* Nov 26. DOI: 10.1002/ bit.27639.
30. Lakshmi, K., R. Valiyaparambth, J. Velu, H. Hari, and V. Srinivasavedantham. 2020. Gene expression studies of Saccharum spontaneum, a wild relative of sugarcane in response to salinity stress. *Biotechnology and Applied Biochemistry.*
31. Madhumathi, R., T. Arumuganathan, R. SnehaIyer, R. Shruthi and K. Shruthhi. 2020. Soil nutrient analysis using machine learning techniques. *International Journal of Scientific Research and Engineering Development.* Special issue on National E-Conference on Communication, Computation, Control and Automation 2020 (CCCA-2020). Paper ID - CCCA2020-08: Page 1-6.
32. Mahendran, B., P. Mahesh, R. Gopi, K. Chandran and M. Nisha. 2020. Herbivore diversity of a unique, islanded and managed sugarcane agro-ecosystem comprising *Saccharum* germplasm. *Insect environment* 20: 61-63.
33. Mahendran, B., P. Mahesh, R. Gopi, K. Chandran and M. Nisha. 2020. Herbivore diversity of a unique, islanded and managed sugarcane agro-ecosystem, *Insect Environment* 23 (4): 66-68.
34. Mahesh, P., J. Srikanth, B. Mahendran, K. Chandran, B. Singaravelu and K.P. Salin. 2020. Scale insect *Melanaspis glomerata* (Green) (Homoptera: Diaspididae) in world collection of Saccharum spontaneum L. *International Journal of Tropical Insect Science,* 40: 933–941. https://doi.org/10.1007/ s42690-020-00151-6.
35. Mahesh, P., J. Srikanth, B. Mahendran, K. Chandran, B. Singaravelu and K.P. Salin. 2020. Scale insect Melanaspis glomerata (Green) (Homoptera: Diaspididae) in world collection of *Saccharum spontaneum L. International Journal of Tropical Insect science.* https://doi.org/10.1007/s42690-020-00151- 6.
36. Manimekalai, R., S. Gayathri, G. Hemaprabha, A. Selvi and M. Kandalam. 2020. Role of NGS and SNP Genotyping methods in Sugarcane improvement programs. Critical reviews in Biotechnology DOI: 10.1080 /07388551. 2020. 1765730.
37. Manju Lekshmi, N., G. B. Sreekanth, N. P. Singh, A. Vennila, R. Ratheesh Kumar and P.K. Pandey. 2020. Ecopath modelling approach for the impact assessment of a small-scale coastal aquaculture system in Goa, India. *Indian Journal of Fisheries* 67 (3): 39-51(This publication is from work done at ICAR-CIFE, Mumbai).
38. Meena, M.R., Ravinder Kumar, C. Appunu, R. Karuppaiyan, Neeraj Kulshreshtha and Bakshi Ram. 2020. Current breeding and genomic approaches to enhance the cane and sugar productivity under abiotic stress conditions. *Biotech 3.*
39. Mohanan, M.V., A. Pushpanathan, Sarath Padmanabhan, T. Sasikumar, S. Dharshini, J. Ashwin Narayan, R. Arun Kumar, R. Sathishkumar, S.N. Karuppasamy, R. Subbiah, Bakshi Ram and C. Appunu. 2020. Ectopic expression of DJ-1/PfpI domain containing *Erianthus arundinaceus* Glyoxalase III (EaGly III) enhances drought tolerance in sugarcane. *Plant Cell Reports* 39 (11): 1581-1594.
40. Murali, P., R. Revathi, S. Balamurali and A.S. Tayade. 2020. Integration of RNN with GARCH refined by whale optimization algorithm for yield forecasting: a hybrid machine learning approach. *Journal of Ambient Intelligence and Humanized Computing* DOI 10.1007/s12355-018-0677-0.
41. Murali, P., Revathy, R., S. Balamurali and A.S. Tayade.2020. Integration of RNN with GARCH refined by whale optimization algorithm for yield forecasting: a hybrid machine learning approach. Journal Ambient Intell Human Comput. https://

doi.org/10.1007/s12652-020-01922-2.

42. Nandakumar, M., P. Malathi, A. Ramesh Sundar and R. Viswanathan. 2020. Useof green fluorescent protein expressing *Colletotrichum falcatum* for precise host- pathogen interaction studies in sugarcane. *Sugar Tech* 22 (1): 112–121 DOI: 10.1007/ s12355-019-00751-8.

43. Nandakumar, M., P. Malathi, A. Ramesh Sundar and R. Viswanathan. 2020. Host-pathogen interaction in sugarcane and red rot pathogen: Exploring expression of phytoalexin biosynthesis pathway genes. *Indian Phytopathology* DOI: 10.1007/s42360-020-00306-y.

44. Nithya, K., B. Parameswari and R. Viswanathan. 2020. Mixed infection of *Sugarcane yellow leaf virus* and Grassy Shoot Phytoplasma in yellow leaf affected Indian sugarcane cultivars. *Plant Pathology Journal* 36 (4): 364-377.

45. Nithya, K., B. Parameswari, A. Bertaccini, G.P. Rao and R. Viswanathan. 2020. Grassy shoot: the destructive disease of sugarcane. *Phytopathogenic Mollicutes* 10 (1): 10-24.

46. Nithya, K., B. Parameswari, S.K. Holkar and R. Viswanathan. 2020. Detection of sugarcane grassy shoot phytoplasma through scanning electron microscopy. *Indian Phytopathology* (In press).

47. Ovalle, W. and R. Viswanathan. 2020. Sustaining sugarcane production in Guatemala and Nicaragua through efficient disease management approaches. *Sugar Tech* 22 (3): 361–366 DOI: 10.1007/s12355-020-00801-6.

48. Peter, S.C., M. Naveenarani, V. Manoj, Sarath Padmanabhan, S. Dharshini, J. Ashwin Narayan, G. Suresha, C. Mahadevaiah, R. Valarmathi, G. Hemaprabha, Bakshi Ram and C. Appunu. 2020. Isolation, characterization and expression analysis of stress responsive plant nuclear transcriptional factor subunit (NF YB2) from commercial Saccharum hybrid and wild relative *Erianthus arundinaceus. Journal of Sugarcane Research* 10: 1-11.

49. Pooja, A.S. Nandwal, M. Chand, A. Kumari, B. Rani, V. Goel and N. Kulshreshtha. 2020. Soil moisture deficit induced changes in antioxidative defense mechanism of four sugarcane varieties differing in their maturity. *Indian Journal of Agricultural Sciences* 90(3): 55–60.

50. Prathap, D.P., P. Murali, V. Venkatasubramanian. 2020. Barriers to ICT Usage: An Assessment among the Sugarcane Farmers in Disadvantaged Districts of Tamil Nadu, India. *Sugar Tech.* DOI: https://doi.org/10.1007/s12355-020-00889-w

51. Rajkumar, R., T. Arumuganathan, S. Saira Banu, N. Karthick and Libin Baby. 2020. Design and Development of IoT based soil moisture sensing system. *International Journal of Creative Research Thought* 8 (5): 2148-2152.

52. Raju, G., K. Shanmugam and K. Lakshmi. 2020. High-throughput sequencing reveals genes associated with high-temperature stress tolerance in sugarcane. *3 Biotech* 10: 1-13.

53. Rajula Shanthy T and Gurumoorthy. 2020. Trash management practices in sugarcane cultivation: A socioeconomic analysis.*Indian Research Journal of Extension Educatio n*. 20(4):1-8.

54. Rajula Shanthy T, C. Jayabose, Bakshi Ram. 2020. Need based technological interventions in tribal villages under Tribal Sub Plan. *International Journal of Science, Environment and Technology.* 9(4): 696–704.

55. Ramasubramanian, T. 2020. Impact of organic manures on the persistence of imidacloprid in the sandy clay loam soil of tropical sugarcane crop ecosystem. *Environmental Monitoring and Assessment* 192: 403.

56. Ramasubramanian, T. and M. Paramasivam. 2020. Bifenthrin in the tropical sugarcane ecosystem: persistence and environmental risk assessment. *Environmental Science and Pollution Research* https://doi.org/10.1007/s11356-020-10757-5.

57. Ramasubramanian, T. and M. Paramasivam. 2020. Dissipation kinetics and environmental risk assessment of thiamethoxam in the sandy clay loam soil of tropical sugarcane crop ecosystem. *Bulletin of Environmental Contamination and Toxicology* 105: 474–480..

58. Ramasubramanian, T. and M. Paramasivam. 2020. Soil persistence and environmental risk assessment of chlorpyrifos under different organic manuring in the tropical sugarcane ecosystem. *International Journal of Environmental Analytical Chemistry* DOI:10.1080/03067319.2020.1838493.

59. Ramasubramanian, T., T. Sonai Rajan and E. Madhu Sudhanan. 2020. Instar determination for sugarcane internode borer *Chilo sacchariphagus indicus* (Kapur) (Lepidoptera: Crambidae). *Journal of Asia-Pacific Entomology* https://doi.org/10.1016/j.aspen.2020.10.010.

60. Revathy, R., P. Murali and S. Balamurali. 2020. Hadoop Big Data Mining: An Effective Map Reduce Tool for Classifying Sugarcane Yield Data. *Plant Archives* 20 (2): 4245-4250.

61. Revathy, R., P. Murali, V. Venkatasubramanian, D. Puthira Prathap and S. Balamurali. 2020. An Appraisal of Indian Jaggery and Confectionery Exports in the Global Market: Markov Chain Model Approach. *Sugar Tech* https://doi.org/10.1007/s12355-020-00866-3.

62. Sankaranarayanan, C. and K. Hari. 2020. Integration of Arbuscular Mycorrhizal and nematode antagonistic fungi for the biocontrol of root lesion nematode Pratylenchus zeae Graham, 1951 on Sugarcane. Sugar Tech. https://doi.org/10.1007/s12355-020-00876-1.

63. Sankaranarayanan, C. and K. Hari. 2020. Integration of arbuscular mycorrhizaland nematode antagonistic fungi for the biocontrol of root lesion nematode *Pratylenchus zeae* Graham 1951 on sugarcane. *Sugar Tech* https://doi.org/10.1007/s12355-020-00876-1.

64. Selvi, A., K. Devi, R. Manimekalai and P.T. Prathima. 2020. Comparative analysis of drought- responsive transcriptomes of sugarcane genotypes with differential tolerance to drought. *3 Biotech* DOI: 10.1007/s13205-020-02226-0. B130.

65. Sobhakumari, V.P., K. Mohanraj, N.V. Nair, H.K. Mahadeva swamy and Bakshi Ram. 2020.ytogenetic and molecular approaches to detect alien chromosome introgression and its impact in three successive generations of *Erianthus procerus X Saccharum. Cytologia* 85(4): 341-346.

66. Sobhakumari, V.P. 2020. Evolutionary dynamics of chromosomal diversity in *Saccharum spontaneum* population from Punjab and Haryana, India. *Cytologia* 85(4): 313-318.

67. Suganya, A., P. Govindaraj, G. Hemaprabha and Bakshi Ram. 2020. AS 04-2097 (INGR20070) - A drought tolerant interspecific hybrid of sugarcane with broadened genetic base. *Indian journal of plant genetic resources,* 33.

68. Valarmathi, R., H.K. Mahadeva Swamy, K. Preethi, J. Ashwin Narayan, C. Appunu and Hifzur Rahman. 2020. Characterization and in silico analyses of RTCS gene from sugarcane encoding LOB protein family of transcription factors: a key regulator of shoot-borne root initiation. *Journal of Sugarcane Research.* 10: 12-23.

69. Vasantha, S., S. Venkataramana and R. Arun kumar. 2019. Sucrose synthesis and accumulation in contrasting commercial hybrids of sugarcane. *Journal of Sugarcane Research* 9 (1): 45-54.

70. Viswanathan, R. 2020. Fusarium diseases affecting sugarcane production in India. *Indian Phytopathology* 73: 415–424 DOI: 10.1007/s42360-020-00241-y.

71. Viswanathan, R. 2020. Sustainable sugarcane cultivation in India through threats of red rot by varietal management. *Sugar Tech* DOI: 10.1007/s12355-020-00882-3.

72. Viswanathan, R. and N.M.R. Ashwin. 2020. Brown spot of sugarcane: an emerging disease in South Western region in India. *Journal of Sugarcane Research* 10: 87-93

https://doi.org/10.37580/JSR.2020.1.10.87-9.

73. Viswanathan, R. and R. Selvakumar 2020. Varietal breakdown to red rot in sugarcane revealed by comparing two *Colletotrichum falcatum* inoculation methods. *Sugar Tech* 22 (6): 1063–1075 DOI: 10.1007/s12355-020-00855-6.

74. Viswanathan, R., P. Padmanaban and R. Selvakumar. 2020. Emergence of new pathogenic variants in *Colletotrichum falcatum,* stalk infecting ascomycete in sugarcane: role of host varieties. *Sugar Tech* 22 (3): 473–484 DOI: 10.1007/s12355-019-00780-3.

