वार्षिक प्रतिवेदन
Annual Report
2023

भाकृअनुप-भारतीय गन्ना अनुसंधान संस्थान,
लखनऊ
ICAR-Indian Institute of Sugarcane Research
Lucknow

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ICAR-Indian Institute of Sugarcane Research

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From the Director's Desk

The performance of Indian sugar industry has been enviable during the previous year, with a sugar production of more than 32.0 million metric tons (MMT) in the sugar season 2022-23. The area under the crop crossed 5.0 million ha during 2022-23. The corresponding sugar recovery was 10.79% before diversion for ethanol production. During 2022-23, with a production of more than 500 crore litres of ethanol, the country has been able to save Rs. 24,300 crores in foreign exchange, besides ensuring energy security. The additional revenue generated by the sugar mills through the sale of ethanol has added to the economic security of the industry as well as the cane growers. The estimates for sugar production in the coming year is expected to be 36.0 MMT. The sugar consumption is expected to be around 31.0 MMT in 2023-24, with the demand from ethanol and potable alcohol industry adding to the domestic and commercial sugar consumption. A rough estimate indicates that the ethanol production capacity in the country is about 1400 crore litres out of which, more than 60% is sourced from sugar industry. In order to achieve the target of 20% blending by 2025-26, about 1016 crore litres of ethanol is required and total requirement of ethanol including for other uses is 1350 crore litres. For this, about 1700 crore liters of ethanol producing capacity is required to be in place by 2025. All these facts point towards an immediate need for the country to gear up to the demand for enhanced sugarcane as well as sugar production, to cater to the demands, keeping in mind the various challenges like climate change and associated risks. This should also take care of the sustainability and productivity factor, making the industry profitable.

Even with the largest sugar consumption base in the world, we are yet to tap into the huge potential the country has, with respect to the sugar recovery levels. Effective crop production and management strategies and development of improved high yielding climate resilient varieties have helped us to tackle the problem to a great extent. ICAR-Indian Institute of Sugarcane Research, Lucknow, a major link in the robust sugarcane research and development network in India, has played a significant role through its innovative, cost-effective and sustainable technological interventions, ensuring that India retains its position as a major player with respect to the sugarcane and sugar production, among the major sugarcane growing countries of the world.

The newly released varieties form the Institute viz., CoLk 14201, CoLk 15206, CoLk 16202, CoLk 15466 and CoLk 16466 have ensured the constant availability of improved sugarcane varieties with high yield, sugar content, disease and pest resistance and good ratoonability to the stakeholders, coupled with supply of quality seed. Crop production strategies have helped in identifying the favourable irrigation regimes, emphasizing the role of sugarcane crop as a whole as an effective rain-water harvester, rather than that of a water guzzler, as is the general belief, identifying nano-coated urea as an effective technology for nutrient management etc. A sugarcane-based integrated farming system for small holders has been shown to add to the economic security of the sugarcane growers to a great extent.

Integrated plant protection measures to manage the major diseases like red rot have shown to hold high promise. Bio-control of insect pests has been taken up by the Institute. The application of cutting edge technologies like genome editing, and AI-based techniques with a long term goal of effective disease and pest management has been taken up by ICAR-IISR. Elucidating the physiological and biochemical mechanisms underlying multiple stress responses, invigoration of plant biomass in ratoons through growth regulators, assessing the suitability of sugarcane trash as a feed stock for bio-ethanol production etc., have been other significant initiatives of the Institute during the period.

ICAR-IISR continues to be the flag bearer for sugarcane mechanization in the country. The machinery like sugarcane cane node planter and sugarcane trash management machinery are some of the new additions, apart from the several minor and hand held machineries developed and tested during the year. Ergonomic evaluation has also been carried out for many of these machineries. A patent was granted to the institute for sugarcane combined ratoon management device and trash management machinery. Drone based management practices are being standardized and fine-tuned for precision sugarcane agriculture. Weed management and application of plant protection chemicals and weedicide using drones are being standardized. New infrastructure has been added in the Institute, with the development of a Molecular Biology laboratory and Central Biotechnology facility in the Division of Crop Improvement and Molecular Plant Pathology laboratory in the Division of Crop Protection.

The research activities are being supported by well-planned extension activities and other outreach programmes. Several trainings and skill development programmes were organized during the period at the Institute, aiding in the large scale adoption of the institute technologies. The *Krishi Vigyan Kendras* (KVKs) at Lucknow and Lakhimpur Kheri have carried out transfer of technology activities extensively, not only in sugarcane but also in other crops. On-farm trials, Front Line Demonstrations, capacity building of farm youth, farmers and other stakeholders have helped in the extensive dissemination of technologies.

As a part of the IARI Mega University academic programme, initiated by IARI New Delhi, the institute is heading the IARI Lucknow hub and imparts education in Agriculture and related disciplines, at UG, PG and Ph D levels, in partnership with other ICAR institutions at Lucknow. Undergraduate course in B.Sc. (Hons.) in Agriculture and M.Sc. (Agriculture) and Ph.D courses in a few disciplines have been initiated from the academic year 2023-24. The scientists of all the participating institutes are a part of the IARI faculty and are guiding students in their MSc and PhD research work.

ICAR-IISR has redefined its research priorities keeping in mind the inherent complexities of the crop as well as the emerging challenges. The Institute envisages marching ahead with innovative and sustainable initiatives to make the nation an indispensible player in the global sugar scenario, through its farmer-centric innovations, leading to a holistic development in the Indian sugar industry. The institute has taken up many collaborative programmes with ICAR-SBI, National Sugar Institute, Vasantdada Sugar Institute, SNSI, Belagavi and other institutions. Also the institute is partnering with UP and Bihar governments, UPCAR, UPCST, industry associations like Indian Sugar Mills Association, Sugar Technologists Association of India, UP Sugar Mills Association and various sugar mills to spread improved sugarcane production and protection technologies mechanization and improved varieties. The outreach activities conducted by the institute in UP and Bihar effectively demonstrated integrated management of red rot and top borer in sugarcane.

This Annual Report is a comprehensive review of the Institute's research, outreach and related activities during the year 2023.We are very thankful to the Council for providing adequate funds for the research and other activities. We gratefully acknowledge the unstinted and constant support and guidance from Hon'ble Secretary, DARE and DG, ICAR, Dr. Himanshu Pathak, DDG (CS), Dr. T.R. Sharma, ADG (CC), Dr. Prasanta Dash, ADG (Seeds), Dr. D.K. Yadava, former ADG (CC), Dr. R.K. Singh and all other officials at ICAR, New Delhi. The efforts of the Annual Report Committee, all the Heads of the Divisions/In-charge Sections, In-Charge and members of PME Unit and all other staff in providing information, in compiling, editing and bringing out the Annual Report on time is highly appreciated.

(R. Viswanathan)
Director

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From the Director's Desk

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Executive Summary

Crop Improvement

- Three sugarcane varieties were released and notified by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops (The Gazette of India notification S.O. 4222 (E) dated the 25 September, 2023); two varieties viz.. CoLk 14201 (Early) and CoLk 15206 (Midlate) for commercial cultivation in North West Zone of India and one variety CoLk 16466 (Early) for commercial cultivation in North Central and North Eastern Zone of India.
- An early maturing sugarcane variety CoLk 16202 was identified for its release in North West Zone of India and a mid-late maturing variety CoLk 16470 was identified for its release in North Central and North Eastern Zone of India by the Varietal Identification Committee during All India Coordinated Research Project on Sugarcane Workshop held at Dr. RPCAU, Pusa on 26-27 October, 2023.
- Three early maturing sugarcane clones, i.e., CoLk 23201 (LG 17222), CoLk 23202 (LG 19014) and CoLk 23203 (LG 16487) and three mid-late maturing clones viz. CoLk 23204 (LG 18410), CoLk 23205 (LG 18907) and CoLk 23206 (LG 15670) were accepted for multi-location testing in North West Zone of India during the AICRP(S) Workshop-2023 organized at Dr. RPCAU, Pusa.
- Applications of three sugarcane varieties namely, CoLk 15201 (*IKSHU*-11), CoLk 15207 (*IKSHU*-12) and CoLk 15466 (*IKSHU*-13) were filed for registration under the Protection of Plant Variety and Farmers Right Act, 2001.
- Two high sugar genetic stocks LG 15533 and LG 16581 with sucrose % juice values 20.0 % in January month have been included in NHG at ICAR-SBI, Coimbatore after quarantine screening.
- A total of 31645 samples comprising of banana (27605), sugarcane (270) and potato (3970) were tested for genetic fidelity and quality including virus indexing of sugarcane for sugarcane mosaic virus (SCMV), sugarcane yellow leaf virus (ScYLV), sugarcane bacilliform virus (SCBV), and phytoplasma; banana bract mosaic virus (BBrMv), cucumber mosaic virus (CMV), banana bunchy top virus (BBTV) and banana streak virus (BSV) for banana and PVX, PVY, PVA, PVM, PVS, PLRV, PALCV, GBNV and PSTVd for potato.
- Nano LCMS/MS based proteomics analysis revealed eighteen proteins implicated in MAPK signalling pathway in *C. falcatum* of which, twelve were the part of core MAPK signalling pathway, whereas remaining were indirectly implicated. String association networks of MAPK proteins revealed strong association with numerous other proteins involved in the process of pathogenesis/virulence. The investigation further revealed occurrence of 21 catalases in red rot resistant (BO 91) and susceptible (CoJ 64) cultivars of sugarcane with more number and enhanced abundance of catalase proteins in resistant cultivar as compared to the susceptible one. qRT-PCR-based real time expression analysis of selected six catalase genes corresponding to identified proteins was performed to substantiate the findings of proteomics. qRT-PCR also validated the predominance of four MAPKKKs, three MAPKKs, and five MAPKs implicated in MAPK signaling pathway in *C. falcatum* samples cultured with sugarcane stalks.
- An important differential alternate splicing (AS) event was identified within the β-subunit of pyrophosphate-fructose 6-phosphate 1-phosphotransferase (PFP) that was associated with early sucrose accumulation in sugarcane. Premature stop codons that could result in truncated proteins were also detected in genes coding for aquaporin, aldolase, cytochrome C-oxidase, ribophorin and plant plasma membrane intrinsic proteins. A major proportion of these AS events and premature stop codons was validated for their differential enrichment in an independent set of sugarcane varieties having high and low sucrose content.
- A highly significant SNP (FDR 0.01) was identified to be associated with the trait through genome wide association mapping for resistance to three races of red rot pathogen (CF01, CF08 and CF09) using a panel of 174 sugarcane varieties that was followed by genomic prediction for red rot resistance using this panel as training population. A set of 144 F1 (MS 68/47 X CoV 92102) clones used as testing population was genotyped through GBS for determining their predicted red rot resistance values and a set of 10 F1 clones with high prediction values for red rot resistance and sucrose content were used as parental lines.
- Approximately 10430 quintals of seed cane of 12 early and mid-late maturing varieties was produced at IISR, Lucknow under ICAR Seed Project and a total of 18,676.37 quintals of breeder

