



Cryopreservation: Advancing long-term conservation of sugarcane genetic resources

Sugarcane is an important commercial crop serving as a primary source of sugar, bioethanol, renewable energy and numerous industrial products. The success of future sugarcane breeding programmes depends on the availability and conservation of diverse genetic resources. ICAR-SBI, Coimbatore maintains one of the world's richest collections of sugarcane germplasm, comprising over 4000 accessions of *Saccharum* species and related genera. Traditionally, sugarcane germplasm is maintained in field gene banks, which requires extensive land, labour and financial resources and remains vulnerable to pests, diseases, natural disasters and climate-related risks. Therefore, developing alternative methods for secure long-term conservation has become a priority for safeguarding valuable genetic resources.

Cryopreservation: A modern approach to germplasm conservation

Cryopreservation is considered as the most reliable method for long-term conservation of vegetatively propagated crops. The technique involves storing living plant tissues in liquid nitrogen at ultra-low temperatures (-196°C), where all metabolic and cellular activities are effectively halted. Under these conditions, plant materials can be preserved for extended periods without genetic alteration. Recognizing the importance of cryogenic conservation, systematic studies were done to develop efficient cryopreservation protocols for *Saccharum* species to identify suitable

explants, optimize cryogenic procedures, and understand the biological factors influencing survival and regeneration following cryostorage.

Evaluation of different explants and cryopreservation techniques

The research focused on three types of explants: apical meristems; meristem-derived axillary buds and dormant nodal buds. Several cryopreservation approaches were evaluated, including: two-step freezing; desiccation followed by direct immersion in liquid nitrogen; vitrification; encapsulation-dehydration. A diverse set of *Saccharum* genotypes, including wild species and commercial

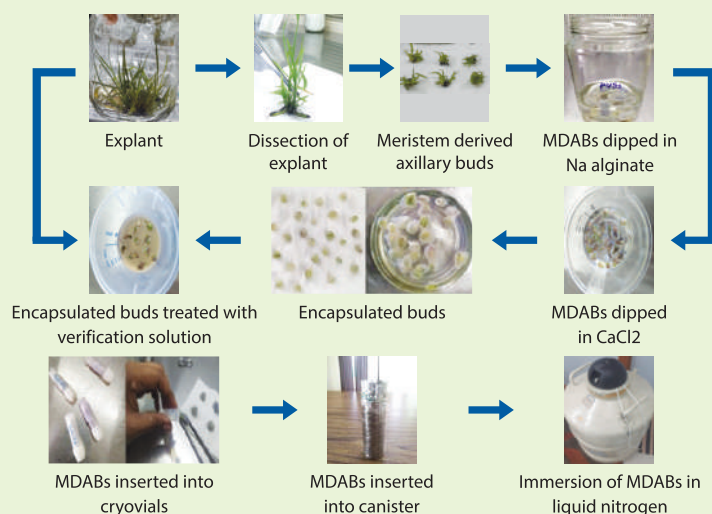


Fig. 1. Steps in Encapsulation-vitrification method

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sugarcane cultivars, were subjected to these treatments to determine their suitability for long-term storage. Among the techniques evaluated, encapsulation-dehydration emerged as the most promising method. This approach involves encapsulating explants in alginate beads, followed by controlled dehydration before immersion in liquid nitrogen. The procedure minimizes ice crystal formation and improves survival during freezing and thawing (Fig. 1).

Successful regeneration

One of the most significant achievements of the study was the successful regeneration of cryopreserved materials after exposure to liquid nitrogen. Meristem-derived axillary buds of *S. spontaneum* clone IND 2019-2045 and the commercial sugarcane variety Co 86032 demonstrated excellent recovery under encapsulation-dehydration protocols. Similarly, dormant nodal buds of several *S. spontaneum* accessions successfully regenerated following cryogenic treatment using both encapsulation-dehydration and desiccation-direct immersion methods. The regeneration of viable plants after cryostorage confirmed the suitability of these explants for long-term conservation purposes. The study also established that meristem-derived axillary buds possess significant potential as a practical and efficient explant source for sugarcane cryobanking. This represents an important milestone, as it is among the first successful reports demonstrating the usefulness of meristem-derived axillary buds for cryopreservation of *Saccharum* germplasm.