75. Viswanathan, R., R. Selvakumar, K. Manivannan, R. Nithyanandam and K. Kaverinathan. 2020. Pathogenic behaviour of soil borne inoculum of *Colletotrichum falcatum* in causing red rot in sugarcane varieties with varying disease resistance. *Sugar Tech* 22 (3): 485–497 DOI: 10.1007/s12355-020-00800-7.

Books/Compendiums/Training Manuals

1. Chandran, K. 2020. Sugarcane Genetic Resources. In Training Manual "Recent Scientific Interventions and Practices of Sugarcane Breeding, Production and Utilization for Doubling Farmers Income" ICAR-Sugarcane Breeding Institute Coimbatore – 641007, Tamil Nadu & National Agriculture Development Cooperative Ltd. Baramulla – 193103, J & K, 04.12.20.

2. Gowda, M.J.C., A. Balamatti, H. Philip, D. Puthira Prathap and S. George. 2020. Agricultural Extension for sustainable development. Mysuru: Samvahana Publishers. p 224. ISBN 978-81-938357-5-3.

3. Puthira Prathap, D., 2020. Proceedings and Recommendations of the 50th Golden Jubilee Sugarcane Research and Development Workshop of Tamil Nadu & Puducherry [*SBI R&D Series: TN - 50 (2019-P)*]

4. Puthira Prathap, D., M. Senthilkumar, S. Usharani, N. Sriram, H. Philip, M.J. Chandregowda and A. Balamatti. 2019. *Book of Abstracts.* Mysuru: International Conference on Extension for Strengthening Agricultural Research and Development. ISBN 978-81-945904-0-8.

5. Rajula Shanthy T, Bakshi Ram 2020 Sugarcane cultivation practices (Tamil). Extension Publication No. 290(2020). ICAR-Sugarcane Breeding Institute, Coimbatore. pp.130.

6. Rajula Shanthy T, Bakshi Ram 2020 Advances in sugarcane cultivation (Tamil). Extension Publication No. 293(2020). ICAR-Sugarcane Breeding Institute, Coimbatore. pp.130.

7. Venkatasubramanian, V., P. Murali, D. Puthira Prathap, T. Arumuganathan and K. Hari. 2020. Agri-Preneurship through Agro-Based Technologies, ICAR-Sugarcane Breeding Institute, Coimbatore, Tamil Nadu, India, ISBN: 978-93-85267-25-3. P. 261.

8. Venkatasubramanian, V., P. Murali, D. Puthira Prathap, T. Arumuganathan and K. Hari. 2020. Compiled and developed an E-Book on "Promoting Agri-preneurship through Sugarcane based Technologies". E-Book (CD) published by ICAR-Sugarcane Breeding Institute, Coimbatore.

Chapters in Books/Training Manuals

1. Alarmelu, S. 2020. Sugarcane varieties. In: Recent trends in scientific sugarcane cultivation. PP: 17-30.

2. Anusha, S., A.S. Tayade and P. Geetha. 2020. Weed management in sugarcane for sustainable productivity. In: Training manual on "Recent Scientific Interventions and Practices of Sugarcane Breeding, Production, Protection and Utilization for Doubling Farmer's Income".

3. Arun Kumar, R., S. Vasantha, D. Pooja, C. Appunu and V. Krishnapriya. 2020. Temperature extremes in sugarcane: an overview. In: (Gurumurthy S., Senjam Jinus S. Eds.) Management of Abiotic Stress in Crop Plants, Innovative Publication. pp. 172-138.

4. Bhuvaneswari, M, Ramasubramanian, M, Prathap, D Puthira & Senthilkumar, M. 2020. Socio-economic impact of migrant

workers on their farm families (Tamil). In Senthilkumar, R et al (Eds.) *Agricultural Extension,* New Delhi: Scientific Tamil Society for Agriculture. p162

5. Geetha, P. and A.S. Tayade. 2020. Ratoon management technology in sugarcane. In: KarumbuSagupady (Tamil) (Eds). T. Rajulashanthy and Bakshi Ram, ICAR-Sugarcane Breeding Institute, Coimbatore. pp: 90-96.
6. Geetha, P., A.S. Tayade and S. Anusha. 2020. Integrated Farming System in Sugarcane - A way for doubling farmer's income. 21 Days Advanced National Training Programme (ANTP 2020) On "Recent Scientific Interventions and Practices of Sugarcane Breeding, Production and Utilization for Doubling Farmers Income".
7. Gomathi, R. 2020. Impact of Temperature Extremes on Sugarcane Growth and Development. In. Recent Scientific Interventions and Practices of Sugarcane Breeding, Production, Protection and Utilization for Doubling Farmers Income"(through online mode) published by ICAR-Sugarcane breeding Institute, Coimbatore and National Agriculture Development Cooperative Ltd. Baramulla – 193103, J &K.
8. Harinath Babu, K., R.M. Devarumath, A.S. Thorat, V.M. Nalavade, Mayur Saindane, C. Appunu and P. Suprasanna. 2020. Sugarcane Transgenics: Developments and Opportunities. In Genetically Modified Crops (P. B. Kavi Kishor et al. (eds.), Springer Nature Singapore Pte Ltd.
9. Murali, P. 2019. Costing and Economic analysis of custom hiring centre" by. CIAE/ RC/2019 Technical Bulletin No.1. Edited by Dr. S. Balasubramanian et.al 2019. Published for Modern Training course on Model Training Course on Establishment of Agro Processing and Farm Machinery Custom Hiring Centres.
10. Murali, P., D. Puthira Prathap. 2020. Use of ICT in Agricultural Marketing, Editors Dr. P. Chandra Shekara Dr. V. K. Jayaraghavendra Rao Manoj Kumar Agrawal. Jaipur: CCS NIAM, p25-36
11. Rajula Shanthy T, S. Alarmelu S, C. Jayabose, P. Malathi. 2020. Developing a mobile app on sugarcane for technology dissemination. In Singh AK et al. (Eds). Agricultural Extension Socioeconomic implications. Division of Agricultural Extension. Indian Council of Agricultural Research, New Delhi. 32-34.
12. Rajula Shanthy T 2020 'Cane Adviser – A mobile app on sugarcane'. Advanced national training program on 'Recent scientific interventions and practices of sugarcane breeding, production and utilization for doubling farmers income conducted by National Agriculture Development Cooperative Ltd. Baramulla, J&K during 1-21 December 2020.
13. Ram, B and R. Karuppaiyan. 2020. Current scenario of sugarcane agriculture. In: Sugarcane cultivation (Tamil). Eds. T. Rajula Shanthy and Bakshi Ram). ICAR-Sugarcane Breeding Institute, Coimbartore. Extension publication No 290: 1-19.
14. Ramasubramanian, M., M. Senthil Kumar and D. Puthira Prathap. 2020. Is Value Chain a 'reality' or 'misnomer' in Farmer Producer Companies (FPCs)? Facts from Field in Tamil Nadu. In Gowda, M.J.C et al (Eds.) Agricultural Extension for sustainable development. Mysuru: Samvahana Publishers. pp. 184-197.
15. Ramasubramanian, M, Prathap, D Puthira & Senthilkumar, M. 2020. Training needs of CEOs and Managing Directors of FPOs (Tamil). In Senthilkumar, R et al (Eds.) Agricultural Extension, New Delhi: Scientific Tamil Society for Agriculture. p162
16. Ramasubramanian, T., M. Mohan, R. Gandhi Gracy and S. Santoshkumar. 2020. Insecticide Resistance Monitoring Bioassays: Principles and Techniques. In: *Compendium on Insecticide Resistance: Biochemical and Molecular Perspectives and Strategies for Combating Resistance to Insecticides.* Mohan,

M., R. Gandhi Gracy, T. Venkatesan, M. Sampathkumar, K. Subaharan, G. Sivakumar, K. Srinivasamurthy, Nishtha Nayyar, Aditi Agrawal, B.R. Basavaarya, and P. Jyoti (Eds.), NBAIR Publications Series No. 2/2020, ICAR-National Bureau of Agricultural Insect Resources, Bengaluru, pp. 29-37.

17. Ramasubramanian, T., M. Mohan, T. Venkatesan, K. Sunil and V. Linga. 2020. Neurotoxic Insecticides and Their Mode of Action. In: *Compendium on Insecticide Resistance: Biochemical and Molecular Perspectives and Strategies for Combating Resistance to Insecticides.* Mohan, M., R. Gandhi Gracy, T. Venkatesan, M. Sampathkumar, K. Subaharan, G. Sivakumar, K. Srinivasamurthy, Nishtha Nayyar, Aditi Agrawal, B.R. Basavaarya, and P. Jyoti (Eds.), NBAIR Publications Series No. 2/2020, ICAR-National Bureau of Agricultural Insect Resources, Bengaluru, pp. 21-28.

18. Ramya, A., A. Vennila, C.S. Purushothaman, M.T. Shilta and R.G.K. Lekshmi. 2020. Phosphorus mobilizers from mangrove ecosystem and their role in desalination of agricultural lands. In: Research Trends in Agriculture Sciences (ed. R.K. Naresh). AkiNik Publications, New Delhi. ISBN 978-93-90070-88-6 pp. 63-81.

19. Tayade, A.S., P. Geetha, S. Anusha, R. Arun Kumar and S. Vasantha. 2020. Agronomic Interventions for the Management of Drought in Sugarcane. In: (Eds) Jeyakumar, P., M. K. Kalarani, A. Senthil and D. Vijayalakshmi. Advances in Crop Physiology for Sustainable Agriculture. ISBN: 978-93-88932-22-6.

20. Vasantha, S. 2019. Seaweeds-growth promoters in sugarcane and crop plants. In Souvenir of National workshop on advanced trends in marine macro algal taxonomy, cultivation & utilization, Organized by Botanical Survey of India, Coimbatore, during 21-25 October, 2019. pp. 103-111.

Technical/Popular articles

1. Alarmelu, S. G. Hemaprabha, U.S. Natrajan, K.G. Somrajan, R.M. Shanthi, P. Govindaraj, K. Elayaraja, S. Sheelamary, K. Mohanraj, V. Srinivasan, A. Anna Durai, Bakshi Ram. R.Viswanathan, K.P. Salin, Arjun Tayade and I. Rajendran. 2020. Co 12009 (Sankalp): Praydwipiyay Khestra Me Kheti Ke Liye ek Madhyam Deri Se Paknewali Prajati. (in Hindi) Ganna Prakash, ICAR-Sugarcane Breeding Institute, Coimbatore, Tachniki Bulletin *Ganna Prakash* 5 (5): 7-8.

2. Anusha, S., Arjun Tayade, P. Geetha and V. Krishnapriya. 2020. Ganne Me Sukha Prabandhan Ke Liye Sasya Vaigyanik Hastkshep.(in Hindi) *Ganna Prakash,* ICAR-Sugarcane Breeding Institute, Coimbatore, Tachniki Bulletin 5 (5): 27-30.

3. Arjun Tayade and S. Maheshwari. 2020. ICAR-Ganna Prjanan Santhan, Coimbatore Ki Hindi Gatvidhiya. (in Hindi) *Ganna Prakash,* ICAR-Sugarcane Breeding Institute, Coimbatore, Tachniki Bulletin 5 (5): 33-35.

4. Arjun Tayade, P. Geetha and S. Anusha. 2020. Ganne Me Udad Ki Antarfasal Ugakar Fasal Vividhikar Dwara Ushnakatibandhiya Bharat Me Labh Aur Khadya Suraksha Me Sudhar. (in Hindi) *Ganna Prakash,* ICAR-Sugarcane Breeding Institute, Coimbatore, Tachniki Bulletin 5 (5): 33-35.

5. Arumuganathan, T. 2020. Machinery for Sugarcane Cultivation. In: *Refresher Training Course Manual on "Farm Mechanisation for Established Agripreneurs"* (Eds. R. Senthil Kumar, M. MuthamilSelvan and RavindraNaik), Technical Bulletin No. CIAE/RC/2020/Technical Bulletin No.2. pp; 1-92, 21–24th February, 2020, ICAR-CIAE-RC, Coimbatore, Tamil Nadu.

6. Bakshi Ram, 2020. Co 0238: The wonder variety of sugarcane for subtropical India. *ICAR News* 26 (2): 24-26.

7. Bakshi Ram, 2020. ICAR-SBI. 2020. ICAR-Sugarcane Breeding Institute: Offering World-Class Research and Development for Improving Sugarcane Production. Cover Story Published in

Magazines.insightssuccess.in, March 2020. http://magazines.insightssuccess.in/10-Best-Research-Institutes-In-India-March2020/#page=1.