seed of five distinct sugarcane varieties was produced under Bihar Seed Project at four key centres in Bihar, including IISR Regional Centre, Motipur; New Swadesi Sugar Mills, Narkatiaganj; Harinagar Sugar Mills, Harinagar; and Tirupati Sugars Ltd., Bagaha. Production of disease-free and genetically pure seed cane through micropropagation of new sugarcane varieties was continued and ~5000 plantlets of *in vitro* multiplied sugarcane varieties CoLk 09204, CoLk 14201 from previous year were acclimatized and transferred to field whereas, ~10000 plants of variety CoLk 14201 were acclimatized in mist chamber.

Crop Production

- Study about time of ratoon initiation revealed the highest plant count at 150, 180, and 210 days after ratoon initiation (DARI) in the February-initiated ratoon crop (1,47,242.8), followed by March (1,41,070), April (1,30,123), and May (1,28,642) initiation. Highest ratoon cane yield was recorded with the February initiated ratoon crop, significantly surpassing the yields of April and May ratoon crops. The increase in cane yield were 16.8%, 15.4%, and 5.9% more in February, March, and April respectively compared to May-initiated ratoons.
- Sugarcane ratoon initiated on 15th February was significantly superior over ratoon initiated on 15th December of previous year in all the growth and yield parameters. Sugarcane yield increased by 25.78 percent in February - initiated ratoon over December - initiated ratoon (68.52 t/ha).
- Sugarcane based-cropping systems with medicinal and aromatic crops showed highest rice equivalent yield (73.5 q/ha) of Tulsi (*Ocimum sanctum*) under Tulsi-Stevia- Sugarcane (spring) - Sugarcane ratoon-Mint (*kharif* season) system. Similarly, the maximum wheat equivalent yield (109.7 q/ha) of wild marigold (*Tagetes minuta*) was recorded under Tulsi-Wild Marigold (Two cut) - Sugarcane (spring) - Sugarcane ratoon-mint during Rabi season.
- For autumn sugarcane based integrated farming system, the highest net income was registered upon sugarcane crop integrated with vegetable crops + horticultural crops + backyard poultry + dairy + fisheries + vermicompost that fetched net income of Rs.7,80,165/ha (additional income of Rs. 4,53,040/ha). Spring planted sugarcane integrated with enterprises *viz*. vegetables + horticultural crop + backyard poultry + dairy + fisheries + vermicomposting (*Eisenia fetida*) fetched net income of Rs. 7,61,276 /ha (additional income of Rs. 4,50,981/ha) over sugarcane sole cropping.
- Nano-coated urea showed slower release characteristics compared to the conventional neem-coated urea available in the market. The application of 100% recommended dose of nutrients (RDN) through nano-coated urea resulted in increased plant height, cane girth, and per cane weight compared to using 100% RDN of conventional urea. Additionally, use of just 50% dose as nano-coated urea, either in two or three splits, yielded an equivalent number of millable canes when compared to applying 100% recommended dose of nitrogen using neem-coated urea.
- Use of microbial consortia along with 75% RDF improved cane and sugar yield by 8.8 and 13 % compared to the recommended dose of fertilizer (100%) without microbial consortia (62.3 and 6.57 t/ha).The third ratoon cane yield decreased by 16.2 and 27.4% compared to the second (76.7 t/ha) and first (88.6 t/ha) ratoon crop, respectively.
- Band placement of fertilizer significantly increased the cane yield (7%) and proved better than broadcasting method. Five splitting of N & K nutrients significantly improved cane and sugar yield compared to three splitting done conventionally.
- Irrigation regimes exerted significant influence over growth and yield of sugarcane. In plant crop, significantly higher number of tillers (140 DAP), number of millable canes, average cane weight, cane length and cane yield were recorded with IW: CPE ratio being 1.0 and 0.8 than IW: CPE ratio 0.6. Irrigation in trenches (90.69 t/ha) or in the alternate trenches (89.33 t/ha) harvested statistically at par cane yield as with flood irrigation (85.69 t/ha). Under different irrigation regimes, the best water productivity (193.01 L/kg) was recorded with IW: CPE ratio 0.8. Among methods of irrigation, the trench irrigation generated the lowest water footprint (122.71 L/kg). In ratoon crop, highest ratoon yield was harvested under the irrigation regime with IW: CPE ratio 0.8 statistically similar to that recorded with IW: CPE ration 1.0.The best irrigation water productivity in ratoon cultivation was found under the irrigation regime having IW: CPE ratio 0.6 (83.20 L/kg) followed by IW: CPE ratio 0.8 (91.35 L/kg).The skip trench irrigation recorded the best water productivity (50.82 L/kg) followed by irrigating all the trenches (66.16 L/kg).
- Partitioning of water footprint among green, blue and grey components revealed that rains contribute about 75-78% to total water footprint and the crop depends on irrigation water only for 12-15% of its water requirement. Ratoon gets about 61% to total water footprint contribution from the rains and depends on irrigation only for 25% of its crop water needs.

Crop Protection

- The survey in different sugar mill command areas, farmers' fields and in IISR farm showed the presence of red rot, wilt, twisted top (pokkah boeng), RSD, leaf scald and viral diseases with different levels of severity.
- A total of 1,307 RGB images of healthy and injured symptoms of insects, pests, diseases and physiological disorders were captured under controlled and real-time situations under different light conditions. In total, a repository of 15,746 RGB images is being maintained in the Division of Crop Protection, ICAR-IISR, Lucknow.
- Mapping of ratoon stunting disease (RSD) in a collection of varieties being maintained for DUS testing revealed varying degrees of cane node infection ranging from <10% to >40%. Over the years, the varieties exhibited a change in the intensity of resistance and susceptibility.
- Out of the 68-mosaic symptomatic sugarcane and sorghum samples collected from different areas of Uttar Pradesh, Bihar and Maharashtra, 25 positive samples had a 590bp band of RNA for sugarcane mosaic (SCSMV) disease. The sequencing of the bands revealed 100% identity of these with sequences of SCSMV.
- *Trichoderma harzianum* application through sett treatment recorded less twisted top disease development (5.33% disease incidence), and it improved plant growth-promoting traits and plant physiological parameters.
- The management of RSD by chemical delivered through STD showed reduced cane node infection and increased cane height, cane girth, and internode length in combination of STD and Streptocyclin at 18 ppm.
- Application of 65g of Thiophanate methyl or 50g of Carbendazim, or 20 ml of Propiconazole formulations in 5 litres of water in the drone tank in 1250 m^2 area was found to be effective in managing red rot. The treated plots of the outreach program were either free from red rot or had 1-10% incidences, whereas the neighbouring untreated fields had 60-70% infections.
- Abundance of microarthropods (first quartile as lower baseline and third quartile as upper base line) can be used as an indicator for monitoring soil health. Shannon, Berger parker and Chao1 indices are also useful in assessing sugarcane agroecosystems.
- Three species of termites *Odontotermes vaishno Bose, Odontotermes bellahunisensis Holmgren and Odontotermes horni (Wasmann)* were recorded for the first time from sugarcane. Bacteroidetes and Proteobacteria were the two most predominant phyla present in the gut, with *Treponema* and *Pseudomonas* being the dominant bacterial genus. Chlorantraniliprole was the safest insecticide against termite with reference to environmental impact. Sheesham - based diet for rearing of termite was developed in laboratory.
- The rate of oviposition of sugarcane adapted top borer strain of *Trichogramma chilonis* was significantly higher in the first three days of oviposition. The fecundity of sugarcane adapted internode borer strain of *T. chilonis* was maximum in 7♀: 1♂ ratio, followed by 4:1 and 5:1 ratios. Mustard aphid solution as a food source supported maximum progeny (107.8/pupa) of *Tetrastichus howardii* as compared to other nutrients regimes. Maximum fresh pupa were retrieved from the host pupa stored for 5 days and it decreased drastically at 30 days of storage.
- The incidence of first brood of top borer was significantly high in CoS 8436, CoLk 14201, CoLk 16204, CoLk 11206, CoS 767, CoJ 64, CoLk 94184, CoLk 8102 and Co 0238 and CoLk 16203 and CoLk 13204 were least susceptible. The incidence of stalk borer in standing cane (August) varied from 9.0 to 48.7% in twenty varieties. The most susceptible variety for stalk borer was CoLk 13204.The least susceptible varieties were Co 7717, CoJ 64 and Co 05011. Pink mealy bug infestation was observed in July which increased to more than 80% in some varieties by August.
- Application of Karanj seed extract, bottle brush extract, besharm extract and neem extract were effective against different broods of top borer. Damage by termite in standing crop was low in treatment with Besharm hydrate followed by latjeera (extract and hydrate), neem hydrate, and karanja extract. Essential oils from Tulsi were effective against IV brood of top borer followed by bottle brush.