Confirmation of genetic stability

An essential requirement of any cryopreservation programme is the preservation of genetic integrity. Regenerated plants of Co 86032 were subjected to molecular characterization using Sequence-Related Amplified Polymorphism (SRAP) markers (Fig. 2). Molecular analysis revealed completely monomorphic banding patterns between cryopreserved plants and their original donor plants. The absence of detectable genetic variation confirmed that the cryopreservation procedures preserved genetic fidelity and did not induce undesirable genetic changes. These findings provide confidence in the use of

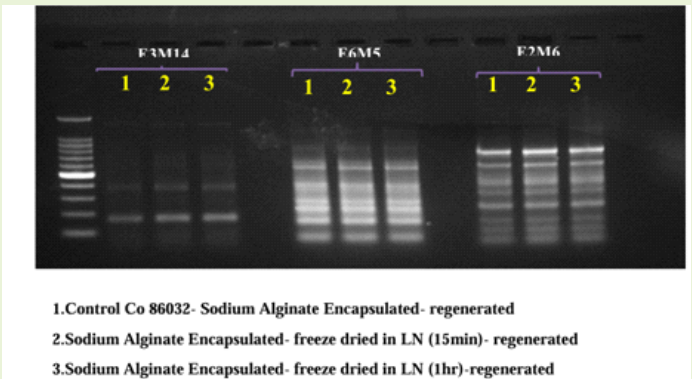


Fig. 2. Genetic fidelity study in Co 86032

cryogenic techniques for long-term conservation of elite breeding materials and wild germplasm resources.

Understanding cryoinjury through cellular studies

Although successful regeneration was achieved in selected genotypes, some explants exhibited reduced survival and delayed recovery after cryo-storage. To understand the reason, detailed histological studies were conducted. *S. spontaneum* clones IND 2019-2045 and IND 2019-2035, along with sugarcane cultivar Co 11015, were examined microscopically following cryogenic treatment. Cross-sectional analyses revealed varying degrees of damage in epidermal tissues, hypodermal cell layers, and vascular bundles in terms of progressive cellular shrinkage, tissue disorganization, membrane damage, browning of tissues, and collapse of vascular structures in sensitive genotypes.

Commercial cultivars show good cryogenic stress tolerance

Co 11015 exhibited comparatively lower levels of cellular damage than the *S. spontaneum* accessions studied. Cellular organization was maintained for a longer period during recovery, and vascular tissues remained relatively intact suggesting that genetic differences among genotypes influence their response to cryogenic stress. Understanding such variability will be valuable for developing genotype-specific cryopreservation protocols and improving survival rates across diverse germplasm collections (Fig. 3).

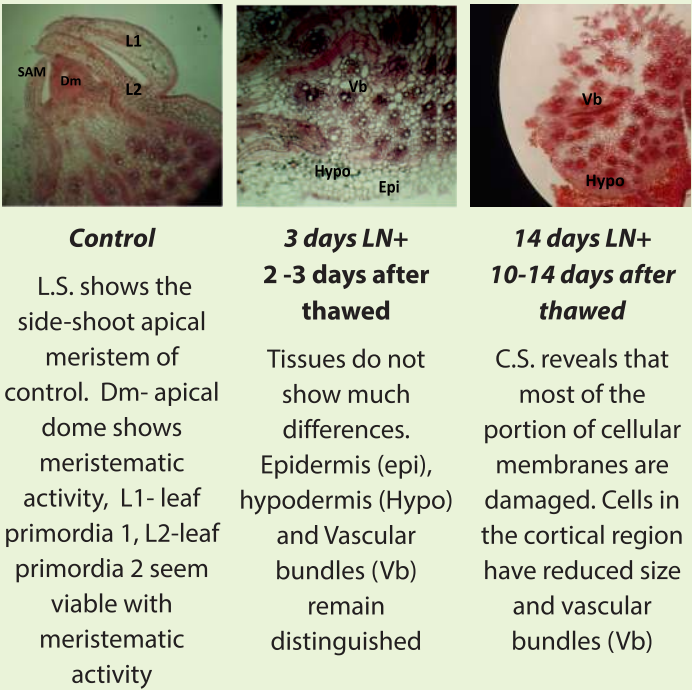


Fig. 3. Histological (light microscopy) analysis of MDAB at different intervals of LN treatment and post-thaw culture in Co 11015