8. Bakshi Ram, 2020. Wonder variety of sugarcane Co 0238. ICAR Reporter (April to June): 21-22.
9. Bakshi Ram, G. Hemaprabha, R. Karuppaiyan, N.V. Nair and R. Viswanathan 2020. Co 06034 (Karan 11). A new midlate sugarcane variety released for North Western zone of India. *SBI News* 36 (4): pp.1-2.
10. Bakshi Ram, R. Karuppaiyan, Ravinder Kumar, M.R. Meena, Neeraj Kulshreshtha, G Hemaprabha, M.L. Chhabra and S.K. Pandey. 2020. Co 13035 (Karan 14): Uttari Paschami kshetre ke liye ak madhyam deri se pakne wali nai ganna prajati *Ganna Prakash* (Rajbhasha Patrika). 5 (5): 9-12.
11. Bakshi Ram, S. Alarmelu and T.Rajula Shanthy. 2020. Promising Sugarcane Varieties. *Extn Publication* No. 291.
12. Chandran, K., M. Nisha, B.Mahendran and R. Gopi. 2020. "Samrambha Sadhyatha thurannu Then Sarkara" Karshakan September 2020 (Malayalam), A Rrashtra Deepika Publication, Kerala; pp. 52-54.
13. Geetha, P., Arjun Tayade and S. Anusha. 2020. Ganna Adhareet Fasal Pranali Se Utpadan Me Labh. (in Hindi) Ganna Prakash, ICAR-Sugarcane Breeding Institute, Coimbatore, Tachniki Bulletin 5 (5): 24-26.
14. Mahesh, P., D. Puthira Prathap and R. Nirmala. 2019. Karumbu payiril eli sartha uyirinangal yerpaduthum sedhsngalum avatrai kattupaduthum muraigalum (Tamil). Valarum Velanmai 10 (7): 19-25.
15. Mahesh, P., J. Srikanth and D. Puthira Prathap. 2020. Karumbu vayalgalil kaatuppandri melaanmai – Wild boar management in sugarcane fields (Tamil), *Uzhavarin Valarum Velanmai* (TNAU), 11 (7), 48-51.
16. Murali, P. 2019. Costing and Economic analysis of custom hiring centre" by. CIAE/ RC/2019 Technical Bulletin No.1. Edited by Dr. S. Balasubramanian et.al 2019. Published for Modern Training course on Model Training Course on Establishment of Agro Processing and Farm Machinery Custom Hiring Centres.
17. Murali, P. and D. Puthira Prathap. 2020. *"Use of ICT in Agricultural Marketing"*. Institutionalising COVID Period Innovations in Agricultural Marketing @2020, CCS NIAM. Editors Dr. P.Chandra Shekara, Dr. V.K. Jayaraghavendra Rao and Manoj Kumar Agrawal. ISBN: 978-81-943252-4-6.
18. Puthira Prathap, D. 2020. From the Editor's Desk. *Journal of Extension Education,* 32(1). doi:http://dx.doi.org/10.26725/JEE.2020.1.32.6421
19. Rajula Shanthy T 2020. Success story ofa sugarcane entrepreneur (Hindi). *Ganna Prakash* 5(5):79-80.
20. Rajula Shanthy T 2020. Stress management for a healthy life (Hindi). *Ganna Prakash* 5(5):83-87.
21. Sheelamary, S. 2020. Major types of agricultural farming in India and its importance. *Indian Farmer* 7 (05): 408-414.
22. Sheelamary, S. and G.K. Sujayanand. 2020. Precise Genome editing tools for crop improvement. *Just agriculture* 1 (4): 165-169.
23. Sheelamary, S., K. Lakshmi and G. K. Sujayanand. 2020. Biofortification of crops to address global Zn deficiency. *Biotica Research Today* 2 (11): 1215-1217.
24. Srikanth, J., N. Geetha, B. Singaravelu, T. Ramasubramanian, P. Mahesh, L. Saravanan and K.P. Salin. 2019. Fall armyworm *Spodoptera frugiperda* on sugarcane in India. *SBI News* 39 (3): 1-3.
25. Srikanth, J., P. Mahesh and D. Puthira Prathap, 2019. Ganna phasal ko janglee suvvaron se bachaane ke liye prabhandhan [Hindi] [Management of wild boar in sugarcane]. *Ganna Prakash* Rajbhaasha Patrika 4 (4): 65-67.
26. Vasantha, S., R. Arun Kumar, Rajesh kumar, Braj Mohan and R. Gomathi. 2020. Jaggery

quality of sugarcane grown under salinity. *Khethi,* November 2020: pp 45-47.

27. राम, ब., हेमप्रभा, जी., करुप्पैयन, आर., नायर, एन. वि. एवं विश्वनाथन, आर. 2017. को 06034 (करण 11)-उत्तर पश्चीमी क्षेत्र के लिये एक मध्यम देरी से पकने वाली गन्ना प्रजाती. गन्ना प्रकाश. भा.कृ.अनु.प. गन्ना प्रजनन संस्थान. कोयम्बत्तूर 2 (2): 9-10.

Presentations in Conferences / Symposia / Seminars / Others

1. Agisha, V.N., N.M.R Ashwin, R.T. Vinodhini, A. Ramesh Sundar, P. Malathi andR. Viswanathan. 2020. Development of a GFP-tagged *Sporisorium scitamineum* strain to visualize *in planta* colonization in sugarcane. Proceedings in National Symposium (virtual) on Advances in crop Health Management conducted by IPS-SZ at IARI, Wellington, The Nilgiris, Tamil Nadu on 1-2 December 2020.

2. Alarmelu, S., A. Anna Durai, H.K. Mahadevaswamy, G. Hemaprabha and Adhini S. Pazhany 2020. Investigation for diversity in parental stocks of sugarcane *(Saccharum spp),* 2020. In: 2nd International Conference and Exhibition on Sustainability-Innovation & Diversification in Sugar and Allied Industry held during January 31-February 2, 2020 at Pune.

3. Alarmelu, S., G. Hemaprabha and Bakshi Ram. 2020. Co 12009 (Sankalp) – New Midlate variety for Peninsular Zone In: 78th Virtual STAI Convention held during 20-21, October 2020 at New Delhi.

4. Alarmelu, S., S.P. Adhini, S. Sheelamary and C. Jayabose. 2020. Genetic diversity for yield traits in prebreeding material of *Saccharum spp* In: 2nd International Conference and Exhibition on Sustainability-Innovation & Diversification in Sugar and Allied Industry held during January 31- February 2, 2020 at Pune.

5. Amala Mol, D., K.V. Lakshana, N.M.R. Ashwin, A. Ramesh Sundar, P. Malathi, C. Appunu and R. Viswanathan. 2020. Elucidating the functional facets of the fungal effectors, *Cf* EPL1 &*Cf*PDIP1through transient ectopic expression in tobacco. Proceedings in National Symposium (virtual) on Advances in crop Health Management conducted by IPS-SZ at IARI, Wellington, The Nilgiris, Tamil Nadu on 1-2 December 2020.

6. Amala Mol, D., N.M.R. Ashwin, K.V. Lakshana, A. Ramesh Sundar, P. Malathi, C. Appunu and R. Viswanathan. 2020. Developing an inducible vector system for controlled expression of effector proteins of the filamentous fungi, *Colletotrichum falcatum.* 7th International conference, 2020, IARI, New Delhi. Phytopathology in sustaining UN sustainable development goals. 16-20 January 2020. pp. 407.

7. Amit, Y. and R. Manimekalai. 2020. XI National Symposium of Indian Association of Mycoplasmologists (IAM) National Centre for Microbial Resource (NCMR), National Centre for Cell Science (NCCS), Pune, India December 02 to 05, 2019. Phytopathogenic Mollicutes. 10 (1): 104-110.

8. Anusha, S., A.S. Tayade and P. Geetha. 2020. Weed management in sugarcane for sustainable productivity. 21 days Advanced National Training Programme (ANTP 2020) on "Recent Scientific Interventions and Practices of Sugarcane Breeding, Production, Protection and Utilization for Doubling Farmer's Income" from 1st to 21st December 2020 organized by ICAR-Sugarcane Breeding Institute, Coimbatore and National Agriculture Development Cooperative Limited, Baramulla 193103, Jammu and Kashmir in virtual mode.

9. Bakshi Ram, P. Govindaraj, G. Hemaprabha, K. Mohanraj, S. Sheelamary, H.K. Mahadevaswamy , V. Vinu, R.M. Shanthi, R. Karuppaiyan, C. Mahadevaiah, V. Sreenivasa and A. Anna durai. 2020. Principal investigator's report: 2019-20. Varietal Improvement Programme (All India Coordinated Research Project on Sugarcane). Published by ICAR - Sugarcane Breeding Institute, Coimbatore. 554 pages.

10. Bakshi Ram. 2020. Co 0238 – Its impact, management and what's next? Presented in:

Annual Convention of STAI held in Delhi during October 20-21, 2020 (Online).

11. Bakshi Ram. 2020. Impact of Co 0238, its management and new promising varieties. Presented in: Sugar Tech 2020 organized by CII on October 22, 2020 (Online).

12. Bakshi Ram. 2020. Latest advancements in sugarcane varieties. Presented in: Green Sugar Summit 2020 on *Making Indian Sugar Sector World Class in Green* held during 6&7 August 2020 (Online).

13. Bakshi Ram. 2020. Sugarcane Breeding in India: Prospects and Problems. Presented in: 2nd International Conference and Exhibition 2020 organized by Vasantdada Sugar Institute, Pune, India from January 31 to February 2, 2020.

14. Bakshi Ram. 2020. Sugarcane: Varieties and Management. Presented an invited lecture in: "Executive Development Programme" organized by National Sugar Institute, Kanpur during August 24-28, 2020 (Online).

15. Geetha, P. Doubling the income 2020. of small farms through Sugarcane Based Farming System for TN- NADP during the Meeting to review the progress under the chairmanship of Shri. Gagandeep Singh Bedi, Agriculture Production Commissioner (APC) on18.12.2020 through online Zoom Meet.

16. Geetha, P., A.S.Tayade and S. Anusha. 2020. Integrated Farming System in Sugarcane- A way for doubling farmer's income.
21 Days Advanced National Training Programme (ANTP 2020) On"Recent Scientific Interventions and Practices of Sugarcane Breeding, Production and Utilization for Doubling Farmers Income" Organized by ICAR-Sugarcane Breeding Institute, Coimbatore – 641007, Tamil Nadu and National Agriculture Development Cooperative Ltd. Baramulla – 193103, J&K. 01.12.2020 to 21.12.2020.

17. Gopi, R., B. Mahendran, K. Chandran, R. Viswanathan, M. Nisha, P.P. Gireesan and Mayalekshmi. 2020. Diseases and disease resistance in flowering clones of world collection of sugarcane (*Saccharums*pp) germplasm In: Proceedings of international e-conference on 'Advances and Future Outlook in Biotechnology and Crop Improvement for Sustainable Productivity' held at University of Horticultural Sciences, Bagalkot held during 24-27 November 2020.

18. Gopi, R., R. Viswanathan, K. Chandran, M. Nisha, B. Mahendran, P.P. Girishan and Mayalekshmi. 2020. Status of diseases in sugarcane germplasm at Kannur. In the Proceedings of Indian Phytopathological Society (South Zone), National symposium (virtual) on Advances in crop health management held during December 1-2, 2020, at ICAR-IARI, Regional Station, Wellington, The Nilgris, Tamil Nadu, India.

19. Hemaprabha, G., K. Mohanraj, S. Alarmelu and Bakshi Ram. 2020. Genetic improvement for sugar yield traits of Co canes evolved during a century of breeding at ICAR Sugarcane breeding Institute. Presented in the 78 Virtual Annual Convention & International Sugar Expo 2020 October 20-21, 2020.

20. Jeyalekshmi, K., S.K. Mouriya, N.M.R. Ashwin, K. Nalayeni, A. Ramesh Sundar, P. Malathi and R. Viswanathan. 2020. Development of an efficient method for apoplastic protein extraction from *Sporisorium scitamineum* infected sugarcane meristems. Proceedings in National Symposium (virtual) on Advances in crop Health Management conducted by IPS-SZ at IARI, Wellington, The Nilgiris, Tamil Nadu on 1-2 December 2020.

21. Krishnapriya, V. 2020. Oral presentation in workshop: ECRA Group Monitoring Workshop held at BITS-PILANI, Hyderabad, organised by DST-SERB, New Delhi on 14-15 February 2020.

22. Lakshana, K.V., D. Amala Mol, N.M.R. Ashwin, A. Ramesh Sundar, P. Malathi, C. Appunu and R. Viswanathan. 2020. Site directed mutagenesis in PAMPs/ Effector coding genes of *Colletotrichum falcatum* through PEG mediated protoplast transformation system. Proceedings in National Symposium (virtual) on Advances

in crop Health Management conducted by IPS-SZ at IARI, Wellington, The Nilgiris, Tamil Nadu on 1-2 December 2020.

23. Lakshmi, K. 2020. Participated in an International Plant Biology (Conference 2020) and presented a paper titled: "Novel insights into the genetic control of Phenylpropanoid pathway of Erianthus, a potential bioenergy crop" during 27-31 July; Washington DC, USA.

24. Lakshmi, K., P.P. Thirugnanasambandam, A. Furtado, F.C. Botha and R.J. Henry. 2020. Isolation and Characterization of Full-Length Phenylalanine Ammonium Lyase and Cinnamyl Alcohol Dehydrogenase Genes Involved in Lignin Biosynthesis of *Erianthus arundinaceus.* Multidisciplinary Digital Publishing Institute Proceedings 36 (1): 174.

25. Madhumathi, R. and T. Arumuganathan. 2020. Soil moisture analysis using IOT. Souvenir on One day Workshop on "Sensor Interface and Integration for R &D work" organised by The Institution of Engineers (India), Coimbatore Local Centre, Coimbatore in association with Department of Mechanical Engineering, PSG College of Technology, Coimbatore held at PSG College of Technology, Coimbatore on 24th January, 2020, pp. 17.