Plant Physiology & Biochemistry

- A significant positive correlation was found between chlorophyll stability index (CSI) and stress tolerance index suggesting that stay green character may be one of the visual screening criteria for single/ multiple stress tolerance. The leaf tissue K concentration dropped below the critical deficiency level under different stresses. The leaf K had a significant correlation with stress tolerance index which suggest that maintenance of high leaf K concentration may be one of the important traits for multiple abiotic stress tolerance.

- Transcriptomic study revealed that five K transporter genes were significantly downregulated under drought, salinity and waterlogging which indicate that upregulation of K transporter genes may play a significant role in maintenance of high leaf tissue K concentration and hence better stress tolerance.
- Transcriptome analysis using four samples (S1, S2, S3, S4) having leaf tissue of control and waterlogging induced plants of CoLk 94184 and CoJ 64 varieties revealed a total of 295618 unigenes. These were further processed using seven databases (Nr, Uniprot, GO, KOG, PFAM, KEGG and Transcription factor).
- Effect of two silica compounds *viz.*, silicon dioxide and silicic acid as a basal dose and their foliar application at 90 and 120 DAP were assessed for the germination and substrate mobilization. Significant changes were observed in the germination (%), reducing sugar content and acid invertase activity with silica, as compared to control. Maximum sprouting % was found with silicic acid at the rate of 200 kg ha-1 at both 20 and 45 DAP (30.15 and 42.44 %).
- In the experiment conducted in autumn on CoLk 94184, effect of treatments of ethrel, *jeevamrutha*, and water for the setts priming and control was studied. Results obtained indicated 83 and 69 % increase in germination with Ethrel, and 40.86 and 68% in Jeevamrutha treated setts as compared to untreated setts at both 20 and 45 DAP.
- A new pre-treatment method was found to be highly efficient and effective for downstream bio-catalytic hydrolysis of various sugarcane lignocellulosic biomass materials. The optimal conditions for the hydrogen peroxide–acetic acid pre-treatment was 75°C, 2.5 h, and an equal volume mixture of hydrogen peroxide and acetic acid. Compared to previous pre-treatment processes under the same conditions, the pre-treatment was more effective at increasing enzymatic digestibility.
- Tiller numbers and biomass accumulation till 210 DAP indicated that maximum improvement in sett sprouting and biomass dynamics occurred with Ethrel spray as compared to water spray and control. Maximum sprouting % was recorded with Ethrel spray @100 ppm > NAA spray @ 50 ppm > NAA spray @ 100 ppm against water spray and control at 20, 30 and 45 DAP. At 120 DAP, average initial shoot numbers were highest with Ethrel spray (1,22,735 shoots ha-1) followed by NAA spray @ 50 and 100 ppm (1,15,966 and 91,078 shoots ha-1 respectively against 72,286 and 50,207 shoots ha-1 with water spray and control) respectively.

Agricultural Engineering

- A prototype tractor-operated cane node planter was developed and tested, leading to design modifications in the cane node metering mechanism. The modified metering mechanism was fabricated, integrated with the mainframe, and underwent preliminary laboratory and field testing. The performance was satisfactory, and detailed field testing is planned for this year.
- A new prototype of tractor-operated trash mulcher-cum-stubble shaver device for sugarcane ratoon crop, capable of performing ratoon initiation and trash management has been field tested with satisfactory results. It covers two rows of sugarcane and includes a stubble shaving unit operating after trash shredding. It is equipped with a chemical spraying unit for faster trash decomposition. A patent was applied, and revised claims were submitted in March 2023 (Application No. 202211007706).
- Design and development of matching implements for various farm operations in controlled traffic farming (CTF) was carried out. A field experiment was laid in the IISR farm for one hectare to study the CTF and conventional sugarcane cultivation. The sugarcane planting was done at different row spacing in November 2022. The weeding and interculturing were done with modified machines while maintaining the same wheel lane. The performance of the modified weeder and interculturing machine was satisfactory in accomplishing the unit operations involved. A new two cane rows machine, furrower-cum-packer which will make ridges and firm them to avoid lodging was developed.
- Ergonomic evaluation of a new manual sugarcane stripper-cum-detopper was conducted at IISR farm for stripping of dry and green leaves from the harvested cane and cutting of green top. One person could clean 85-110 kg of cane per hour with this tool. Testing indicated acceptable heart rates and light to moderately heavy workloads for male and female workers, respectively. The energy expenditure rate was 7.41 and 7.91 kJ/min with male and female farm workers, respectively. Additionally, a modified manual sett cutting machine with an attached seat improved operator efficiency by over 20%, though heart rates and energy consumption remained moderately high after 30 minutes of continuous work.
- Preliminary testing of a drone for spray rate and nozzle volume was conducted in the lab. Optimization of agrochemical spraying using the

drone in sugarcane began, with Metribuzin and Sempra applied for weed control in December 2023. Initial trials used 30 l/ha water, spraying at 1.0 m height, 5.0 m/s speed, and 3.0 m swath width. Spray distribution parameters were recorded using water-sensitive papers.

- Under Inter Institutional collaborative research project on evaluation of multiple auger planting technique for fruit crops in partially reclaimed sodic soil, a tractor-operated, PTO-driven multiple auger system (MAS) was developed for digging three circular pits simultaneously. The MAS, mounted on a three-point linkage, features a central auger for deep (1.0 m) large-diameter (300 mm) pits and adjacent augers for shallower (0.90 m) smaller-diameter (150 mm) holes. The system includes a main frame, pit digging blades, and power transmission units. Critical parameters like blade angles and auger speed were optimized to ensure clean pits.
- A total of 47 implements were manufactured for conducting field adaptability trials under various agro-climatic and soil conditions. Around 67 prototypes were developed and supplied to various institutes, universities, and KVKs, including PAU, Ludhiana, HAU, Hisar, UAS, Mandya, JAU, Junagadh and KVK, Hapur.
- Prototype feasibility testing of a tractor-operated automatic potato-cum-sugarcane trench planter was conducted at the IISR farm. The planter's performance was evaluated on parameters like sett length, number of setts cut and dropped, furrow depth, soil cover depth, ridge height, seed potatoes dropped, and wheel slippage. The planter, operated by a 30-kW tractor, achieved an effective field capacity of 0.127 ha/h, requiring 8 hours per hectare. The cost of planting with the machine was Rs 3500 per ha, compared to Rs 13600 per ha manually, resulting in a 74.20% cost saving and a 90.1% labor saving.
- Prototype feasibility testing of a pedal-operated paddy thresher was conducted in Sitapur district, comparing its performance with conventional methods. Operated by both male and female workers for 50 hours, it achieved a threshing capacity of 60-85 kg/h with 92-97% efficiency. The thresher is suitable for small and marginal farmers.
- A solar-powered manual paddy thresher was developed for small and marginal farmers, featuring a main frame, drum, DC motor, battery, and solar panel. Preliminary testing at IISR farm showed a capacity of 1.5 q/h and an estimated cost of Rs. 25,000. Additionally, a hand-held manual nursery transplanter for vegetables and sugarcane seedlings was developed, and a small sugarcane harvesting system is being modified for further testing.
- A five-day farmer's training program on "Mechanisation of Sugarcane-Based Cropping Systems for Small Holdings" was held from October 9-13, 2023, at ICAR-IISR Lucknow, with 19 farmers from five districts of Uttar Pradesh participating. Additionally, a Field Day on "Improved Technologies for Sugarcane Mechanisation" was organized in Dashrathmau, Ayodhya, on October 4, 2023, in collaboration with Balrampur Chini Mill, Rauzagaon, with over 150 farmers attending.

Diversification and Value-addition in Sugarcane

- The IISR model jaggery unit was improved with better air provision for combustion, self-rotating ventilating fans, high-volume exhaust fans, and three-phase electrical points for equipment operation. Additionally, a hydraulic system was developed for producing small powder jaggery cubes, replacing manual pressure application.
- An air heater, measuring 182 cm by 76 cm, was fabricated and installed in a frame, inclined at 41° south, with a blower and mixing chamber for integrated drying. The heater connects to the drying chamber *via* a 76 cm pipe, incorporating inputs for electrical and waste heat recovery systems.
- Millet *Panjiri,* a nutritional supplement, was prepared using wheat flour, jowar flour, roasted Bengal gram, hemp seed powder, gond, almonds, and other ingredients sourced locally. Ingredients like flax seeds and hemp seeds were roasted for 5 minutes and ground into fine flour. Mixed with jaggery and ghee, the homogeneous mixture was packed into airtight pouches after preparation.