Implications for sugarcane germplasm conservation

The research on regeneration studies and cellular investigations has:

- Identified meristem-derived axillary buds and dormant nodal buds as promising explants for cryogenic storage.
- Established encapsulation-dehydration as an effective cryopreservation technique for *Saccharum* species.
- Confirmed the genetic stability of regenerated plants using molecular markers.
- Generated new knowledge on cellular responses and cryoinjury mechanisms during ultra-low temperature storage.
- Provided a foundation for establishing a dedicated cryobank for sugarcane genetic resources.

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In vitro reinvigoration - A novel approach to improve flowering in Saccharum officinarum

Success of sugarcane breeding program depends mainly on the availability of flowering clones as parents for hybridisation. Initiatives to broaden the genetic base with manipulation/management of flowering in *S. officinarum* was done via micropropagation. Meristem tip culture rejuvenates degenerated clones, restoring the physiological state necessary to trigger flowering.

Flowering and rejuvenation

Flowering is a multifactorial process governed by the interplay of genetics, photoperiod, plant age and physiological state. In most species, floral transition commences once a plant attains maturity but this threshold can be altered under in vitro conditions. Micropropagated plants undergo partial rejuvenation, resetting them towards a more juvenile yet reproductively competent physiological state.

Clones selection and micropropagation

Meristem tips of 20 shy or non-flowering clones of *S. officinarum* were inoculated and sub-cultured on filter paper bridges in MS medium supplemented with GA₃ 0.5 mg/l + kinetin 1.07 mg/L + NAA 0.5 mg/l + riboflavin 5.0 mg/l; BAP 4.0 mg/l (added for regeneration in selected clones); 1/2 MS + NAA 8.0 mg/l + 5% sucrose/l (for rooting) (Fig. 4). Initial inverted culture of explants reduced phenolic exudation. Elongation, differentiation, and multiplication were monitored.



Fig. 4. Production of mericlones (a) shoot tip elongation, (b) regeneration, (c-d) hardening

In vitro reinvigoration and flowering response

Successful regeneration was obtained in eight clones (IND 04-1377, Ogles selection, NG 77-137, NG 77-154, 28 NG 210, IJ 76-314, Saipan G, NG 77-142). Approximately 320 plantlets of IND 04-1377, 202 of NG 77-154, 108 of IJ 76-314 and 45 plantlets of Saipan-G were hardened in plastic tumblers which were covered individually with polybags for 10 days for proper establishment and transplanted in field in pits after 30-40 days. Morphologically, the TC plants resembled their parental clones. Genetic fidelity test demonstrated their uniformity with the presence of monomorphic fragments. Flowering was observed in tissue culture (TC) rejuvenated plants of the non-flowering clone IND 04-1377 and the shy-flowering clone IJ 76-314 during late November to early December.

Table 1. Flowering performance of rejuvenated *S. officinarum* clones

Clone	Status (Pre-TC)	Year 1 flowering (%)	Sustenance	Pollen fertility (%)
IND 04-1377	Non-flowering	90 (Year 1)	100% (Year 2)	57.6
IJ 76-314	Shy-flowering	60 (Year 1)	Regular	52.8

Meiotic and pollen studies

Meiotic analysis of TC plants showed normal meiosis with few laggards in the typical clone IJ 76-314. In the atypical clone IND 04-1377, secondary association of bivalents was observed; laggards ranged 0-5, with micronuclei (1-3) in 70% of tetrads, indicative of the complex polyploid genome. Pollen fertility (%) reached 52.8 in IJ 76-314 and 57.6 in IND 04-1377, the levels suitable for effective hybridisation.