26. Madhumathi, R., T. Arumuganathan and R. Shruthi. 2020. "Soil NPK and Moisture Analysis using Wireless Sensor Network", The 11th International Conference on Computing, Communication and Networking Technologies (ICCCNT 2020), July 1-3, 2020, Indian Institute of Technology, Kharagpur, India (Published in IEEE Xplore, DOI: 10.1109/ICCCNT49239.2020.9225547).

27. Madhumathi, R., T. Arumuganathan, R. Shruthi and R. Snehalyer. 2020. "Soil nutrient analysis using colorimetry method", The International Conference on Smart Technologies in Computing, Electrical and Electronics (ICSTCEE 2020), October 9-10, 2020, REVA University, Bengaluru, India (Published in IEEE Xplore. DOI: 10.1109/ ICSTCEE49637.2020.9277182).

28. Mahesh, P., J. Srikanth, B. Singaravelu, D. Puthira Prathap and M. Balasubramaniyan. 2020. Infestation levels of sugarcane shoot borer *Chilo infuscatellus* in Cauvery delta zone of Tamil Nadu, India. Souvenir of International Web Conference on Perspective on Agricultural and Applied Sciences in COVID-19 Scenario (PAAS-2020), 4-6 October 2020, Agricultural & Environmental Technology Development Society (AETDS), Uttarakhand, India.

29. Mahesh, P., J. Srikanth, B. Singaravelu, D. Puthira Prathap and R. Nirmala. 2020. Management of rats in sugarcane. Naadalavya 5-aavadu Velaan Ariviyal Tamil Aaraachi Maanadu [Tamil] [5th National Conference on Agricultural Scientific Tamil]. 9-10 October, 2020, Tamil Nadu Agricultural University, Coimbatore, India.

30. Mahesh, P., J. Srikanth, K.P. Salin, B. Singaravelu, K. Chandran and B. Mahendran. 2020. Natural regulation of sugarcane leaf hopper *Pyrilla perpusilla* (Walker) (Homoptera: Lophopidae) in a crop island scenario. In: Proceedings of International Seminar on Transboundary Pest Management (ISTPM 2020). (Eds. Sathiah, N, Muthukrishnan, N, Prabakar, K, Ramaraju, K, et al.,) pp. 199-200. Department of Agricultural Entomology, Centre for Plant Protection Studies, TNAU, Coimbatore, India. 4-5 March 2020.

31. Mahesh, P., J. Srikanth, N. Geetha, B. Singaravelu and R. Nirmala. 2020. Fall armyworm attack in sugarcane (Tamil). Naadalavya 5-aavadu Velaan Ariviyal Tamil Aaraachi Maanadu [Tamil] [5th National Conference on Agricultural Scientific Tamil]. 9-10 October 2020, Tamil Nadu Agricultural University, Coimbatore, India.

32. Murali, P. 2020. Economics of sugarcane and agripreneurship for doubling farmers' income in the Advanced Training Programme on Recent scientific interventions and practices of sugarcane breeding, production and utilization for doubling farmers income during 1-21 December 2020 on 11 December 2020.

33. Murali, P. 2020. Sugarcane based agri-preneurship in the innovative training program on Recent technologies of agribusiness management and agri entrepreneurship on 14 October 2020.

34. Murali, P. 2020. Webinar on 'Use of ICT in Agricultural Marketing in COVID period' on 14 May 2020 organized by CCS National Institute of Agricultural Marketing, Jaipur, Rajasthan.

35. Murali,P. 2020. Cost account management & farmers' produce trade and commerce (Promotion and Facilitation) Bill, 2020 and The Farmers (Empowerment and Protection) Agreement of Price Assurance and Farm Services Bill, 2020 in the National Farmer's Day on 23 December 2020 on organized by Regional Chapter -The Institute of Cost Accountants of India – Coimbatore.

36. Nalayeni, K., C. Franchin, L. Barnabas, N.M.R. Ashwin, P. Carletti, A.R. Trentin, P. Malathi, R. Viswanathan, A. Masi and A. Ramesh Sundar. 2020. Quantitative proteomics analysis of haploid and dikaryotic stages of *Sporisorium scitamineum* - novel insights into the pathogenesis of the sugarcane smut fungus. 7th International conference, 2020, IARI, New Delhi. Phytopathology in sustaining UN sustainable development goals. 16-20 January 2020. pp. 403.

37. Punithavalli, M and A. Jebamalai mary. 2020. Inhibitory activities of proteinase inhibitors on developmental characteristics of sugarcane *Chilo infuscatellus* (Snellen). International Seminar on Transboundry pest Management, TNAU, Coimbatore, Tamil Nadu. p.108.

38. Rajula Shanthy, T., S. Alarmelu, C. Jayabose, P. Malathi, Bakshi Ram. 2019. M-extension in sugarcane: An initiative towards digital India. In: 2nd International Conference & Exhibition on Sustainability - Innovation and diversification in sugar and allied industry from 31 January to 2 February 2020.

39. Rajula Shanthy, T., 2020. Cane Adviser, a mobile app on sugarcane in the Advanced Training Programme on Recent scientific interventions and practices of sugarcane breeding, production and utilization for doubling farmers income during 1-21 December 2020.

40. Ramesh Sundar, A., N.M.R. Ashwin, L. Barnabas, K. Nalayeni, D. Amalamol, P. Malathi and R. Viswanathan. 2020. Leveraging proteomics to decipher the interactome of disease resistance in sugarcane. Understanding regulatory mechanism through NGS approach. 7th International conference, 2020, IARI, New Delhi. Phytopathology in sustaining UN sustainable development goals. 16-20 January 2020, pp 399.

41. Ramesh Sundar, A., N.M.R. Ashwin, P. Malathi, C. Appunu and R. Viswanathan. 2020. Unlocking molecular toolbox of the enigmatic interaction involving Sugarcane and *Sporisorium scitamineum.* Proceedings in National Symposium (virtual) on Advances in crop Health Management conducted by IPS-SZ at IARI, Wellington, The Nilgiris, Tamil Nadu on 1-2 December 2020.

42. Sankaranarayanan, C. 2020. Diagnosis & management of plant parasitic nematodes with special emphasis on sugarcane nematodes. *"International Webinar* on "Bio intensive Management of Plant Parasitic Nematodes" organized by National Institute of Plant Health Management, Department of Agriculture, Cooperation & Farmers' Welfare, Ministry of Agriculture & Farmers' Welfare, Government of India, Hyderabad-500030, India on 27 November 2020.

43. Sankaranarayanan, C. 2020. Entomopathogenic nematodes for control of white grubs in sugarcane. 21 Days Advanced National Training Programme (ANTP 2020) on "Recent Scientific Interventions and Practices of Sugarcane Breeding, Production, Protection and Utilization for Doubling Farmers Income" organized by ICAR SBI, Coimbatore and National Agricultural Development Cooperative Ltd., Baramulla, J&K. on 12 December 2020.

44. Sobhakumari, V.P. 2020. Advances in plant cytogenetics. Abstract and Souvenir of

National Seminar on Exploring the scope of plant science - 2020 - Plenary lecture – p.3. held at Queen Mary's College, Chennai during 9-10 January 2020.

45. Sobhakumari, V.P., Anjana Krishna and Sreya Antony. 2020. Classical and molecular cytogenetic (GISH) studies in species and hybrids of sugarcane. Abstracts of National conference on "Plant Biotechnology: Present and future, PBPF-2020" held at St. Berchman's College, Changanassery, Kerala. 27-28 February 2020.

46. Suganya, A., K. Mohanraj and R. Karuppaiyan. 2020. Sugarcane wild relatives and their cytogenetic peculiarities in interspecific and intergeneric crosses with differential chromosome transmission patterns'. In Proc.: 2nd International conference and exhibition on suatainability-innovation and diversification in sugar and allied industry at VSI, Pune.

47. Tayade, A.S., P. Geetha and S. Anusha. 2020. Integrtaed Nutrient Management in Sugarcane. 21 days Advanced National Training Programme (ANTP 2020) on "Recent Scientific Interventions and Practices of Sugarcane Breeding, Production, Protection and Utilization for Doubling Farmer's Income"from 1st to 21st December 2020 organized by ICAR-Sugarcane Breeding Institute, Coimbatore and National Agriculture Development Cooperative Limited, Baramulla 193103, Jammu and Kashmir in virtual mode.

48. Tayade, A.S., P. Geetha, S. Anusha, P. Govindaraj and C. Palaniswami. 2019. Agronomic performance of elite sugarcane genotypes. AICRP Group Meet during 19- 20 October, 2020.

49. Thirugnanasambandam, P.P., K. Lakshmi, A. Furtado, F.C. Botha and R.J. Henry. 2020. Control of Sugar and Fibre: Insights from Sugarcane Transcriptome Analyses. Multidisciplinary Digital Publishing Institute Proceedings 36 (1): 204.

50. Thirugnanasambandam, P.P., K. Lakshmi, A. Furtado, F.C. Botha and R.J. Henry. 2020. Control of Sugar and Fibre: Insights from Sugarcane Transcriptome Analyses Multidisciplinary Digital Publishing Institute Proceedings 36 (1): 204.

51. Valarmathi, R., H.K. Mahadeva Swamy and C. Appunu. 2020. Deciphering the drought tolerance mechanism in sugarcane wild relative *Erianthus arundinaceus:* Anatomical plasticity of shoot borne roots. International Plant Physiology Virtual Conference on Prospects of Plant Physiology for Climate Proofing Agriculture, Organized by Society for plant Physiology, December 6-7, 2020.

52. Valarmathi, R., H.K. Mahadevaswamy and C. Appunu. 2020. Photosynthetic efficiency and its correlation with drought adaptive root traits in sugarcane germplasm under water deficit condition. International webinar on "Plant Physiology Paradigms towards agricultural Sustainability under Climate Change" Organized by Bihar Agricultural University, Sabour, Bhagalpur, September 15, 2020.

53. Vasantha, S. 2019. Delivered an Invited lecture "Sugarcane for prosperity and posterity" in the International Seminar jointly organized by Botany and Chemistry Departments, Vellalar College of Arts & Science for Women on 19th December, 2019, Vellalar College, Erode.

54. Vasantha, S. 2019. Seaweeds-growth promoters in sugarcane and crop plants. In Souvenir of National workshop on advanced trends in marine macro algal taxonomy, cultivation & utilization, Organized by Botanical Survey of India, Coimbatore, during 21-25 October, 2019. pp. 103-111.

55. Vasantha, S. 2020. Participated in 5th National Conference on" Agricultural Scientific Tamil" organized by TNAU, Coimbatore and Agricultural Scientific Tamil Society (SciTSA), New Delhi during October 20, 2020.

56. Viswanathan, R. 2020. Addressing varietal degeneration to sustain sugarcane cultivation in India. Materials Innovation for Sustainable Agriculture (MISA 2020),

November 12, 2020, Orlando, UCF, Florida (Virtual mode).

57. Viswanathan, R. 2020. Emerging sugarcane pests and diseases. Webinar on "Combating post-COVID-19 challenges in sugarcane sector: Appropriate Technologies and approaches" on 25 June 2020, ICAR-SBI, Coimbatore.

58. Viswanathan, R. 2020. Impact of climate change on sugarcane diseases and development of new diseases in sugarcane. 2nd International Conference and Exhibition on "Sustainability – Innovation and Diversification in Sugar and Allied Industry, 31January to 2 February, 2020 at VSI, Pune, pp. 84.

59. Viswanathan, R., M. Nandakumar, P. Malathi and A. Ramesh Sundar. 2020. Molecular basis of red rot resistance in sugarcane: understanding regulatory mechanism through NGS approach. 7th International Conference on Phytopathology in Achieving UN Sustainable Development Goals", Indian Phytopathological Society, January 16-20, 2020, ICAR-IARI, New Delhi, pp. 12.

11. RESEARCH PROJECTS

1. Breeding superior sugarcane varieties of different maturity with improved cane yield, quality and resistance to biotic and abiotic stresses
2. Enhancement of sugarcane germplasm and development of pre-breeding material
3. Sugarcane genomics and molecular markers
4. Gene discovery and genetic transformation in sugarcane
5. Development of cropping systems and improved agronomic practices to enhance sugarcane productivity
6. Enhancing physiological efficiency of sugarcane
7. Natural resource management for enhancing productivity and sustainable sugarcane production
8. Host resistance, interactomics, pathogen variability, diagnosis and disease management in sugarcane
9. Studies on sugarcane pests and their management
10. Basic and applied studies of sugarcane phytonematodes and entomopathogenic nematodes
11. Economic and statistical studies in sugarcane and sugar production system
12. Transfer of sugarcane technologies
13. Standardization of true seed production technique through developing homozygous parental lines and apomixes
14. All India Coordinated Research Project (Sugarcane)

12. CONSULTANCY, PATENTS, COMMERCIALIZATION OF TECHNOLOGIES

- ICAR-SBI has signed MoU with OXYTECH Corporation, Pvt (ltd) Coimbatore for licensing of Soil Moisture indicator (SMI) technology on 09-12-2020.
- Licenced liquid jaggery production technology to Cropnrich Agri Private Limited, Wayanad on 01-09-2020.