Economics, Statistics & ICT

- Based on the criteria of sugarcane intensiveness and growth rates in sugarcane area and productivity, cane growing districts were grouped into different categories for four major growing states Uttar Pradesh, Maharashtra, Karnataka and Tamil Nadu. The highly intensive sugarcane growing districts in UP has experienced positive growth in botj area and productivity levels but the main sugarcane growing districts in three tropical states have experienced decline in area and productivity levels during past decades. In UP, the eight districts have recorded a positive and significant growth both in sugarcane area and productivity levels. The three districts each from Maharashtra and Karnataka and four of Tamil Nadu have recorded negative growth in sugarcane area and productivity levels.

- India exports sugar and confectionery products to 170 -182 countries every year in the World. India's sugar and confectionary export was worth of 3016 million USD during TE 2021 which grew by 41.42% per year during past 5 years. Top 5 destinations for Indian sugar exports were the Sudan, Indonesia, Somalia, Iran and Sri Lanka. These 5 countries accounts for 45.29% of Indian sugar exports while top 10 countries accounts for 68.66% of total sugar exports. It highlights that the Indian sugar exports are highly concentrated to few developing countries. Analysis of trade profile of each South Asian country reveal that sugar is neither a major import nor an export commodity in total trade as well as in aggregate agricultural trade. However, India had comparative advantage in supply-side for sugar exports to SA countries (as RCA >1), which also gained comparative advantage in sugar exports. Three South Asian countries viz., Sri Lanka, Bangladesh and Afghanistan are amongst top 10 countries which demand Indian sugar. Hence, the country - specific sugar demand preferences should be analyzed and suitable policy and strategy are needed to increase sugar exports to the SA countries.

Biologic Control Centre, Pravaranagar, Maharashtra

- A field evaluation of *Heterorhabditis indica* against white grub showed 16.58% clump mortality in the *H. indica*-treated plot compared to 35.89% in the untreated control. This *H. indica*-killed white grub produced sufficient numbers of IJs under field conditions in sugarcane.
- Insecticidal activity of entomopathogenic bacterial isolates *Paenibacillus* sp. and *Bacillus* sp. were found promising against white grub *Holotrichia serrata*, causing 60% and 40-60% mortality in third-instar grubs respectively. *Bacillus* sp. isolate Bt1 and Bt2 were identified as *Bacillus thuringiensis* by 16S *rRNA* partial sequences, which have been deposited in NCBI GenBank and respectively, designated as IISRBCCEB01 (Acc. No. OQ504327) and IISRBCCEB02 (Acc. No. OQ504330).
- Gum-producing and sucrose-degrading bacterial isolates degrade sucrose by 28% and 22.5%, respectively, after 12 hours of inoculation. Based on 16S rRNA partial sequences, sucrose degrading bacterial isolates no. 2, 3, 4, 7, 10, and 11 were identified as *Klebsiella* sp, *Pantoea dispersa*, *Enterobacter* sp (IISRBCCSB02, Acc. No. OQ504353) *Lysinibacillus* sp, *Klebsiella* sp (IISRBCCSB01, Acc. No. OQ504350) and *Pantoea agglomerans*, respectively.
- The *Cercospora* sp. associated with the brown spot of sugarcane showed maximum growth and sporulation in the culture media containing 25% green leaf extract supplemented with 20% V8 at 25ºC.
- PCR-based assays for identification of mating type indicated that all the isolates of *Fusarium* sp. associated with pokkah boeng of sugarcane possess MAT-1 idiomorph.
- *In vitro* bioassay of mycoparasitic fungi showed a 91.85 ± 2.41 % reduction in germination of uredospore and 72.51 ± 5.55% and 74.91±4.64% parasitization in uredospores of rust pustules at $2x10^6$ and $2x10^8$ spore per ml.
- *In-vitro* bioassay of entomopathogenic fungi against whitefly *Aleurolobus barodensis* revealed 59.09% and 82.28% parasitization, while in-field bioassay 28.37% and 72.62% parasitization was observed in the nymph and pupae stages after the 4th and 8th day after inoculation.
- Hymenopteran parasitoid reported in the whitefly *Aleurolobus barodensis* nymph and pupae was identified as *Habrobracon* sp. by 28S D2 subunit partial sequence.
- First reported the infestation of a scale insect in sugarcane in the range of 10-20 nymphs/leaf on the lower surface, which on a high level of infestation causes the drying of leaf lamina. Heavy secretion of honeydew leads to blackening due to sooty mold growth and the scale insect was identified as *Icerya pilosa* Green (Family: Monophlebidae).

Sugar beet

- Seed production of sugar beet varieties was done at Sugarbeet Breeding Outpost, Mukteshwar while 149 germplasm were maintained at IISR, Lucknow. The genotypes LKC 11, LKC 2000, and LKC HB showed better performance under water-limiting conditions, whereas, LKC 2006 and LS 6 performed the best under saline conditions. The variety LS 6 performed the best under high temperature conditions. Higher incidence of *Cercospora* leaf-spot disease, *Fusarium* yellows, *Sclerotium* root rot along with minor incidences of leaf minor, spiders, beetles, Myzus, Bihar hairy caterpillar and grasshoppers along with viral diseases was noticed. *Spodoptera* spp. (army worm) was the major insect. LKC 2020 had the highest ethanol content followed by LKC 2010.