Hybridisation and hybrid performance

Backcrosses and interspecific crosses were made with TC plants as females; 104 seedlings generated from 12 crosses involving TC plants and elite hybrids was evaluated at 12 months. Molecular profiling with 12 SSR primers confirmed hybridity in all 28 tested seedlings from three crosses. Two hybrids developed from IJ 76-314 TC-3 exhibited 2n+n chromosome transmission, consistent with second-division restitution, while the remaining showed n+n transmission (Fig.5).



Fig.5. Flowering and hybridisation in micropropagated plants: (a) hybridisation, (b) anthesis, (c) pollen fertility, (d) fluff germination, (e,f) hybrids at 12 months

Key findings

- Meristem tip culture successfully induced flowering in a previously non-flowering *S. officinarum* clone (IND 04-1377) with 90% flowering in Year 1, reaching 100% by Year 2 and in shy-flowering clone (IJ 76-314) with 60% flowering in Year 1, reaching regular flowering in later years.
- Molecular markers confirmed hybrids with Brix up to 20.6%, cane height up to 3.4 m were obtained from TC-parent crosses demonstrating the potential.

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OUTREACH ACTIVITIES

Training programs

The following three one-day training programs (Fig. 6) were organized:

- Eleven cane staff of Kallakurichi coop sugar mill unit I on 7 May 2026
- 43 farmers from RARS, Perumalapalle, Andhra Pradesh on 12 June 2026
- 45 farmers of Kallakurichi coop sugar mill on 22 June 2026



Fig. 6. Participants of one day training programs

Exposure visits

Conducted 18 exposure visits for 452 students, 54 farmers and 80 staff from the states of Andhra Pradesh, Karnataka, Jharkhand and Tamil Nadu.

Field demonstration

A field demonstration on the use of entomopathogenic nematodes (EPN) for the management of white grub in sugarcane was conducted for 50 sugarcane farmers in Dharmapuri district on 14 May 2026 (Fig. 7). Licensed EPN products were introduced by ABI (SugarcaneEdge®) and ICAR-SBI incubatee. As a significant outcome of the programme, the incubatee secured an open tender for the supply of 1,000 kg of EPN for large-scale application across approximately 1,200 acres within the factory command area, demonstrating the commercial potential of the technology.



Fig. 7. Field demonstration on the use of entomopathogenic nematodes

ICAR CSR & Technology Portfolio Conclave 2026

ICAR-SBI participated in the ICAR CSR & Technology Portfolio Conclave 2026 - Second Roadshow held on 23 June 2026 at ICAR-NIANP, Bengaluru, organized by Agrinnovate India Limited, New Delhi. It served as an exhibition and networking platform for showcasing technologies developed across the ICAR system.

OTHER ACTIVITIES

PROGRAMS ORGANIZED

Awareness program

An awareness program on 'Newly notified four labour codes replacing the old 29 labour laws' was organized on 28 April 2026. Shri T.J. Ramesh Kumar, Labour Enforcement Officer (Central), Coimbatore, Ministry of Labour & Employment



Fig. 8. Awareness lecture on the newly notified labour codes

explained the newly notified four labour codes. All the contractors, contractual labourers, administrative staff of the Institute participated (Fig. 8).

Quinquennial Review Team meeting

The newly formed Quinquennial Review Team (QRT) 2020-2024 of the Institute comprises Prof. Swapan Kumar Datta, Former DDG (CS), VC, VBU as the Chairman and Dr. Bushan L. Jalali, Ex-Director of Research, HAU, Hissar; Dr. Man Singh, Former Project Director, WTC, ICAR-IARI; Dr. Gursharan Singh, Ex-Dean PGS, Punjab Agricultural University; Dr. N.V.



Fig. 9. QRT meeting in progress



Fig. 10. QRT visiting germplasm field

Naidu, Former Director of Research, ANGRAU; Dr. P. Ramasundaram, Former National Coordinator - NAIP & NAHEP (ICAR) and Dr. Roshan Lal Tamak, Executive Director & CEO, DCM Shriram Ltd, Haryana as members. The I Phase of the Quinquennial Review Team meeting of ICAR-Sugarcane Breeding Institute, Coimbatore was held during 26-30 May 2026 for reviewing the research activities carried out during the period of five years (Fig. 9-10).