- Licenced EPN formulation for white grub control to T.Stanes and Co Ltd on 02-09-2020.
- Licenced liquid jaggery production process to Nijass Associates, Kannur, Kerala on 12.10.2020

13. EVENTS

At Coimbatore

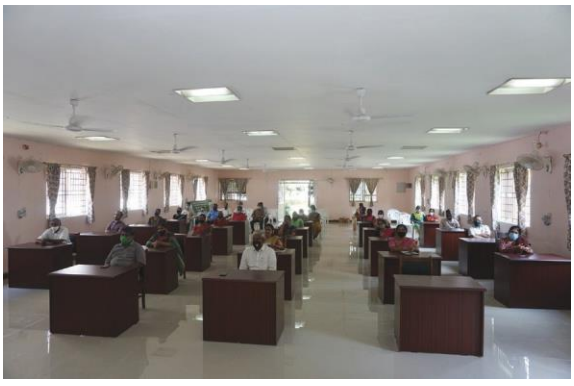
Independence Day

Independence Day was celebrated in the Institute on 15 August 2020. Dr. Bakshi Ram, Director, ICAR-SBI hoisted the National flag and addressed the staff (Fig. 132).

Fig. 132. Independence Day celebration (15 August 2020)

Hindi Day Celebration

Hindi Day was celebrated on 29 September 2020 (Fig. 133). 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. Bakshi Ram, Director, ICAR-SBI.



Hindi Workshop

Quarterly Hindi Workshops were conducted on

Fig. 133. Hindi Day celebration

20 June 2020, 26 September 2020, 22 December 2020 and 23 March 2020 wherein Dr. P. Ganesan, HOD, Hindi Department, Sugana Institute of Poultry Management, Udumelpet and Dr. Ramesh Kumar, HOD, Hindustan College of Arts and Science, Coimbatore was the Chief Guest and he spoke on Noting and drafting in Hindi.

Gandhi Jayanthi celebration

On the occasion of 150th birth anniversary of Mahatma Gandhi, a webinar was organized on 2 October 2020. A special lecture on 'Gandhian philosophy in the backdrop of agricultural transformation' was delivered by Dr. J. Venkataprabhu, Director, Directorate of Planning and Monitoring, Tamil Nadu Agricultural University.

Brainstorming Session on Sugarcane based ethanol production for sustainable fuel ethanol blending programme

Organized 'Brainstorming Session on 'Sugarcane based ethanol production for sustainable fuel ethanol blending programme' (online) on 18 September 2020 sponsored by NAAS, New Delhi under the chairmanship of Dr. Mangala Rai, Former President NAAS and DG, ICAR & Secretary DARE, co-chaired by Dr. T. Mohapatra, President, NAAS and DG, ICAR & Secretary DARE. Dr Bakshi Ram, Director, ICAR-Sugarcane Breeding Institute, Coimbatore served as the Convener of the session.

Release of commemorative coin on FAO

One Hundred and Eleven staff of the institute participated in the virtual programme with respect to release of commemorative coin on Food and Agricultural Organization (FAO) at 75th and World Food Day held on 16 October 2020.

Webinar on 'Combating post-COVID-19 challenges in the sugarcane sector through appropriate technologies and approaches

ICAR-Sugarcane Breeding Institute, Coimbatore organized a webinar on 'Combating post-COVID-19 challenges in the sugarcane sector through appropriate technologies and approaches' on 25 June 2020 to tackle the COVID crisis by sugarcane farmers and sugar factories. While inaugurating the webinar, Smt. Reeta Harish Thakkar IAS, Commissioner of Sugar, Government of Tamil Nadu and Managing Director, Tamil Nadu Sugar Corporation, said that this webinar is a welcome initiative from ICAR-Sugarcane Breeding Institute.

Constitution Day pledge

Constitution Day pledge was taken by the Director and the staff of the Institute on 26 November 2020.

'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.

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.

Soil health cards and masks were distributed to the farmers of MGMG village Rindal, Badegaon,

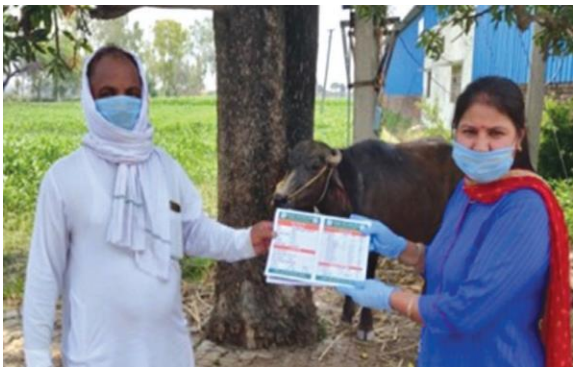


Fig. 134. Distribution of Soil Health Cards and masks to farmers

Fig. 135. Distribution of Soil Health Cards and masks to farmers of Mahmadpur

Fig. 136. Field visit to seed field

Fig. 137. Krishi Gosthi at Budhanpur village on 28 November 2020

Landora, Makhumajra under RKVY project and also sensitized them about sugarcane protection technologies on June 11, 2020 (Fig. 134).

Scientists of ICAR-SBI, Karnal along with cane development officials of Karnal Cooperative sugar mills, Karnal organized Krishi Gosthi at MGMG village Mahmadpur (Karnal) and also distributed soil test report and face masks to the farmers on 30 September 2020 (Fig. 135).

Visits were made to the seed field of variety Co 15023 with inter crops (wheat and garlic) of Mr. Balwant Singh at MGMG village Rindal on 23 December 2020 (Fig. 136).

Krishi Gosthi was organized with thecollaboration of Piccadily sugar mill, Bhadson, Karnal at village Budhanpur on 28 November 2020. (Fig. 137). About 46 farmers and sugar mill officials were participated and interacted with scientists.

'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 2020 (Fig. 138).

At Karnal

Innovative Sugarcane Farmers Workshop 2020: Organized one-day Innovative Sugarcane Farmers Workshop sponsored by SSRD on 27 February 2020 (Fig.139).

'Kisan Mela'

Organized two days Ganna Kisan Mela during 28 -29 Feb. 2020 about 2400 farmers and sugar mill officials from Haryana, Punjab, UP, Uttarakhand, Rajasthan, Gujarat and Maharashtra attended this event (Fig. 140).

Fig. 138. Cleanliness Drive Campaigns during Swachchhta Pakhwada

Fig. 139. Innovative Sugarcane Farmers Workshop at Karnal

Fig. 140. 'Kisan Mela' at ICAR-SBI, RC, Karnal

Fig. 141. 'Kisan Diwas' at village Rindal on 23 December 2020

'Kisan Diwas'

Celebrated Kisan Diwasor National Farmers' Day at village Rindal to mark the birth anniversary of fifth Prime Minister, Choudhary Charan Singh on 23 December 2020 (Fig. 141). Scientists were discussed with farmers about importance of healthy seed production, Identification of sugarcane varieties and management ofInsect–pests, diseases and nutrient - deficiency in sugarcane crop and answered the questions asked by the farmers. Farmers were also appraised about the cleanliness of their fields and village surroundings.

14. COMMITTEES

RESEARCH ADVISORY COMMITTEE MEETING

The XXVI Research Advisory Committee meeting of the Institute was held online on 19 December 2020. Dr. S. Solomon, Former Director, Indian Institute of Sugarcane Research, Lucknow served as the Chairman. Other expert members were Dr. S.R. Bhat, New Delhi; Dr. Chandish R. Ballal, Retd. Director, ICAR-NBAIR, Bengaluru; Dr. H. K. Senapati, Ex-Dean PGF cum DRI, Odisha Univ. of Agr. & Technology, Bhubaneswar, Odisha; Dr. J.P. Alex, Director of Extension Education, Kerala Agricultural University, Thrissur; Dr. R.K Singh, ADG Commercial Crops, ICAR, New Delhi, Dr. Bakshi Ram, Director, ICAR SBI and Dr. P. Govindaraj, Member Secretary. The meeting was attended by the Heads of Divisions / Regional Station Karnal, Research Centres at Kannur and Agali and Heads of Sections and all scientists.

Dr. Bakshi Ram formally welcomed the expert members and presented the global and Indian sugar scenario and major achievements of the Institute during 2019-20. Dr. P. Govindaraj, Member Secretary presented the Action Taken Report of the recommendations of previous RAC. This was followed by presentations on the achievements of the Divisions/ Centres / Sections by Drs. G. Hemaprabha, C. Palaniswami, R. Viswanathan, S.K. Pandey, T. Rajula Shanthy, K. Chandran, V. Srinivasa and P. Murali.

Dr. S. Solomon, Chairman and the members congratulated Director and staff of the Institute for the commendable progress made during the period.

Dr. S. Solomon and the members gave their views based on the reports presented and sought more clarifications on specific research aspects. There were deliberations to take the research activities of the institute to greater heights. The recommendations of RAC are:

1. Germplasm collection should focus on specific traits of importance and targeted explorations should be conducted to enrich the germplasm resources. Core collections of germplasm of Saccharum species need to be identified for better focus on trait enhancement through pre-breeding using molecular markers. Enhancement of cryopreservation and in vitro conservation facility as a complementary mode of world sugarcane germplasm conservation should be explored.
2. In the true seed varietal development programme inbred parents with improved homozygosity, better combining ability and heterotic ability needs to be explored. Haploid production through wide hybridization should be carried out with irradiated pollen of related wild Saccharum species for better results.
3. The transcriptomics research programme at the institute needs a critical review in terms of useful genes identified for employing them in MAS. Biotechnology group should focus on the genetic transformation in sugarcane on one or two major traits of relevance, which could be useful for the crop improvement / crop protection programmes. Efforts must be taken by the Institute to become a member of the International Sugarcane Consortium to augment full genome sequencing. Hence more fund allocation may be sought from ICAR and the required budget should be included in the current EFC document.
4. Basic work on genetics and cytogentics of sugarcane may be initiated to understand the nature of chromosome pairing (homologous/homeologous) and segregation. Also, molecular marker work should focus on finding markers that show Medelian inheritance to facilitate construction of linkage maps, tagging of simple traits and to support cytogentic analyses.
5. Ratoon management and enhancement of physiological efficiency of ratoon, leading to increased ratoon productivity should be studied. Validate root system traits

for better/enhanced nutrient uptake in challenging environments (such as water/ salt stress) and correlate with the growth and productivity of plant as well as successive ratoon crops.

6. Climate resilient/smart technologies should be developed for improved cane productivity in plant and ratoon crops vis-a-vis higher sugar accumulation/ productivity. Quantification of the Carbon footprint (CF) and Water footprint (WF) of sugarcane production in the different agro-climatic zones need to be taken up for sustainable and profitable sugarcane production, inclusive of ratoon crop.
7. Diversification of sugarcane is the need of the hour and growing energy demand ofthe nation necessitates assessment of the potential of sugarcane and energy cane biomass for lignin and 2G ethanol. It is imperative to identify and develop high value feed stocks for production of ethanol, chemicals/ therapeutics, cogeneration, paper/pulp and bio-plastics.
8. The sugar industry in sub-tropical India is concerned about the disease infestation in the wonder variety Co 0238 by a new virulent pathotype of red rot. It is suggested that (a) ICAR-SBI and ICAR-IISR pathologists should undertake a massive screening program of all the varieties under cultivation in NW region (b) quality seed production facility needs to be strengthened at Karnal center (c) ICAR-SBI should arrange seed treatment kiosks in 5-6 sugar mills in eastern U.P. & Bihar using Seed Treatment Device + Thiophenate methyl in the ensuing spring planting season to contain the red rot and improve field life of Co 0238 (d) A virtual brainstorming workshop of Sugarcane Pathologists of SBI/IISR/UPCSR and CDOs of U.P. and Bihar should be organized as early as possible to check the growing menace of red rot in Uttar Pradesh & Bihar (e) Pathologists & biochemists should also investigate the reasons for the sudden breakdown of resistance of Co 0238 to red rot.
9. Severity of YLD has not been properly addressed in many parts of the country especially in the subtropics, its effective management through raising tissue culture based nursery should be worked out. Cane yield and sucrose losses due to YLD should be worked out. It is also imperative to identify the disease-resistant sources to YLD in sugarcane germplasm and utilize them to breed YLD-resistant varieties. Explore the efficacy of serial HWT treatments for the establishment of virus/phytoplasma free seed cane nurseries for the new promising varieties as being applied in several western countries
10. Toxicological data needs to be generated for registration and commercialization of efficient entomopathogenic fungi and bacteria. The requisite funding for outsourcing the work needs to be included in the EFC document. A clear recommendation on the specific bioagent to be used for each region should emerge for the sustainable management of white grubs based on the research findings in the Crop Protection Division on the effectiveness of potential isolates of entomopathogenic fungi, bacteria and nematodes in different agro-climatic zones. A holistic pest management module (for insect pest and disease management) should be validated in Farmers' fields. Kannur center should further explore the feasibility of utilizing the naturally occurring EPF, Hirsutella sp. for biocontrol of Pyrilla and other important sugarcane sucking pests
11. Cost of cultivation vis a vis productivity of sugarcane for different sugarcane agro-climatic regions need to be worked out and compared for the profitability of the farmers. Large scale field experiments with greater incorporation of bio-based technologies/ green technologies should be tried in each agro-climatic zone for reducing the cost of production and doubling farmers income. Expansion of ICAR-SBI activities for large scale commercialization of technologies through ABI by developing appropriate

entrepreneurship development programmes should be emphasized. Extension division has to establish linkages with more KVKs to conduct demonstrations and field trials.