कार्यकारी सारांश

फसल सुधार

- कृषि फसलों के लिए फसल मानकों, अधिसूचना और किस्मों के विमोचन पर केंद्रीय उप–समिति द्वारा तीन गन्ना किस्मों जिसमें दो किस्में अर्थात..कोलख 14201 (अगेती) एवं कोलख 15206 (मध्य क्षेत्र) को भारत के उत्तर पश्चिमी क्षेत्र में व्यावसायिक खेती के लिए और गन्ने की एक अगेती किस्म कोलख 16466 को भारत के उत्तर मध्य और उत्तर पूर्वी क्षेत्रों के लिए वाणिज्यिक खेती के लिए संस्तुत की गई एवं (भारत का राजपत्र अधिसूचना एस.ओ. 4222 (ई) दिनांक 25 सितंबर, 2023) के द्वारा अधिसूचित की गई।
- गन्ने की शीघ्र पकने वाली गन्ना किस्म कोलख 16202 को भारत के उत्तर पश्चिमी क्षेत्र एवं मध्य–देर से पकने वाली किस्म कोलख 16470 किस्म को भारत के उत्तर मध्य और उत्तर पूर्वी क्षेत्र के लिए डॉ. आरपीसीएयू, पूसा में आयोजित अखिल भारतीय समन्वित गन्ना अनुसंधान परियोजना कार्यशाला के दौरान किस्म पहचान समिति द्वारा चिन्हित की गई।
- तीन शीघ्र पकने वाली गन्ना क्रंतक जैसे कोलख 23201 (एलजी 17222), कोलख 23202 (एलजी 19014) और कोलख 23203 (एलजी 16487) और तीन मध्य–देर से पकने वाली क्रंतक जैसे कोलख 23204 (एलजी 18410), कोलख 23205 (एलजी 18907) एवं कोलख 23206 (एलजी 15670) को भारत के उत्तर–पश्चिम क्षेत्र में बहु–स्थानिक मूल्यांकन परीक्षण हेतु डॉ. आरपीसीएयू, पूसा में आयोजित अखिल भारतीय समन्वित गन्ना अनुसंधान परियोजना कार्यशाला –2023 स्वीकृत किए गए।
- पौध किस्म और कृषक अधिकार संरक्षण अधिनियम, 2001 के तहत पंजीकरण के लिए गन्ने की तीन किस्मों अर्थात् कोलख 15201 (इक्षु –11), कोलख 15207 (इक्षु –12) और कोलख 15466 (इक्षु –13) का आवेदन किए गए थे।
- गन्ने के दो उच्च शर्करा जेनेटिक स्टॉक एलजी 15533 और एलजी 16581 जिनमें सुक्रोज की मात्रा जनवरी महीने में 20.0% थी, को भाकृअनुप : गन्ना प्रजनन संस्थान, कोयंबटूर में राष्ट्रीय संकरण उद्यान (एनएचजी) में शामिल करने के लिए भेजा गया ।
- आनुवंशिक निष्ठा और गुणवत्ता के लिए केला (27605), गन्ना (270) और आलू (3970) सहित कुल 31645 नमूनों का परीक्षण किया गया था, जिसमें मोजेक वायरस (एससीएमवी), पीले पत्ती का वायरस (एससीआईएलवी), बैसिलिफॉर्म वायरस (एससीबीवी) और फाइटोप्लाज्मा तथा केले में ब्रैक्ट मोजेक वायरस (बीबीआरएमवी), खीरे मोजेक वायरस (सीएमवी), बंची टॉप वायरस (बीबीटीवी) और केला स्टिक वायरस (बीएसवी) तथा आलू में पीवीएक्स, पीवीए, पीवीएम, पीवीएस, पीएलआरवी, पीएलसीवी, जीबीएनवी और पीएसटीवीडी शामिल थे।
- नैनो एलसीएमएस/ एमएस आधारित प्रोटिओमिक्स विश्लेषण से *सी. फाल्काटम* में एमएपीके सिग्नलिंग पाथवे में शामिल अठारह प्रोटीन का पता चला, जिनमें से बारह कोर एमएपीके सिग्नलिंग पाथवे का हिस्सा थे, जबकि शेष अप्रत्यक्ष रूप से फंसे हुए थे। एमएपीके प्रोटीन के स्ट्रिंग एसोसिएशन नेटवर्क ने रोगजनक/विषाणुता की प्रक्रिया में शामिल कई अन्य प्रोटीन के साथ मजबूत जुड़ाव का पता चला। जांच में आगे गन्ने की लाल सड़न प्रतिरोधी (बीओ 91) और अतिसंवेदनशील (सीओजे 64) किस्मों में 21 कैटेलेज की उपस्थिति का पता चला, जिसमें अतिसंवेदनशीलता की तुलना में प्रतिरोधी किस्म में उत्प्रेरक प्रोटीन की की प्रचुरता में वृद्धि हुई है। प्रोटीन के निष्कर्षों को प्रमाणित करने के लिए पहचाने गए प्रोटीन के अनुरूप चयनित छह उत्प्रेरक जीन का क्यूआरटी–पीसीआर आधारित वास्तविक समय अभिव्यक्ति विश्लेषण किया गया था। क्यूआरटी–पीसीआर ने गन्ने के डंठलों के साथ संवर्धित *सी. फाल्काटम* नमूनों में शामिल चार एमएपीके, तीन एमएपीके और पांच एमएपीके की प्रबलता को भी मान्य किया।
- गन्ने में प्रारंभिक सुक्रोज संचय से जुड़ी पाइरोफॉस्फेट–फ्रक्टोज 6–फॉस्फेट 1–फॉस्फोट्रांसफरेज (पीएफपी) के -–सब्यूनिट के भीतर एक महत्वपूर्ण अंतर वैकल्पिक इस्पलाइजिंग (एएस) घटना की पहचान की गई थी। समय से पहले बंद होने वाले कोडन जिसके परिणामस्वरूप छाटें गए प्रोटीन भी एक्वापोरिन, एलोडोलेज, साइटोक्रोम सी–ऑक्सीडेज, रिबोफोरिन और प्लाज्मा झिल्ली आंतरिक प्रोटीन के लिए जीन कोडिंग में पाए गए थे। ए.एस. घटनाओं और समय से पहले रुकने वाले कोडनों के रूप में इनका एक बड़ा अनुपात उच्च और कम सुक्रोज सामग्री वाली गन्ना किस्मों के एक स्वतंत्र सेट में उनके अंतर संवर्धन के लिए मान्य किया गया था।
- 174 गन्ना किस्मों के एक पैनल का उपयोग करके लाल सड़न रोगजनक (सीएफ 01, सीएफ 08 और सीएफ 09) की तीन प्रजातियों के प्रतिरोध के लिए जीनोम वाइड एसोसिएशन मैपिंग के माध्यम से विशेषता के साथ जुड़े होने के लिए एक उच्च महत्वपूर्ण एसएनपी (एफडीआर 0. 01) की पहचान की गई थी, जिसके बाद इस पैनल का उपयोग ट्रेनिंग पॉपुलेशन के रूप में लाल सड़न प्रतिरोध के लिए जीनोमिक भविष्यवाणी की गई थी। परीक्षण पॉपुलेशन के रूप में उपयोग किए गए 144 एफ1(एमएस 68/47 एक्स कोव 92102) क्लोनों के एक सेट को उनके पूर्वानुमानित लाल सड़न प्रतिरोध मूल्यों के निर्धारण के लिए जीबीएस के माध्यम से जीनोटाइप किया गया था और लाल सड़न प्रतिरोध और सुक्रोज सामग्री के लिए उच्च पूर्वानुमान मूल्यों वाले 10 एफ1 क्लोनों के एक सेट को वंशावली के रूप में उपयोग किया गया था।
- आईसीएआर बीज परियोजना के तहत आईआईएसआर, लखनऊ में 12 अगेती और मध्य–देर से पकने वाली किस्मों

के लगभग 10430 क्विंटल गन्ना बीज का उत्पादन किया गया और बिहार बीज परियोजना के तहत बिहार के चार प्रमुख केंद्रों जिनमें आईआईएसआर क्षेत्रीय केंद्र, मोतीपुर, नई स्वदेशी चीनी मिल्स, नरकटियागंज, हरिनगर चीनी मिल्स, हरिनगर एवं तिरुपति शुगर्स लिमिटेड, बगहा पर पाँच अलग–अलग गन्ना किस्मों के कुल 18,676.37 क्विंटल प्रजनक बीज का उत्पादन किया गया। नई गन्ना किस्मों के सूक्ष्म प्रवर्धन के माध्यम से रोग मुक्त एवं आनुवंशिक रूप से शुद्ध गन्ना बीज का उत्पादन जारी रखा गया तथा पिछले वर्ष की *इन–विट्रो* प्रवर्धित गन्ना किस्मों कोलख 09204, कोलख 14201 के लगभग 5000 पौधों को अनुकूलित कर खेत में स्थानांतरित किया गया, जबकि कोलख 14201 किस्म के लगभग 10000 पौधों को मिस्ट चौंबर में अनुकूलित किया गया।

फसल उत्पादन

- पेड़ी प्रादुर्भित के समय के बारे में अध्ययन से पता चला है कि पेड़ी लगाने के 150, 180 और 210 दिन बाद पेड़ी प्रारम्भ (डीएआरआई) फरवरी में पेड़ी प्रादुर्भित की फसल में सबसे अधिक पौधों की संख्या (1,47,242.8), उसके बाद मार्च (1,41,070), अप्रैल (1,30,123) एवं मई (1,28,642) पाई गई। सबसे अधिक पेड़ी गन्ने की पैदावार फरवरी में पेड़ी प्रादुर्भित की फसल में पाई गई, जो अप्रैल और मई में पेड़ी लगाने की फसल से काफी अधिक थी। फरवरी, मार्च और अप्रैल में पेड़ी लगाने की फसल की तुलना में गन्ने की पैदावार में क्रमशः 16.8%, 15.4% और 5.9% की वृद्धि हुई।
- 15 फरवरी को शुरू किया गया पेड़ी प्रादुर्भन सभी विकास और उपज मापदंडों में पिछले वर्ष के 15 दिसंबर को शुरू किए गए पेड़ी प्रादुर्भित से काफी बेहतर था। फरवरी में शुरू की गई पेड़ी की फसल में दिसंबर में शुरू की गई पेड़ी (68. 52 टन/हेक्टेयर) की तुलना में 25.78 प्रतिशत की वृद्धि हुई।
- औषधीय और सुगंधित फसलों के साथ गन्ना आधारित फसल प्रणालियों में तुलसी–स्टीविया–गन्ना (बसंत) – गन्ना पेड़ी–पुदीना (खरीफ मौसम) प्रणाली के तहत तुलसी *(ओसीमम सैंक्टम)* की उच्चतम धान समतुल्य उपज (73.5 क्विंटल/हेक्टेयर) दर्ज की गई। इसी तरह, रबी मौसम के दौरान तुलसी–जंगली गेंदा (दो कट) – गन्ना (बसंत) – गन्ना पेड़ी–पुदीना के तहत जंगली गेंदा *(टैगेटेस मिनुटा)* की अधिकतम गेहूं समतुल्य उपज (109.7 क्विंटल/हेक्टेयर) दर्ज की गई।
- शरदकालीन गन्ना आधारित समेकित कृषि प्रणाली से गन्ने के साथ। सब्जी बागवानी फसलों, मुर्गी पालन, डेयरी, मत्स्य पालन, वर्मीकम्पोस्ट के साथ एकीकृत गन्ना फसल पर उच्चतम शुद्ध आय 7,80,165 रुपये प्रति हेक्टेयर रुपये के साथ 4,53,040 रुपये प्रति हेक्टेयर की अतिरिक्त आय पाया गया। बसंतकालीन गन्ना आधारित समेकित कृषि प्रणाली से गन्ने के साथ सब्जियों, बागवानी फसल, घर के पीछे मुर्गी पालन, डेयरी, मत्स्य पालन, वर्मीकम्पोस्टिंग (ईसेनिया फेटिडा) के साथ एकीकृत गन्ना फसल पर शुद्ध आय 7,61,276 रुपये प्रति हेक्टेयर के साथ 4,50,981 रुपये प्रति हेक्टेयर की अतिरिक्त आय पाया गया।
- नैनो–लेपित यूरिया ने बाजार में उपलब्ध पारंपरिक नीम–लेपित यूरिया की तुलना में धीमी गति से मुक्त होने की विशेषताओं को दिखाया। नैनो–कोटेड यूरिया के माध्यम से पोषक तत्वों (आरडीएन) की 100% अनुशंसित पोषक के प्रयोग से पारंपरिक यूरिया के 100% आरडीएन का उपयोग करने की तुलना में पौधे की ऊंचाई, गन्ने की मोटाई और प्रति गन्ने के वजन में वृद्धि पाई गई। इसके अतिरिक्त, नैनो–कोटेड यूरिया के रूप में केवल 50% खुराक का उपयोग, दो या तीन बार में, नीम–कोटेड यूरिया का उपयोग करके नाइट्रोजन की 100% अनुशंसित पोषक की तुलना में मिल योग्य गन्ने की समान संख्या प्राप्त हुई।
- माइक्रोबियल कंसोर्टिया (62.3 और 6.57 टन प्रति हेक्टेयर) के बिना उर्वरक की अनुशंसित खुराक की शतप्रतिशत की तुलना में 75% आरडीएफ के साथ माइक्रोबियल कंसोर्टिया का उपयोग गन्ना और चीनी की उपज में 8.8% और 13% की वृद्धि हुई। तीसरी पेड़ी फसल की गन्ना उपज में क्रमशः दूसरी (76.7 टन प्रति हेक्टेयर) और पहली (88.6 टन प्रति हेक्टेयर) पेड़ी फसल की तुलना में 16.2% और 27.4% की कमी आई।
- उर्वरक को पट्टी में लगाने से गन्ने की उपज में (7%) की उल्लेखनीय वृद्धि हुई और यह छिड़काव विधि से बेहतर साबित हुई। नाइट्रोजन और पोटाश के पोषक तत्वों को पारंपरिक तरीके से की गई तीन बार की तुलना में पांच बार खेतों में छिड़काव करने से गन्ने और चीनी की उपज में उल्लेखनीय सुधार हुआ।
- सिंचाई व्यवस्था ने गन्ने की वृद्धि और उपज पर महत्वपूर्ण प्रभाव डाला। पौधों की फसल में, बुआई के 140 दिन बाद टिलर की संख्या, मिल योग्य गन्नों की संख्या, औसत गन्ने का वजन, गन्ने की लंबाई और गन्ने की उपज में उल्लेखनीय वृद्धि दर्ज की गई, जिसमें आईडब्ल्यू : सीपीई अनुपात 0.6 की तुलना में 1.0 और 0.8 रहा। गहरी नाली (ट्रेंच) में सिंचाई (90.69 टन/हेक्टेयर) या एकांतर गहरी नाली में (89.33 टन/हेक्टेयर) जल दृप्लावन सिंचाई (85. 69 टन/हेक्टेयर) के बराबर गन्ने की उपज प्राप्त हुई। विभिन्न सिंचाई व्यवस्थाओं के तहत जल उत्पादकता, आईडब्ल्यूः सीपीई अनुपात 0.8 के साथ सबसे अच्छी (193. 01 लीटर/किग्रा) दर्ज की गई। सिंचाई के तरीकों में, गहरी नाली (ट्रेंच) सिंचाई में सबसे कम जल पदचिह्न (फूट प्रिंट) 122.71 लीटर/किग्रा प्राप्त हुआ।
- हरे, नीले और भूरे घटकों के बीच पानी के पदचिह्न के विभाजन से पता चला कि बारिश कुल पानी के पदचिह्न में लगभग 75–78% का योगदान करती है और फसल अपनी पानी की आवश्यकता के केवल 12–15% के लिए सिंचाई के पानी पर निर्भर करती है। पेड़ी की फसल में, आईडब्ल्यूः सीपीई अनुपात 0.8 के साथ सिंचाई व्यवस्था अंतर्गत सबसे अधिक पेड़ी की उपज प्राप्त की गई, जो सांख्यिकीय रूप से आईडब्ल्यूः सीपीई अनुपात 1.0 के साथ