International Yoga Day

International Day of Yoga was celebrated on 19 June 2026 (Fig. 11). Presiding over the event, Dr. P. Govindaraj, Director of the Institute emphasized yoga's role in maintaining physical, mental and spiritual health. He urged participants to adopt regular yoga practice as a way of life and recalled the contributions of Agathiyar and other sages in promoting holistic health traditions. Dr. L. Devarajan delivered a talk on yoga's relevance in today's fast-paced, stressful lifestyles and explained this year's International Day of Yoga theme, 'Yoga for healthy ageing'. Smt. K. Jothimani spoke on meditation, highlighting its benefits in stress reduction, improved



Fig. 11. Yoga Day celebration

concentration and overall well-being. The Temple of Consciousness, Coimbatore conducted the subsequent yoga and wellness session for Institute staff. Shri S. Ramesh, a certified trainer from the Ministry of AYUSH, together with Smt. L. Padmavathi and Smt. Meena from the Temple of Consciousness, led a guided session demonstrating simplified kundalini yoga, surya namaskar and other practices aimed at enhancing general health. Dr. D. Puthira Prathap earlier welcomed the gathering highlighting the positive effects of asanas on both body and mind.

'Kisan Utsav' cum 'Khet Bachao Abhiyan'

PM-KISAN implemented by the Ministry of Agriculture, Cooperation and Farmers' Welfare aims to supplement the financial needs of all landholding farmers' families by procuring various inputs to ensure proper crop health and appropriate yields, commensurate with the anticipated farm income as well as for domestic needs. The release of 23rd instalment of PM-KISAN scheme by Honourable Prime Minister of India, Shri Narendra Modi was tele viewed at the Institute by over 250 participants (Fig. 12).

The day was also celebrated as 'Kisan Utsav' along with Central Institute for Cotton Research - Regional Station, wherein awareness campaign was organized under 'Kheti Bachao Abhiyan' being implemented in the country during 1-30 June 2026. Dr. P. Govindaraj, Director, ICAR-SBI in his Presidential Address recalled the contributions of the Institute and emphasised the role of science and technology in realizing Viksit Bharat in 2047. He emphasized the idea of 'Save the soil, Save farming, Save Farmers'.

Smt. M. Tamilselvi, Joint Director of Agriculture, Coimbatore district explained farmers about the various government schemes such as PM-Kisan Samman Nidhi, Crop Insurance Scheme, Kisan Credit Card and the importance of farm mechanization. Dr. T. Rajula Shanthi, Principal Scientist and Head, Extension coordinated the events of the Day and explained the farmers on balanced use of fertilizers, use of soil health cards, importance of soil health for productive agriculture, need for improved seeds, green manuring and organic / natural farming. The event brought together farmers, scientists and extension functionaries underscoring



Fig. 12. Tele viewing of the release of 23rd instalment of PM-KISAN scheme

a shared commitment to improve soil health and sustainable agricultural development.

Meetings organized

- ◆ Sadhana Saptah, i-Got Karmayogi', Webinar was conducted by ICAR Headquarters at ICAR-SBI, Coimbatore; all the staff participated in the webinar presented by Dr. M.L. Jatt, Director General, ICAR on 06 April 2026. All the staff of the institute attended Mission Karmayogi during Sadhana Saptah during 2-8 April 2026 and completed three courses on Artificial Intelligence and three market place courses in iGOT Karmayogi portal during Sadhana Saptah and earned AI Daksh badge
- ◆ Samuhik Charcha, a broad discussion of sugarcane breeding research was conducted on 10 April 2026 at ICAR-SBI, Coimbatore. The event was led by Dr. P. Govindaraj, Director, ICAR-SBI and all the scientific category staff put forth their views on contemporary issues related to sugarcane breeding research
- ◆ Institute Joint Staff Council Meeting held on 10 June 2026
- ◆ Senior Officers Committee Meetings held on 07 April 2026, 06 May 2026 and 09 June 2026
- ◆ Assessment Committee Meeting for considering the promotion of Scientists held on 12 June 2026 through hybrid mode (online/offline)
- ◆ Grievance Committee Meetings held on 16 April 2026, 11 May 2026 and 19 June 2026
- ◆ Women Cell Meeting held on 16 June 2026
- ◆ Internal Committee Review Meeting held on 23 June 2026
- ◆ Selection Committee Meetings for engagement of Part time Medical Officer, SRF, YP I, YP II, Skilled Worker and for regularization of eight Casual Labourers at ICAR-SBI, RC, Karnal held on 29 April 2026, 07 May 2026, 08 May 2026, 20 May 2026, 03 June 2026, 08