12. There should be joint efforts by the scientists in the Extension and Economics Sections to undertake cross section analysis of the reasons for differential adoption of varieties and other technologies across different socio economic status of farmers and also improvement in the livelihood of the farmers. The technologies developed, their spread, impact and success stories should be digitally documented for easy access to farmers, entrepreneurs and other users. The content and functionalities of mobile application developed by ICAR-SBI has to be updated at frequent intervals, for which funds have to be made available.
13. Supply chain and value chain management of sugarcane and its products may be studied involving extension scientists and economist. Supply chain interruptions due to temporal changes necessitated by the COVID 19 situation should be studied.

INSTITUTE RESEARCH COUNCIL MEETING

The Institute Research Council meeting was conducted from 20-25 July 2020. The progress of the ongoing research projects was reviewed and suggestions were offered. Thirteen sub-projects were concluded and 15 new sub-projects were approved for the coming year.

15. PARTICIPATION IN CONFERENCES, MEETINGS, WORKSHOPS, SYMPOSIA AND SEMINARS

Title	Date	Participant (s)
International conference on Recent trends in agriculture towards food security and rural livelihood by Faculty of Agriculture, Annamalai University	3-4 January 2020	Dr. K. Mohanraj
NADP Stakeholder's Workshop on Remote sensing based information on crop coverage, yield estimation and drought monitoring organized at the Department of Remote Sensing & GIS, Tamil Nadu Agricultural University, Coimbatore	7 January 2020	Dr. T. Arumuganathan
National Seminar on Exploring the scope of plant science- 2020 - Plenary lecture held at Queen Mary's College, Chennai	9-10 January 2020	Dr. V.P. Sobhakumari
7th International Conference on Phytopathology in achieving UN Sustainable development goals by Indian Phytopathological Society, ICAR-IARI, New Delhi	16-20 January 2020	Dr. R. Viswanathan
Launch program of sugarcane seed sustainability programme 'Rasdhara' in collaboration with Pregmatix India for production of quality seed of ICAR-SBIRC, Karnal varieties and promotion of mechanization in sugarcane at Meham Sugar Mill, Meham	21 January 2020	Dr. S.K. Pandey Dr. Ravinder Kumar

Steering Committee meeting of Directorate of Open and Distance Learning of Tamil Nadu Agricultural University, Coimbatore	22 January 2020	Dr. T. Rajula Shanthy

Title	Date	Participant (s)
32nd Kerala Science Congress expo, at Yuvakshetra Institute of Management Studies, Mundoor, Palakkad	24-27 January 2020	Dr. K. Chandran Dr. M. Nisha Dr. R. Gopi Dr. B. Mahendran
Workshop on Israeli Innovation for Indian Agriculture at Indo Israel International Joint Conference on Sustainable Cities organized jointly by Tel Aviv University (TAU), Agricultural Research Organisation, Volcani Center (ARO), PSG College of Technology (PSGCT) and Kumaraguru College of Technology (KCT) held at KCT, Coimbatore	29 January 2020	Dr. T. Arumuganathan
2nd International Conference and Exhibition on Sustainability – Innovation and diversification in sugar and allied industry, VSI, Pune	31 January- 2 February 2020	Dr. Bakshi Ram Dr. R. Viswanathan Dr. S. Alarmelu Dr. A. Suganya Dr. T. Rajula Shanthy
ECRA Third Group Monitoring Workshop held at BITS-Pilani, Hyderabad campus, Hyderabad	15 February 2020	Dr. G.S. Suresha
National conference on Plant biotechnology: Present and future, PBP, 2020 held at St. Berchman's College, Changanassery, Kerala	27-28 February 2020	Dr. V.P. Sobhakumari
Rural India Business Conclave at ICAR-CPCRI, Kasaragod	1-3 March 2020	Dr. P. Murali
International Seminar on Trans boundary pest management (ISTPM 2020). Department of Agricultural Entomology, Centre for Plant Protection Studies, TNAU, Coimbatore	4-5 March 2020	Dr. P. Mahesh Dr. J. Srikanth Dr. K.P. Salin Dr. B. Singaravelu Dr. K. Chandran Dr. M. Punithavalli Dr. B. Mahendran
150 years of science through the pages of Nature at M.S.Swaminathan Research Foundation, Chennai	6 March 2020	Dr. R. Valarmathi
Zoom meeting with Directors of Crop Science Institutes	17 March 2020	Dr. Bakshi Ram
One-day online workshop on Training Management Information System (TMIS) for HRD Nodal officers of ICAR	8 May 2020	Dr. K. Hari
Joint Annual Group Meeting of AICRP and ICAR Seed Project by ICAR-IISS, MAU	14-15 May 2020	Dr. Bakshi Ram
Webinar on Science, Society and Exponential change: Reimagining the future by Dr.Pratibha Jolly, Former Principal, Miranda House, University of Delhi	20 May 2020	Dr. Bakshi Ram

Title	Date	Participant (s)
Webinar on Approaches of public funded research organizations in Agri-technology generation and its transfer in new normal situation at NAARM, Hyderabad	28 May 2020	Dr. K. Hari
National Webinar on Scope and scenario of agriculture after Covid-19 organized by Maharana Pratap University of Agriculture & Technology, Udaipur, Rajasthan	29 May 2020	Dr. T. Arumuganathan
Webinar on Solar dryer for entrepreneurship delivered by Dr. A.G. Mohod, Head of the Department, College of Agriculture, Dr.Balasaheb Sawant Konkan Krishi Vidyapeeth (DBSKKV), Dapoli, Ratnagiri, Maharashtra organised by Shivramji Pawar Gramin Institute of Agricultural Engineering and Technology, Nanded, Maharashtra	2 June 2020	Dr. T. Arumuganathan
Webinar on Role of drone technology in civil and agriculture sector" for entrepreneurship delivered by Sh. A.J. ArunJeya Prakash, Director & CEO, Aviocian Technologies, New Delhi	6 June 2020	Dr. T. Arumuganathan
Steering Committee of ODL, TNAU	13 June 2020	Dr. T. Rajula Shanthy
Webinar on Farmer Producer Organizations and the transformation of Farming by Dr E Vadivel, Strategic Advisor - Farmer Producer Organizations and Former Dean - Horticulture, TNAU organised by Kumaraguru Institute of Agriculture, Erode	13 June 2020	Dr. T. Arumuganathan
Webinar on Combating post-COVID-19 challenges in sugarcane sector: Appropriate Technologies and approaches organized by ICAR- Sugarcane Breeding Institute, Coimbatore	25 June 2020	All scientists of ICAR-SBI
11th International Conference on Computing, communication and networking technologies organised by Indian Institute of Technology (IIT), Kharagpur, India in association with IEEE Kharagpur Section held at IIT, Kharagpur	1-3 July 2020	Dr. T. Arumuganathan
IPS Webinar on Innovative strategies to reduce aflatoxin contamination in foods by Dr. R. Velazhahan, Associate Professor, Department of Plant Sciences, College of Agricultural and Marine Sciences, Sultan Qaboos University, Muscat, Sultanate of Oman, on the celebration of International Plant Health 2020 Indian Phytopathological Society (South Zone)	9 July 2020	Dr. R. Gopi

Title	Date	Participant (s)
IPS Webinar on Recent developments in plant pathogen detection, discovery and diagnostics for deploying effective managements against emerging diseases by Dr R Selvarajan, Principal scientist (Plant virology), ICAR-NRCB, Trichy.on the celebration of International Plant Health 2020 Indian Phytopathological Society (South Zone)	9 July 2020	Dr. R. Gopi
National E-Conference on Communication, computation, control and automation CCCA-2020 organized by the Department of Electronics and Communication Engineering, Sri Ramakrishna Institute of Technology, Coimbatore	17 July 2020	Dr. T. Arumuganathan
Webinar on Frontline extension in agriculture delivered by Dr. S. Prabhu Kumar, Former Director, ICAR-ATARI Zone I, Ludhiana & Zone VIII, Bangalore, organised by Kumaraguru Institute of Agriculture, Erode	18 July 2020	Dr. T. Arumuganathan
International E-Conference on Covid-19 Global Impacts organized by African - British Journals	20-21 July 2020	Dr. T. Arumuganathan
National webinar on Integrated water management: a paradigm shift for higher productivity in agriculture organized by Faculty of Agriculture, Department of Agronomy, Annamalai University, Chidambaram	30 July 2020	Dr. P. Geetha
International Plant Biology (Conference 2020), presented a paper titled: "Novel insights into the genetic control of Phenylpropanoid pathway of *Erianthus,* a potential bioenergy crop" Washington DC, USA	27-31 July 2020	Dr. K. Lakshmi
Webinar on Organic farming: Need of the hour organized by K.K. Wagh College of Agriculture, Nashik, Maharashtra	6 August 2020	Dr. T. Arumuganathan
Green Sugar Summit 2020 on Making Indian Sugar Sector World Class in Green held (Online)	6 -7 August 2020	Dr. Bakshi Ram
Zoom meeting on NABL Accreditation of ICAR laboratories	13 August 2020	Dr. C. Palaniswami
NPFGGM Review Meeting	18-19 August 2020	Dr. C. Appunu
General Board Meeting of TNAU, Coimbatore	18 August 2020	Dr. Bakshi Ram
Nation webinar on Abiotic stress in agriculture: Geospatial characterization and management options organized by ICAR-National Institute of Abiotic Stress Management, Baramati	27 August 2020	Dr.P.Geetha Dr.S.Anusha

Title	Date	Participant (s)
Executive Development Programme organized by National Sugar Institute, Kanpur during (Online)	24-28 August 2020	Dr. Bakshi Ram
Webinar on Weed science: Challenges in the California rice ecosystems organized by Bioingene.com	28 August 2020	Dr. S. Anusha
Webinar on Response surface methodology - An introduction and its applications in research organised by ICAR – Central Institute of Agricultural Engineering, Regional Centre, Coimbatore	28 August 2020	Dr. T. Arumuganathan
National webinar on Relevance of modelling in nutrient and water management organized by Faculty of Agriculture, Department of Soil Science and Agricultural Chemistry, Annamalai University	4 September 2020	Dr. P. Geetha
Meeting on Intellectual property rights in agricultural research & education in India organized by National Agricultural Higher Education Project & Intellectual Property and Technology Management Unit (ITMU), New Delhi	12-28 September 2020	Dr. P. Murali
Workshop on IPR & Technology commercialization: Status and opportunities in ICAR by ZTMU, IIMR, Hyderabad and IP&TM, ICAR, New Delhi	15 September 2020	Dr. K. Hari
International webinar on Plant physiology paradigms towards agricultural sustainability under climate change organized by Bihar Agricultural University Sabour, Bhagalpur	15 September 2020	Dr. R. Valarmathi Dr. H.K. Mahadeva Swamy Dr. C. Appunu
Online Review Meeting on Progress on ZTMC activities in ICAR Crop Institutes in the Southern Indian zone ICAR-IIMR, Hyderabad and IP&TM, ICAR, New Delhi	16 September 2020	Dr. K. Hari
Webinar on Mechanisation in value addition of banana and generation of wealth from banana pseudo stem waste organised by ICAR-Central Institute of Agricultural Engineering, Regional Centre, Coimbatore	18 September 2020	Dr. T. Arumuganathan
Brainstorming session on sugarcane based ethanol production for sustainable fuel ethanol blending programme by NAAS and ICAR- Sugarcane Breeding Institute, Coimbatore	18 September 2020	All scientists of ICAR-SBI
Webinar on Current opinion on horticultural mechanisation in India organised by ICAR-Central Institute of Agricultural Engineering, Regional Centre, Coimbatore	25 September 2020	Dr. T. Arumuganathan
Workshop/Lecture on Gandhian Philosophy to commemorate the 150th Birth Anniversary of Mahatma Gandhi by Dr. R.C. Agarwal, DDG (Edn.) and Dr. A.K. Vyas, ADG (HRM), ICAR	29 September 2020	All Scientists of ICAR-SBI