दर्ज की गई उपज के समान है। पेड़ी की खेती में सबसे अच्छी सिंचाई जल उत्पादकता आईडब्ल्यू: सीपीई अनुपात 0.6 (83.20 लीटर/किग्रा) वाली सिंचाई व्यवस्था के तहत पाई गई, इसके बाद आईडब्ल्यू: सीपीई अनुपात 0.8 (91.35 लीटर/किग्रा)। स्किप गहरी नाली सिंचाई ने सबसे अच्छी जल उत्पादकता (50.82 लीटर/किग्रा) दर्ज की, इसके बाद सभी गहरी नाली की सिंचाई (66.16 लीटर/किग्रा) की गई। पेड़ी को कुल जल पदचिह्न में लगभग 61% योगदान वर्षा से मिलता है और यह अपनी फसल के पानी की जरूरतों के केवल 25% के लिए सिंचाई पर निर्भर करती है।

फसल सुरक्षा

- विभिन्न चीनी मिल के अधीनस्थ क्षेत्रों, किसानों के खेतों और आईआईएसआर फार्म में किए गए सर्वेक्षण में लाल सड़न, मुरझान, मुड़ा हुआ शीर्ष (पोक्का बोयंग), आर.एस.डी., पत्ती झुलसा रोग एवं अन्य गंभीरता के स्तर वाले वायरल रोगों की उपस्थिति देखी गई।
- स्वस्थ एवं दैहिक विकारों के ग्रसित कीटों की कुल 1,307 आर.जी.बी. छवियों को विभिन्न प्रकाश स्थितियों के तहत नियंत्रित और वास्तविक समय की स्थितियों में कैप्चर किया गया था। कुल मिलाकर, आईसीएआर–आईआईएसआर, लखनऊ की फसल सुरक्षा विभाग द्वारा–15,746 आर.जी.बी. छवियों का भंडार रखा जा रहा है।
- डीयूएस परीक्षण के लिए रखी जा रही गन्ना किस्मों के संग्रह में पेड़ी स्टंटिंग रोग (आरएसडी) की मानचित्रण से गन्ना नोड संक्रमण की अलग–अलग डिग्री <10% से >40% तक का पता चला। पिछले कुछ वर्षों से, किस्मों ने प्रतिरोधता और संवेदनशीलता की तीव्रता में बदलाव दिखाया है।
- उत्तर प्रदेश, बिहार और महाराष्ट्र के विभिन्न क्षेत्रों से एकत्र किए गए 68–मोजेक लक्षण वाले गन्ने और ज्वार के नमूनों में से, 25 नमूनों में गन्ना मोजेक (एससीएसएमवी) रोग के लिए आरएनए का 590बीपी बैंड था। बैंड के अनुक्रमण से एससीएसएमवी के अनुक्रमों के साथ इनकी 100% पहचान का पता चला।
- सेट उपचार के माध्यम से *ट्राइकोडरमा हारजियानम* के प्रयोग से कम मुड़े हुए शीर्ष रोग विकास (5.33% रोग की घटना) पाया गया, और इसने पौधों के विकास को बढ़ावा देने वाले लक्षणों और पौधों के दैहिकी मापदंडों में सुधार किया।
- एसटीडी के माध्यम से वितरित रसायन द्वारा आरएसडी के प्रबंधन ने 18 पीपीएम पर एसटीडी और स्ट्रेप्टोसाइक्लिन के संयोजन में गन्ना नोड संक्रमण को कम किया और गन्ने की ऊंचाई, मोटाई एवं पोरों की लंबाई में वृद्धि प्राप्त हुआ।
- 1250 वर्ग मीटर क्षेत्र में ड्रोन टैंक में 5 लीटर पानी में 65 ग्राम थियोफैनेट मिथाइल या 50 ग्राम कार्बेन्डाजिम या 20 मिली प्रोपिकोनाजोल फॉर्मूलेशन का प्रयोग लाल सड़न के प्रबंधन में प्रभावी पाया गया। आउटरीच कार्यक्रम के उपचारित भूखंड या तो लाल सड़न से मुक्त थे या उनमें 1–10% संक्रमित थे, जबकि आस–पास के अनुपचारित खेतों में 60–70% संक्रमण थे।
- मृदा के स्वास्थ्य की निगरानी के लिए एक संकेतक के रूप में माइक्रोआर्थ्रोपोड की बहुतायत (निचले बेसलाइन के रूप में पहला क्वार्टाइल और ऊपरी आधार लाइन के रूप में तीसरा क्वार्टाइल) का उपयोग किया जा सकता है। शैनन, बर्गर पार्कर और चाओ1 सूचकांक भी गन्ना कृषि पारिस्थितिकी तंत्र का आकलन करने में उपयोगी हैं।
- गन्ने से पहली बार दीमक की तीन प्रजातियाँ *ओडोन्टोटर्मेस वैश्नो बोस, ओडोन्टोटर्मेस बेलाहुनीसेंसिस होल्मग्रेन एवं ओडोन्टोटर्मेस होर्नी (वासमैन)* पाई गई। बैक्टीरिया एवं प्रोटिओबैक्टीरिया गट में मौजूद दो सबसे प्रमुख फाइला थे, जिसमें *ट्रेपोनेमा* और *स्यूडोमोनास* प्रमुख जीवाणु वंश थे। पर्यावरणीय प्रभाव के संदर्भ में क्लोरेंट्रानिलिप्रोले दीमक के खिलाफ सबसे सुरक्षित कीटनाशक था। दीमक के पालन के लिए शीशम आधारित आहार प्रयोगशाला में विकसित किया गया था।
- गन्ने के अनुकूल *ट्राइकोग्रामा किलोनिस* (चोटी बेधक स्ट्रेन) के अंडनिक्षेपण की दर पहले तीन दिनों में काफी अधिक थी। गन्ने के अनुकूल पर्व बोरर स्ट्रेन टी. चिलोनिस की प्रजनन क्षमता 7♀: 1♂ अनुपात में अधिकतम थी, उसके बाद 4रू1 और 5रू1 अनुपात में थी। खाद्य स्रोत के रूप में सरसों एफिड घोल ने अन्य पोषक तत्वों की व्यवस्था की तुलना में टेट्रास्टिचुशॉवर्डी की अधिकतम संतति (107.8ध्प्यूपा) का समर्थन किया। अधिकतम ताजा प्यूपा 5 दिनों के लिए संग्रहीत परपोषी प्यूपा से प्राप्त किया गया और भंडारण के 30 दिनों में यह काफी कम हो गया।
- टॉप बोरर के पहले ब्रूड की सीओएस 8436, सीओएलके 14201, कोलख 16204, कोलख 11206, सीओएस 767, सीओजे 64, कोलख 94184, कोलख 8102 और सीओ 0238 में काफी अधिक थी और कोलख 16203 और कोलख 13204 सबसे कम संवेदनशील थे। खड़ी गन्ने (अगस्त) में डंठल बोरर की घटना बीस अलग–अलग किस्मों में 9.0% से 48.7% तक भिन्न थी। डंठल छेदक के लिए सबसे संवेदनशील किस्म कोलख 13204 थी। सबसे कम संवेदनशील किस्में सीओ 7717, सीओजे 64 और सीओ 05011 थीं। जुलाई में पिंक मीली बग का संक्रमण देखा गया जो अगस्त तक कुछ किस्मों में 80% से अधिक हो गया।
- करंज बीज अर्क, बोतलब्रश अर्क, बेशर्म अर्क और नीम अर्क का आवेदन शीर्ष बोर के विभिन्न ब्रूडों के खिलाफ प्रभावी थे। स्थायी फसल में दीमक द्वारा नुकसान बेशर्म हाइड्रेट के साथ उपचार में कम था, इसके बाद लाटजीरा (अर्क और हाइड्रेट), नीम हाइड्रेट और करंज अर्क था। तुलसी से आवश्यक तेल शीर्ष बोरर के चौथे ब्रूड के खिलाफ प्रभावी थे, इसके बाद बोटल ब्रश था।