June 2026, 15 June 2026 and 30 June 2026 respectively.

MoU with Government of Bihar

A MoU was signed between Sugarcane Industries Department, Government of Bihar and ICAR-SBI for collaborative activities towards benefit of farmers and sugar industry on 23 June 2026.

Education

- ◆ The Ph.D. viva-voce presentation by Smt. Naveenarani @ G.Lakshmi on her thesis work entitled 'Isolation and characterization of promotor for sugarcane transformation' under the guidance of Dr. C. Appunu was held at the Institute on 22 May 2026
- ◆ A total of 210 students successfully completed 15/21/30 days exposure training under specialized areas such as Biotechnology, Biochemistry, Microbiology and Bioinformatics

Scientific participation

- ◆ Drs. P. Govindaraj and C. Palaniswami: Sensitization program (online) on 'Research data management policy' on 27 April 2026
- ◆ Dr. D. Puthira Prathap: Online meeting regarding 'Communication Strategy in ICAR' on 29 April 2026
- ◆ Drs. P. Malathi and V.P. Sobhakumari: Sensitization program (online) on 'Developing database of gender factsheet of ICAR' on 30 April 2026
- ◆ Director, HDs, Chairman and members, QRT: Preliminary online meeting of the QRT (2020-2024) on 30 April 2026
- ◆ A meeting with Agrythm Technologies Pvt. Ltd, Bidar, Karnataka for a collaborative program in sugarcane for early detection of nutrient deficiencies, pests and diseases was held on 11 May 2026
- ◆ Dr. V.P. Sobhakumari: Board of studies meeting of Calicut University on 11 May 2026
- ◆ Drs. R. Gobu and S. Karthigeyan: 41st Annual Group Meeting of AICRP on Seed (Crops) and 29th Annual Breeder Seed Review Meeting held at SKUAST, Jammu during 13-15 May 2026
- ◆ Dr. Vinayaka: 2nd International Conference (online) on Advances in agricultural sciences, environmental stewardship, biological and life sciences organized by Society of Agricultural Research, Applied Technology and Environmental Science, India in collaboration with Yugra State University, Russia during 23-24 May 2026

- ◆ Principal Investigators and Co-PI of ISMA project: Online Review meeting for sugar mills in sub-tropical region under ISMA project on 1 June 2026
- ◆ Dr. K. Thamilarasi: 14th International Conference (online) on 'Recent innovations and sustainable approached in agricultural, biological and applied sciences for livelihood security' organized by UBKV, West Bengal and Agro-Environmental Development Society, Uttar Pradesh held during 18-20 June 2026

Trainings /Workshop attended

- ◆ Dr. C. Appunu: Short-term International Training on 'Advancing in planta transformation and precise genome editing technologies in crops' at Texas Tech University, Lubbock, Texas, USA under EFC Genome Editing project - Enhancing climate resilience and ensuring food security with genome editing tool from 17 September 2025 to 4 March 2026
- ◆ Drs. H.K. Mahadevaswamy, T. Lakshmi Pathy and R. Gobu: Five days training program on 'Plant variety protection and registration in India: The PPV & FRA Act, 2001' at University of Agricultural Sciences, Bangalore during 22-26 June 2026
- ◆ Dr. P. Megaladevi: Institute orientation training program from 07 May 2026 to 12 July 2026

Awards and Recognitions

- ◆ Dr. C. Appunu received NAAS Fellow Award during ICAR Foundation Day 2026 program on 05 June 2026 (Fig. 13).