Title	Date	Participant (s)
Webinar on Gandhian philosophy in the back drop of agricultural transformation to commemorate the 150th Birth Anniversary of Mahatma Gandhi organised by ICAR-SBI	30 September 2020	All Scientists of ICAR-SBI
One-day National webinar on Halophytes for alleviating salinity stress in agriculture: potentials and problems organised by ICAR-National Institute of Abiotic Stress Management, Baramati	30 September 2020	Dr. K. Hari Dr. P. Geetha Dr. S. Anusha
International Web Conference on Perspective on Agricultural and applied sciences in COVID-19 scenario (PAAS-2020), Agricultural & Environmental Technology Development Society (AETDS), Uttarakhand	4-6 October 2020	Dr. P. Mahesh Dr. J. Srikanth Dr. B. Singaravelu Dr. D. Puthira Prathap
Invited Guest Lecture on October 09, 2020 at ICAR-CICR, Coimbatore on the occasion of Hindi Diwas	9 October 2020	Dr. A.S. Tayade
National webinar on Geospatial approaches for agricultural water management, Dr.Rajendra Prasad Central Agricultural University, Pusa (Bihar) with National Higher Education Project (ICAR),New Delhi	7-9 October 2020	Dr. P. Geetha
Virtual workshop and review meeting on National Agriculture Innovation Fund (NAIF) scheme component – II (ABI)	9- 10 October 2020	Dr. P. Murali
International Conference on Smart Technologies in Computing, Electrical and Electronics (ICSTCEE 2020) held at REVA University, Karnataka, India	9-10 October 2020	Dr. T. Arumuganathan
5th National Conference on Agricultural Scientific Tamil. Tamil Nadu Agricultural University, Coimbatore, India	9-10 October 2020	Dr. P. Mahesh Dr. J. Srikanth Dr. B. Singaravelu Dr. D. Puthira Prathap Dr. R. Nirmala
Demonstration of settling planter in village Jadauli, Karnal	13 October 2020	Dr. S. K. Pandey and Dr. Ravinder Kumar
RAC Meeting of IFGTB, Coimbatore	15 October 2020	Dr. A. Selvi
33rd Biennial Workshop of AICRP on sugarcane	19-20 October 2020	Dr. Bakshi Ram
Annual Convention of STAI held in Delhi 2020 (Online)	20-21 October 2020	Dr. Bakshi Ram Dr. G. Hemaprabha Dr. S. Alarmelu Dr. C. Appunu Dr. K. Mohanraj

Title	Date	Participant (s)
Field day cum training program organized by ICAR-NDRI, Karnal under Project Farmers First in village Nagla Rodan, Karnal	21 October 2020	Dr. S. K. Pandey
Sugar Tech 2020 organized by CII (Online)	22 October 2020	Dr. Bakshi Ram
Webinar on Automation in agricultural mechanisation: An overview organised by ICAR-Central Institute of Agricultural Engineering, Regional Centre, Coimbatore	23 October 2020	Dr. T. Arumuganathan
Addressing varietal degeneration to sustain sugarcane cultivation in India. Materials Innovation for Sustainable Agriculture (MISA 2020), Orlando, UCF, Florida (Virtual mode)	12 November 2020	Dr. R. Viswanathan
Scientific Advisory Committee meeting of MYRADA KVK, Erode	18 November 2 020	Dr. T. Rajula Shanthy
Opening session ceremony of M/s Rana Sugars Pvt Ltd, Butter Seviyan, Punjab and delivered a talk on Settling way production of sugarcane healthy seed	20 November 2020	Dr. Ravinder Kumar
International e-conference on Advances and future outlook in biotechnology and crop improvement for sustainable productivity at University of Horticultural Sciences, Bagalkot	24-27 November 2020	Dr. R. Gopi
Webinar on New education policy and right to education organized by Indian Council of Agricultural Research, New Delhi.	26 November 2020	Dr. B. Mahendran
International Webinar on Impact of water stress on crop productivity: its mitigation and adaptation strategies organized by Center of Excellence on Water Management, Dr.Rajendra Prasad Central Agricultural University, Pusa, Bihar	24-26 November 2020	Dr. P. Geetha
International Colloquium on Crop Physiology organized by Tamil Nadu Agricultural University, Coimbatore	26-27 November 2020	Dr. P. Geetha Dr. S. Anusha
International Webinar on Bio-intensive management of plant parasitic nematodes organized by National Institute of Plant Health Management Department of Agriculture, Cooperation & Farmers Welfare Ministry of Agriculture & Farmers Welfare, Government of India, Hyderabad	27 November 2020	Dr. C. Sankaranarayanan
National Symposium (virtual) on Advances in crop health management conducted by IPS-SZ at IARI, Wellington, The Nilgiris, Tamil Nadu	1-2 December 2020	Dr. R. Viswanathan Dr. A. Ramesh Sundar Dr. P. Malathi Dr. C. Appunu Dr. Ashwin NMR

Title	Date	Participant (s)
International Webinar on Innovations and advances in Agricultural Engineering organised by Agricultural Engineering College and Research Institute, TNAU, Kumulur, Trichy and Directorate of Agri Business Development under NAHEP – Institutional Development Programme	2-4 December 2020	Dr. T. Arumuganathan
International Plant Physiology Virtual Conference on Prospects of Plant physiology for climate proofing agriculture, organized by Society for Plant Physiology	6-7 December 2020	Dr. R. Valarmathi Dr. H.K. Mahadeva Swamy Dr. C. Appunu
XVII meeting of the Institute Management Committee of ICAR-CTCRI (Zoom meeting)	18 December 2020	Dr. C. Palaniswami
Brain Storming Session on Application of UAV in Indian agriculture – Issues and perspectives organised by ICAR – Central Institute of Agricultural Engineering, Bhopal	21 December 2020	Dr. T. Arumuganathan
Special Address during the inauguration of Certificate course on 'Sugarcane Production Technology' in Seminar Hall, WTC, TNAU	28 December 2020	Dr. T. Rajula Shanthy

16. DISTINGUISHED VISITORS

- Shri. Yogendra Kumar, Marketing Director of Indian Farmer's Fertilizer Cooperation ltd, (IFFCO) visited the Institute on 10.01.2020.
- Dr. R. Anandakumar, IAS, Commissioner of Sugar along Managing Directors and Cane heads of sugar factories visited the institute on 1.10.2020 and held discussion regarding the performance of new high sugar varieties and strategies to improve sugar recovery in Tamil Nadu (Fig. 142).
- Shri. Gagandeep Singh Bedi, IAS, Agricultural Production Commissioner & Principal Secretary to Government visited the Institute on 17 December 2020 to appraise the activities of SBI and NADP project.

Fig. 142. Dr. R. Anandakumar, IAS, Commissioner of Sugar, Tamil Nadu interacting with Scientists

17. PERSONNEL

Name	Designation & Discipline	E-mail ID
Bakshi Ram Ph.D.	**Director**	**bryadav2003@yahoo.com**
Division of Crop Improvement		
G. Hemaprabha Ph.D.	Pr. Scientist (Plant Breeding) & Head I/c	ghemaprabha1@gmail.com
N. Rajendra Prasad Ph.D.	Pr. Scientist (Seed Technology)	rajendra@hotmail.com
A.J. Prabakaran Ph.D.	Pr. Scientist (Plant Breeding)	prabakaran.aj@icar.gov.in
R.M Shanthi Ph.D.	Pr. Scientist (Plant Breeding)	rmshanthi288_@rediff.com
D. Neelamathi Ph.D.	Pr. Scientist (Seed Technology)	neelamathi2005@hotmail.com
S. Alarmelu Ph.D.	Pr. Scientist (Plant Breeding)	alar_kannan@rediffmail.com
P. Govindaraj Ph.D.	Pr. Scientist (Plant Breeding)	govindsbi@rediffmail.com
A. Selvi Ph.D.	Pr. Scientist (Plant Biotechnology)	selviathiappan@yahoo.co.in
V.P. Sobhakumari Ph.D.	Pr. Scientist (Gen. &Cyto.)	vpsobhakumari@rediffmail.com
A. Suganya Ph.D.	Pr. Scientist (Economic Botany)	suganyamuns@rediff.com
S. Karthigeyan Ph.D.	Pr. Scientist (Plant Breeding)	karthi.sugarcane@gmail.com
A. Anna Durai Ph.D.	Pr. Scientist (Plant Breeding)	ayyadu@gmail.com
R. Manimekalai Ph.D.	Pr. Scientist (Plant Biotechnology)	rmanimekalai@rediffmail.com
R. Karuppaiyan Ph.D.	Pr. Scientist (Plant Breeding)	Karuppaiyan.R@icar.gov.in
C. Jayabose Ph.D.	Pr. Scientist (Genetics)	jayabosec@yahoo.com
K. Devakumar Ph.D.	Sr. Scientist (Plant Biotechnology)	K_devakumar@yahoo.com
K. Mohanraj Ph.D.	Sr. Scientist (Plant Breeding)	mohangene@yahoo.com
C. Appunu Ph.D.	Sr. Scientist (Plant Breeding)	cappunu@gmail.com
K. Lakshmi Ph.D.	Sr. Scientist (Plant Biotechnology)	lakshmimbb@gmail.com
P.T. Prathima Ph.D.	Sr. Scientist (Plant Biotechnology)	prathimasambandam@gmail.com
C. Mahadevaiah Ph.D.	Scientist (Plant Breeding)	mshesha dri@gmail.com
V. Sreenivasa Ph.D.	Scientist (Plant Breeding)	seenugpb@gmail.com
Adhini S.Palani M.Sc	Scientist (Plant Breeding)	adhinisp@gmail.com
S. Sheelamary Ph.D.	Scientist (Plant Breeding)	sheelajoshkutty@gmail.com
K. Elayaraja Ph.D.	Scientist (Plant Breeding)	elayarajagenetics@gmail.com
R. Valarmathi Ph.D.	Scientist (Eco. Bot. and PGR)	valarmathi.r@icar.gov.in
V. Vinu Ph.D.	Scientist (Plant Breeding)	Vinu.kathu@gmail.com
H.K. Mahadevaswamy Ph.D	Scientist (Plant Breeding)	maddygkvk@gmail.com
T. Lakshmi Pathy M.Sc	Scientist (Plant Breeding)	Pathy4u76@gmail.com
A.K. Remadevi	Chief Technical Officer	A.K.Remadevi@icar.gov.in
A.C. Chandrasekaran	Assistant Chief Technical Officer	AC.Chandrasekaran@icar.gov.in
L. Elango	Technical Officer	L.Elango@icar.gov.in
N. Selvan	Technical Officer	N.Selvan@icar.gov.in
S. Mathesh	Senior Technical Assistant	S.Mathesh@icar.gov.in
R. Raja	Senior Technical Assistant	R.Raja@icar.gov.in
V. Raffee Viola Ph.D.	Senior Technical Assistant	raffeeviola2@yahoo.co.in
K. Selvamuthu	Senior Technical Assistant	Selvamuthu.K@icar.gov.in
P. Harunipriya Ph.D.	Senior Technical Assistant	harunibct@gmail.com
V.P. Rabisha	Technical Assistant	VP.rabisha@icar.gov.in

Name	Designation & Discipline	E-mail ID
K. Dhanapal	Technical Assistant	dhana.dhanapal50@gmail.com
R. Narayanaswamy	Senior Technician	R.Narayanasamy@icar.gov.in
M. Karthick	Senior Technician	M.Karthick@icar.gov.in
M. Kannaian	Technician	M.Kannaian@icar.gov.in
S. Mutharasu	Senior Technician	Mutharasu.S@icar.gov.in
K. Muraleekrishnan	Technician	K.Muraleekrishnan@icar.gov.in
P. Bhuvanamuzhuthudaiyal	Private Secretary	P.Bhuvana@icar.gov.in
R. Monikandan	Skilled Support Staff	Monikandan.R@icar.gov.in
N. Murugesan	Skilled Support Staff	Murugesan.N@icar.gov.in
P. Chinnaswamy	Skilled Support Staff	Chinnasamy.P@icar.gov.in
R. Saraswathi	Skilled Support Staff	Saraswathi.R@icar.gov.in
P. Dhanaraj	Skilled Support Staff	Dhanaraj.p@icar.gov.in
Division of Crop Production		
C. Palaniswami Ph.D.	Pr. Scientist (SCFM) & Head	darsanpalaniswami@yahoo.co.uk
K. Hari Ph.D.	Pr. Scientist (Microbiology)	sbi_hari@yahoo.com
S. Vasantha Ph.D.	Pr. Scientist (Plant Physiology)	vasanthavedantham@yahoo.com
R. Gomathi Ph.D.	Pr. Scientist (Plant Physiol.)	gomathi_sbi@yahoo.co.in
I. Rajendran Ph.D.	Pr. Scientist (Organic Chemistry)	sbi56rajendran@gmail.com
A. Vennila Ph.D.	Pr. Scientist (Soil Science)	avennila@gmail.com
T. Arumuganathan Ph.D.	Pr. Scientist (Farm Machinery & Power)	arumuganathan@gmail.com
A.S. Tayade Ph.D.	Pr. Scientist (Agronomy)	arjuntayade3@gmail.com
R. Arun Kumar Ph.D.	Sr. Scientist (Plant Physiol.)	agri_arun@rediffmail.com
G.S. Suresha Ph.D.	Sr. Scientist (Biochemistry)	sureshgiriyapur@gmail.com
P. Geetha Ph.D.	Scientist (Agronomy)	Geetha.P@icar.gov.in
S. Anusha Ph.D.	Scientist (Agronomy)	anusha.s@icar.gov.in
V. Krishnapriya Ph.D.	Scientist (Plant Physiol.)	Krishnapriya19@gmail.com
P. Sivaraj	Technical Officer	P.Sivaraj@icar.gov.in
M. Gnanavel	Senior Technical Assistant	M.Gnanavel@icar.gov.in
G. Aswathy	Technical Assistant	G.Aswathy@icar.gov.in
M. RajanBabu	Senior Technician	Rajan.Babu@icar.gov.in
T. Kavitha	Senior Technician	kavitha171179@gmail.com
V. Viswanathan	Skilled Support Staff	Viswanathan.V@icar.gov.in
C. Shanmugaraj	Skilled Support Staff	Shanmugaraj.C@icar.gov.in
V. Aravindhadoss	Skilled Support Staff	Aravindhadoss.V@icar.gov.in
V. Indirani	Skilled Support Staff	Indirani.V@icar.gov.in
Division of Crop Protection		
R. Viswanathan Ph.D.	Pr. Scientist (Pl. Patho.) & Head I/c	rasaviswanathan@yahoo.co.in
K.P. Salin Ph.D.	Pr. Scientist (Ag. Ento.)	kpsalin@hotmail.com
N. Geetha Ph.D.	Pr. Scientist (Ag. Ento.)	mvsbi@yahoo.com
A. Ramesh Sundar Ph.D.	Pr. Scientist (Pl. Patho.)	rameshsundar_sbi@yahoo.co.in
J. Srikanth Ph.D.	Pr. Scientist (Ag. Ento.)	srikanth_jsk@yahoo.co.in
C. Sankaranarayanan Ph.D.	Pr. Scientist (Nematol.)	chellappasankar@gmail.com
B. Singaravelu Ph.D.	Pr. Scientist (Ag. Ento.)	bsingaravelu@rediffmail.com
P. Malathi Ph.D.	Pr. Scientist (Pl. Patho.)	emalathi@yahoo.com