पादप कार्यिकी एवं जैवरसायन विभाग

- क्लोरोफिल स्थिरता सूचकांक (सीएसआई) और तनाव सहिष्णुता सूचकांक के बीच एक महत्वपूर्ण सकारात्मक सहसंबंध पाया गया, जिसमें सुझाव दिया गया था कि हरे रंग का चरित्र एकल/बहुगुणक तनाव सहिष्णुता के लिए दृश्य जांच मानदंडों में से एक हो सकता है। पत्ती ऊतक की सांद्रता विभिन्न तनावों के तहत महत्वपूर्ण कमी के स्तर से नीचे पाई गई। पत्ती के पोटेशियम का तनाव सहिष्णुता सूचकांक के साथ एक महत्वपूर्ण सहसंबंध था जो बताता है कि पत्ती में पोटेशियम की उच्च सांद्रता बनाए रखना बहु–अजैविक तनाव सहिष्णुता के लिए महत्वपूर्ण लक्षण में से एक हो सकता है।
- ट्रांस्क्रिप्टोमिक अध्ययन से पता चला कि पांच पोटेशियम ट्रांसपोर्टर जीन सूखा, लवणता और जलभराव के तहत काफी कम विनियमित थे, जो यह दर्शाता है कि पोटेशियम ट्रांसपोर्टर जीन का उत्थान उच्च पत्ती ऊतक के एकाग्रता के रखरखाव में बेहतर तनाव सहिष्णुता में महत्वपूर्ण भूमिका निभा सकता है।
- बेसल खुराक के रूप में दो सिलिका यौगिकों अर्थात सिलिकॉन डाइऑक्साइड और सिलिकॉन एसिड के प्रभाव और बुआई के 90 और 120 दिन पर उनके फोलियो एप्लिकेशन का आकलन अंकुरण और सब्सट्रेट मोबिलाइजेशन के लिए किया गया था। नियंत्रण की तुलना में सिलिका के साथ अंकुरण (%), कम करने वाली चीनी सामग्री और एसिड इनवर्टेस गतिविधि में महत्वपूर्ण परिवर्तन आया। बुआई के 20 और 45 दिन बाद (30.15 और 42.44%) दोनों पर 200 किग्रा प्रति हेक्टेयर की दर से सिलिकिक एसिड के साथ अधिकतम अंकुरण % पाया गया।
- शरद ऋतु में कोलख 94184 पर किए गए प्रयोग में, सेट प्राइमिंग और नियंत्रण के लिए इथरेल, जीवामृत और पानी के उपचार के प्रभाव का अध्ययन किया गया। प्राप्त परिणामों से संकेत मिलता है कि बुआई के 20 और 45 दिन बाद दोनों पर अनुपचारित सेटों की तुलना में इथ्रेल के साथ अंकुरण में 83 और 69% की वृद्धि हुई, जबकि जीवामृत उपचारित सेटों में 40.86 और 68% की वृद्धि हुई।
- विभिन्न गन्ना लिग्नोसेल्यूलोसिक बायोमास सामग्रियों के डाउनस्ट्रीम जैव उत्प्रेरक हाइड्रोलिसिस के लिए एक नई पूर्व–उपचार विधि अत्यधिक कुशल और प्रभावी पाई गई। हाइड्रोजन परोक्साइड–एसिटिक एसिड पूर्व उपचार के लिए इष्टतम स्थिति 75 डिग्री सेल्सियस, 2.5 घंटे, और हाइड्रोजन पेरोक्साइड और एसिटिक एसिड का बराबर मात्रा में मिश्रण था। समान परिस्थितियों में पिछली पूर्व उपचार प्रक्रियाओं की तुलना में, एंजाइमी डाईजेस्टीबिल्टी बढ़ाने में अधिक प्रभावी था।
- बुआई के 210 बाद टिलर की संख्या और बायोमास संचय से यह पता चला कि पानी के छिड़काव और नियंत्रण की तुलना में ईथ्रेल स्प्रे के साथ सेट स्प्रे और बायोमास डायनामिक्स के प्रयोग से अधिकतम लाभ प्राप्त हुआ। बुआई के 20, 30 और 45 दिन बाद अधिकतम अंकुरित प्रतिशत इथ्रेल स्प्रे / 100 पीपीएम > एनएए स्प्रे / 50 पीपीएम स्प्रे > एनएए स्प्रे / 100 पीपीएम के साथ डीएपी पर पानी स्प्रे और नियंत्रण के विरूद्ध पाया गया था। बुआई के 120 दिन बाद, ईथ्रेल स्प्रे औसत प्रारंभिक अंकुर संख्या (1,22,735 अंकुर प्रति हेक्टेयर) के साथ सबसे अधिक थे, उसके बाद एनएए स्प्रे /50 और 100 पीपीएम के साथ क्रमशः 1,15,966 और 91,078 अंकुर प्रति हेक्टेयर और जल छिड़काव एवं नियंत्रण के साथ क्रमशः 72,286 और 50,207 अंकुर प्रति हेक्टेयर थे।

कृषि अभियंत्रण

- ट्रैक्टर से चलने वाले केन नोड प्लांटर का प्रोटोटाइप विकसित और परीक्षण किया गया, जिससे केन नोड मीटरिंग तंत्र में संशोधन डिजाइन किए गए थे। संशोधित मीटरिंग तंत्र का निर्माण करके, मेनफ्रेम के साथ एकीकृत किया गया, और प्रारंभिक प्रयोगशाला और क्षेत्र परीक्षण भी किया गया। प्रदर्शन संतोषजनक रहा, और इस वर्ष के लिए विस्तृत क्षेत्र परीक्षण की योजना बनाई गई है।
- गन्ने की पेड़ी फसल के लिए ट्रैक्टर से चलने वाले ट्रैश मल्चर–सह–स्टबल शेवर डिवाइस का एक नया प्रोटोटाइप, जो पेड़ी आरंभ और ट्रैश प्रबंधन का क्षेत्र परीक्षण में प्रदर्शन संतोषजनक रहा। यह गन्ने की दो पंक्तियों को कवर करता है साथ ही इसमें ट्रैश काटने के बाद काम करने वाली स्टबल शेविंग इकाई शामिल है। यह तेजी से ट्रैश अपघटन के लिए एक रासायनिक छिड़काव इकाई से सुसज्जित है। इसके पेटेंट के लिए आवेदन किया गया था, और मार्च 2023 में संशोधित दावे प्रस्तुत किए गए थे (आवेदन संख्या 202211007706)।
- नियंत्रित ट्रैफिक खेती (सीटीएफ) में विभिन्न कृषि कार्यों से संबंधित उपकरणों का डिजाइन और विकास किया गया। सीटीएफ और पारंपरिक गन्ना खेती का अध्ययन करने के लिए एक हेक्टेयर के लिए आईआईएसआर फार्म में एक क्षेत्र प्रयोग किया गया था। गन्ना बुआई नवंबर 2022 में अलग–अलग पंक्ति अंतराल पर किया गया था। एक ही व्हील लेन को बनाए रखते हुए संशोधित मशीनों के साथ निराई और अंतःकृषि की गई। संशोधित निराई और अंतःकृषि मशीन का प्रदर्शन शामिल इकाई संचालन को पूरा करने में संतोषजनक था। एक नई दो गन्ना पंक्तियों की मशीन, फरोवर–कम–पैकर जो मेंड़ बनाएगा जिससे वे गिरने से बचेंगे।
- कटे हुए गन्ने से सूखे और हरे पत्तों को छीनने और हरे शीर्ष को काटने के लिए आईआईएसआर फार्म में एक नए मैनुअल गन्ना स्ट्रिपर–कम–डिटॉपर का एर्गोनोमिक मूल्यांकन किया गया था। एक व्यक्ति इस उपकरण से प्रति घंटे 85–110 किलो गन्ना साफ कर सकता है। परीक्षण ने क्रमशः पुरुष और महिला श्रमिकों के लिए स्वीकार्य हृदय दर और हल्के से मामूली भारी कार्यभार का संकेत दिया। ऊर्जा व्यय दर क्रमशः पुरुष और महिला कृषि श्रमिकों के साथ 7.41 और 7.91 किलो जूल/मिनट थी। इसके अतिरिक्त, संलग्न सीट के साथ एक संशोधित मैनुअल सेट