Fig. 13. Dr. C. Appunu receiving NAAS Fellowship Award

Trainings /Workshop / Seminar organized

- ◆ An international training of 21 days in tissue culture was organized for two research workers from Sugarcane Research Institute, Fiji during 1-21 April 2026
- ◆ One-day training for sugarcane farmers was organized by ICAR-SBI RC, Karnal in collaboration with KVK Bhagpat, Uttar Pradesh at village Basi, Bhagpaton 09 April 2026

- ◆ One-day Awareness campaign on 'Balanced use of fertilizer' was organized in three villages of Namakkal District for farmers and Cane Development Officers of Ponni Sugars (Erode) Limited on 10 April 2026
- ◆ A three days training program on 'Sampling and analysis of soil and water' for two officials from Ponni Sugars Pvt Ltd., during 15-17 April 2026
- ◆ A four-days training on 'Innovative extension methods for upscaling sugarcane production technologies' for farmers and cane officials, was jointly organized by ICAR- Sugarcane Breeding Institute, Regional Centre, Karnal and Extension Education Institute, Nilokheri (Haryana), Ministry of Agriculture & Farmers' Welfare, GoI, Nilokheri (Haryana) during 27-30 April 2026
- ◆ Training program on 'Growing kitchen garden in tribal houses' sponsored by DAPSTC project combined with ATR, Tiruppur was organized to the residents/farmers of Anamalai Tiger Reserve hamlets, Karumutti and Poochikottamparai, aiming to add nutrition into the diets on 07 May 2026
- ◆ Organized an awareness campaign on 'Healthy life and nutrition amelioration' sponsored by DAPSTC project combined with Anamalai Tiger Reserve project for the tribal farmers at Keel Karattupathy and Thippiparai villages in Tiruppur district on 12 May 2026
- ◆ An exposure training was organized for the benefit of all the students undergoing internship program at the institute during 20-21 May 2026
- ◆ A six days training program on 'Advanced statistical computing and AI driven analytics for agricultural research' was organized to the students /research professionals from State Agricultural Universities and private firms during 01-06 June 2026
- ◆ Organized four one-day Statistical Workshop Series-2026 in collaboration with SSRD, Coimbatore to ICAR-SBI staff and students on 10,17, 24 June and 01 July 2026
- ◆ Organized a one-day training program on 'Sugarcane cultivation' to sugarcane farmers at ICAR-SBIRC, Kannur on 22 June 2026
- ◆ An All India Radio feature on Co 18009-Field Day conducted in Kanjapalli village organized by ICAR-

Sugarcane Breeding Institute in association with Bannari Amman Sugars Ltd., was broadcast through Coimbatore Rainbow FM103 on 11 and 12 April 2026

Distinguished Visitors

- ◆ Dr. D.K. Yadava, Deputy Director General (Crop Sciences), ICAR visited the Institute on 21 June 2026. He paid visits to the sugarcane breeding trials at ECC campus, sett treatment chamber, integrated farming system unit and laboratories. Later, he addressed the scientists from ICAR-SBI, ICAR-CICR, Regional Centre and ICAR-IARI, Wellington (Fig. 14a&b).



Fig. 14a. Dr. D.K. Yadava, DDG (CS) addressing the scientists



Fig. 14b. DDG (CS) visiting experimental fields

Transfer

- ◆ Dr. P. Megaladevi, Scientist (Entomology) transferred from ICAR-Indian Grassland and Fodder Research Institute, Jhansi and joined ICAR-SBI, RC, Kannur on 27 April 2026
- ◆ Dr. V. Venkatasubramanian, Principal Scientist and Former Director, ICAR-Agricultural Technology Application Research Institute (ATARI), Bengaluru joined ICAR-SBI, Coimbatore on 17 June 2026

Retirement

- ◆ Shri P. Chinnaswamy, SSS retired on superannuation on 30 April 2026

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