Name	Designation & Discipline	E-mail ID
R. Selvakumar Ph. D.	Pr. Scientist (Pl. Patho.)	selvakumar2000@gmail.com
V. Jayakumar Ph.D.	Pr. Scientist (Pl. Patho.)	jkpath@rediffmail.com
T. Ramasubramanian Ph.D.	Pr. Scientist (Ag. Ento.)	tramasubbu@gmail.com
L. Saravanan Ph. D.	Sr. Scientist (Ag. Ento.)	laxmansaravanars@gmail.com
M. Punithavalli Ph.D.	Sr. Scientist (Ag. Ento.)	punithaentomol@yahoo.co.in
P. Mahesh Ph.D.	Scientist (Ag. Ento.)	P.Mahesh@icar.gov.in
K. Nithya Ph.D.	Scientist (Pl.Patho.)	knithyapath@gmail.com
R. Nirmala	Chief Technical Officer	nirmala_sukumar@yahoo.com
K. Manivannan	Senior Technical Assistant	K.Manivannan@icar.gov.in
K. Kaverinathan Ph.D.	Senior Technical Assistant	Kaverinathan.K@icar.gov.in
C. Yogambal	Senior Technical Assistant	yogavkp@gmail.com
N.M.R. Ashwin Ph.D.	Technical Assistant	nmr.ashwin@gmail.com
M. Rajesh Kumar	Senior Technician	M.Rajeshkumar@icar.gov.in
R. Nithiyanantham	Senior Technician	R.Nithiyananthам@icar.gov.in
J. Devaraj	Technician	Devaraj.J@icar.gov.in
A. Kala	Technician	ayyasamy.kala@gmail.com
P. Ranganathan	Skilled Support Staff	Ranganathan.P@icar.gov.in
P. Subban	Skilled Support Staff	Subban.P@icar.gov.in
S. Mohan	Skilled Support Staff	Mohan.S@icar.gov.in
P. Rangasamy	Skilled Support Staff	P.Rangasamy@icar.gov.in
L.Tholasiammal	Skilled Support Staff	Tholasiammal.L@icar.gov.in
R. Easwari	Skilled Support Staff	Easwari.R@icar.gov.in
M. Shobhanbabu	Skilled Support Staff	Shobhanbabu.M@icar.gov.in
Statistics and Economics Section		
V. Venkatasubramanian Ph.D.	Pr. Scientist (Agrl. Extn.) and Head (Till 21.07.2020)	subramanian.Venkat@icar.gov.in
P. Murali Ph.D.	Sr. Scientist (Agrl. Econ)	muralisundar@rediffmail.com
D. Subhadra	Chief Technical Officer	D.Subhadra@icar.gov.in
S. Karuppasamy	Senior Technical Assistant	S.Karuppasamy@icar.gov.in
A. Pattiammal	Skilled Support Staff	Pattiammal.A@icar.gov.in
Extension Section		
T. Rajula Shanthy Ph.D.	Pr. Scientist (Agrl. Extn.) and Head	Rajula.shanthy@icar.gov.in
D. Puthira Prathap Ph.D.	Pr. Scientist (Agrl. Extn.)	dp.prathap@icar.gov.in
Malakappa B. Medegar	Senior Technician	MB.Medegar@icar.gov.in
R. Sekar	Skilled Support Staff	Sekar.R@icar.gov.in
PME Cell		
N. Thiraviam	Chief Technical Officer (Till 31.07.2020)	Natarajan.Thiraviam@icar.gov.in
Nici Ashok	Senior Technical Assistant	Nici.Ashok@icar.gov.in
S. Kandasamy	Skilled Support Staff	Kandasamy@icar.gov.in
Estate		
C. Vinayakamurthy	Technical Officer (Electrician)	vinayakamoorthy.c@icar.gov.in
P. Amshaveni	Senior Technical Officer (Civil)	P. Amsaveni@icar.gov.in

Name	Designation & Discipline	E-mail ID
M. Pradheep Kumar	Technicial Assistant	Pradheep.Kumar@icar.gov.in
K. Rangammal	Skilled Support Staff	Rangammal.K@icar.gov.in
A. Shanmugavel	Skilled Support Staff	Shanmugavel.A@icar.gov.in
K. Rajeevan	Skilled Support Staff	Rajeevan.K@icar.gov.in
S. Shanmugam	Skilled Support Staff	Shanmugam.S@icar.gov.in
I. Saravanakumar	Skilled Support Staff	Saravanakumar.I@icar.gov.in
L. Enjerappan	Skilled Support Staff	Enjerappan.L@icar.gov.in
R. Aribabu	Skilled Support Staff	Aribabu.R@icar.gov.in
R. Balaputhiran	Skilled Support Staff	Balaputhiran.R@icar.gov.in
R. Jogappan	Skilled Support Staff	Jogappan.R@icar.gov.in
R. Gopalakrishnan	Skilled Support Staff	Gopalakrishnan.R@icar.gov.in
M. Subramaniam	Skilled Support Staff	Subramaniam.M@icar.gov.in
Farm		
G. Prasad Babu	Technical Officer	G. Prasadbabu@icar.gov.in
P. Sivakumar	Assistant Administrative Officer	Sivakumar.P@icar.gov.in
U. Dinesh	Senior Technician	U.Dinesh@icar.gov.in
K. Praveen Kumar	Technical Trainee	K.Praveenkumar@icar.gov.in
R. Thimmappan	Skilled Support Staff	Thimmappan.R@icar.gov.in
N. Kuppuswamy	Skilled Support Staff	Kuppuswamy.N@icar.gov.in
M. Subbathal	Skilled Support Staff	Subbathal.M@icar.gov.in
M. Nachammal	Skilled Support Staff	M.Nachammal@icar.gov.in
R. Revathi	Skilled Support Staff	R.Revathi@icar.gov.in
R. Rajamani	Skilled Support Staff	Rajamani.R@icar.gov.in
C. Sundaral	Skilled Support Staff	Sundaral.C@icar.gov.in
Library		
T. Shanmuganathan	Senior Technical Officer	T. Shanmuganathan@icar.gov.in
A. Arukkani	Skilled Support Staff	arukkani.a@icar.gov.in
DPC		
S. Maheshwari	Senior Technical Officer (Hindi Translator)	S.Maheshwari@icar.gov.in
Administrative Staff		
S. Rama	Senior Administrative Officer	S.rama@icar.gov.in
Establishment		
V. Asha Kumari	Assistant Administrative Officer	Ashakumari.V1@icar.gov.in
K. Kanageswari	Assistant	kanageswari.k@icar.gov.in
M. Jainub	Upper Division Clerk	Jainub.M@icar.gov.in
N. Priyadharsini	Upper Division Clerk	N.Priyadharsini@icar.gov.in
A. Sathasivam	Lower Division Clerk	sathasivam.a@icar.gov.in
M. Balachandran	Lower Division Clerk	Balachandran.M@icar.gov.in
M. Manickam	Skilled Support Staff	Manickam.M@icar.gov.in
Cash & Bills		

Name	Designation & Discipline	E-mail ID
R. Vanithamuthumaheswari	Assistant Administrative Officer	R.Vanitha@icar.gov.in
K. Usha	Assistant Administrative Officer	Usha.Kumar@icar.gov.in
Kratika Sharma	Assistant	Kratika.Sharma@icar.gov.in
S.K. Anumalaviga	Lower Division Clerk	Anumalaviga.SK@icar.gov.in
Stores		
B.V. Santhosh	Assistant Administrative Officer	BV.Santhosh@icar.gov.in
Yallappa	Assistant	Yallappa@icar.gov.in
Vasudev V. Galagali	Upper Division Clerk	Vasudev.Galagali@icar.gov.in
K. Maruthi	Upper Division Clerk	K.Maruthi@icar.gov.in
A. Sindhu	Lower Division Clerk	Sindhu.A@icar.gov.in
N. Lakshmi	Skilled Support Staff	Lakshmi.N@icar.gov.in
Audit & Accounts		
S.B. Baburaj	Finance & Account Officer	baburajdileep@gmail.com
K. Jayalskshmi	Assistant	Jayalakshmi.K@icar.gov.in
J. Emily Florence Daisy Rani	Assistant	Emily.Daniel@icar.gov.in
S.T. Subramanyan	Upper Division Clerk	St.Subramanyan@icar.gov.in
R. Mahalakshmi	Lower Division Clerk	Mahalakshmi.R@icar.gov.in
M. Thangaraj	Skilled Support Staff	Thangaraj.M@icar.gov.in
P.S. to Director		
M. Lalitha Rani	Private Secretary	M.Lalitharani@icar.gov.in
R. Muruganandham	Skilled Support Staff	Muruganandham.R@icar.gov.in
ICAR-SBI, Regional Centre, Karnal		
S.K. Pandey Ph.D.	Pr. Scientist (Ag. Ento.) &Head I/C	s_kantpandey@yahoo.com
M.L. Chhabra Ph.D.	Pr. Scientist (Pl. Patho.)	mlchhabrasbi@gmail.com
Ravinder Kumar Ph.D.	Sr. Scientist (Pl. Breeding)	raviagricos@gmail.com
B. Parameswari Ph.D.	Sr. Scientist (Pl. Patho)	parampathmem@gmail.com
Minturam Meena Ph.D.	Sr. Scientist (Pl. Breeding)	meena.mintu7@gmail.com
K. Rajasekar Ph.D.	Scientist (Soil Science)	rajsekar.k@icar.gov.in
Pooja Ph.D.	Scientist (Pl. Physiol)	poojadhansu@gmail.com
Birendranath Manjhi	Chief Technical Officer	bnsbircknl2015@gmail.com
Vishal Goel	Assistant Chief Technical Officer	ladwa@rediffmail.com
Pramodkumar	Assistant Chief Technical Officer	pramodkumarrana0011@gmail.com
Vijay Kumar	Senior Technical Assistant	bantirajput@ymail.com
Praveen Kumar	Senior Technical Assistant	Praveen.Kumar1@icar.gov.in
Rajesh Kumar	Senior Technical Assistant	rajesh.Kumar11@icar.gov.in
Rameshchand	Senior Technician	ssstaffsbik@gmail.com
Om Prakash	Skilled Support Staff	Om.Parkash12@icar.gov.in

Name	Designation & Discipline	E-mail ID
Fate Singh	Skilled Support Staff	Fate.Singh@icar.gov.in
Rambir	Skilled Support Staff	Rambir@icar.gov.in
Sompal	Skilled Support Staff	Sompal@icar.gov.in
ICAR-SBI, Research Centre, Kannur		
K. Chandran Ph.D.	Pr. Scientist (Pl. Breeding) & SIC	sbirc@dataone.in
R. Gopi Ph.D.	Sr. Scientist (Pl. Patho)	ramaraj.muthu.gopi2@gmail.com
M. Nisha Ph.D.	Scientist (Pl. Breeding)	nishathanima@yahoo.com
B. Mahendran Ph.D.	Scientist (Ag. Ento.)	mahendran.b@icar.gov.in
P. P. Gireesan	Senior Technical Officer	gireesanpp14@gmail.com
Maya Lekshmi Ph.D.	Senior Technical Assistant	lekshmimaya0@gmail.com
Ravindran	Lower Division Clerk	Ravindran.K@icar.gov.in
P.P. Suraja	Skilled Support Staff	Suraja.PP@icar.gov.in
P. Seema	Skilled Support Staff	Seema.P@icar.gov.in
P.C. Krishnakumar	Skilled Support Staff	krishnakumar.PC@icar.gov.in
ICAR-SBI, Research Centre, Agali		
Shri. S. Jothimani	Technician	Jothimani.S@icar.gov.in