कटिंग मशीन ने 20% से अधिक ऑपरेटर की कार्यकुशलता में सुधार किया, हालांकि 30 मिनट के निरंतर काम के बाद हृदय गति और ऊर्जा खपत मामूली रूप से बढ़ी थी।

- स्प्रे रेट और नोजल वॉल्यूम के लिए ड्रोन का प्रारंभिक परीक्षण प्रयोगशाला में किया गया। गन्ने में ड्रोन का उपयोग करके कृषि–रासायनिक छिड़काव का इष्टतमीकरण शुरू हुआ, दिसंबर 2023 में खरपतवार नियंत्रण के लिए मेट्रिब्यूजीन और सेम्प्रा का छिड़काव किया गया। प्रारंभिक परीक्षणों में 30 लीटर/हेक्टेयर पानी का उपयोग किया गया, जो 1.0 मीटर की ऊंचाई, 5.0 मीटर/सेकेंड की गति और 3.0 मीटर की चौड़ाई पर छिड़कता है। जल–संवेदनशील कागजों का उपयोग करके स्प्रे वितरण मापदंडों को रिकॉर्ड किया गया।
- आंशिक रूप से पुनः प्राप्त सोडिक मिट्टी में फल फसलों के लिए मल्टीपल ऑगर रोपण तकनीक के मूल्यांकन पर अंतर संस्थागत सहयोगी अनुसंधान परियोजना के तहत, एक ट्रैक्टर–संचालित, पीटीओ–चालित मल्टीपल ऑगर सिस्टम (एमएएस) विकसित किया गया था, जो एक साथ तीन गोलाकार गड्ढे खोद सकता है। तीन–बिंदु लिंकेज पर लगाए गए एमएएस में गहरे (1.0 मीटर) बड़े–व्यास (300 मिमी) गड्ढों के लिए एक केंद्रीय ऑगर और उथले (0.90 मीटर) छोटे–व्यास (150 मिमी) छेदों के लिए आसन्न ऑगर हैं। इस प्रणाली में एक मुख्य फ्रेम, गड्ढे खोदने वाले ब्लेड और पावर ट्रांसमिशन इकाइयाँ शामिल हैं। साफ गड्ढे सुनिश्चित करने के लिए ब्लेड एंगल और ऑगर गति जैसे महत्वपूर्ण मापदंडों को अनुकूलित किया गया।
- विभिन्न कृषि–जलवायु और मिट्टी की स्थितियों के तहत फील्ड अनुकूलन क्षमता परीक्षण करने के लिए कुल 47 उपकरणों का निर्माण किया गया था। लगभग 67 प्रोटोटाइप विकसित किए गए और विभिन्न संस्थानों, विश्वविद्यालयों और केवीके को आपूर्ति की गई, जिनमें पीएयू लुधियाना, एचएयू हिसार, यूएएस मंड्या, जेएयू जूनागढ़ और केवीके हापुड़ शामिल हैं।
- आईआईएसआर फार्म में ट्रैक्टर–संचालित स्वचालित आलू–सह–गन्ना खाई प्लांटर का प्रोटोटाइप व्यवहार्यता परीक्षण किया गया। प्लांटर के प्रदर्शन का मूल्यांकन सेट लंबाई, कट और ड्रॉप किए गए सेटों की संख्या, फरो गहराई, मिट्टी कवर गहराई, रिज ऊंचाई, बीज आलू गिरे हुए और व्हील स्लिपेज जैसे मापदंडों पर किया गया था। 30 किलोवाट ट्रैक्टर द्वारा संचालित प्लांटर ने 0.127 हैक्टर प्रति घंटा की प्रभावी क्षेत्र क्षमता हासिल की, जिसके लिए 8 घंटे प्रति हेक्टेयर की आवश्यकता होती है। मशीन के साथ रोपण की लागत 3500 रुपये प्रति हेक्टेयर थी, जबकि मैन्युअल रूप से 13600 रुपये प्रति हेक्टेयर थी, जिसके परिणामस्वरूप 74.20% लागत बचत और 90.1% श्रम बचत हुई।
- पारंपरिक तरीकों के साथ इसके प्रदर्शन की तुलना करते हुए, सीतापुर जिले में एक पैडल संचालित धान थ्रेशर का प्रोटोटाइप व्यवहार्यता परीक्षण किया गया। पुरुष और महिला दोनों श्रमिकों द्वारा 50 घंटे तक संचालित, इसने 92–97% दक्षता के साथ 60–85 किग्रा/घंटा की थ्रेशिंग क्षमता हासिल की। थ्रेशर छोटे और सीमांत किसानों के लिए उपयुक्त है।
- छोटे और सीमांत किसानों के लिए एक सौर संचालित मैनुअल धान थ्रेशर विकसित किया गया, जिसमें एक मुख्य फ्रेम, ड्रम, डीसी मोटर, बैटरी और सौर पैनल शामिल थे। आईआईएसआर फार्म में प्रारंभिक परीक्षण में 1.5 क्विंटल प्रति घंटे की क्षमता और अनुमानित लागत रु. 25,000 है। इसके अतिरिक्त, सब्जियों और गन्ना बीजों के लिए एक हाथ से चलने वाला मैनुअल नर्सरी ट्रांसप्लांटर विकसित किया गया और आगे के परीक्षण के लिए एक छोटी गन्ना कटाई प्रणाली को संशोधित किया जा रहा है।
- 'छोटी जोत के लिए गन्ना आधारित फसल प्रणालियों का मशीनीकरण' पर पांच दिवसीय किसान प्रशिक्षण कार्यक्रम 9–13 अक्टूबर, 2023 से आईसीएआर– आईआईएसआर लखनऊ में आयोजित किया गया, जिसमें उत्तर प्रदेश के पांच जिलों के 19 किसानों ने भाग लिया। इसके अतिरिक्त, 4 अक्टूबर, 2023 को बलरामपुर चीनी मिल, रौजागांव के सहयोग से दशरथमऊ, अयोध्या में "गन्ना मशीनीकरण के लिए उन्नत प्रौद्योगिकी" पर एक फील्ड डे का आयोजन किया गया था, जिसमें 150 से अधिक किसानों ने भाग लिया।

गन्ने में विविधीकरण और मूल्यवर्धन

- आईआईएसआर मॉडल गुड़ इकाई को बेहतर बनाने के लिए दहन, वायु प्रावधान, स्व–घूर्णन वेंटिलेटिंग पंखे, उच्च मात्रा में निकास पंखे और उपकरण संचालन के लिए तीन चरण के विद्युत बिंदुओं के साथ बढ़ाया गया था। इसके अतिरिक्त, एक हाइड्रोलिक प्रणाली विकसित की गई थी जो छोटे पाउडर गुड़ के घन के उत्पादन के लिए, मैनुअल दबाव अनुप्रयोग को प्रतिस्थापित करती है।
- 182 सेमी x 76 सेमी मापने वाला एक एयर हीटर बनाकर एक ब्लोअर और मिक्सिंग चौंबर के साथ 41 डिग्री दक्षिण में झुके हुए फ्रेम में स्थापित किया गया। हीटर एक 76 सेमी पाइप के माध्यम से सुखाने वाले कक्ष से जुड़ता है, जिसमें विद्युत और अपशिष्ट ताप पुनर्प्राप्ति प्रणालियों के लिए इनपुट शामिल होते हैं।
- मिलेट पंजीरी, एक पोषण अनुपूरण है, जो कि गेहूं के आटे, ज्वार के आटे, भुने हुए बंगाल चने, फ्लेक्स के बीज के पाउडर, गोंद, बादाम और स्थानीय रूप से प्राप्त अन्य सामग्री का उपयोग करके तैयार किया गया था। अलसी और फ्लेक्स के बीज जैसी सामग्री को 5 मिनट तक भूनकर बारीक आटा बनाया गया। गुड़ और घी के साथ सजातीय मिश्रण को तैयार करने के बाद एयरटाइट पाउच में पैक किया गया।

अर्थशास्त्र, सांख्यिकी और आईसीटी

- गन्ना क्षेत्र और उत्पादकता में गन्ना सघनता एवं विकास

दर के मानदंडों के आधार पर, गन्ना उत्पादक वाले चार प्रमुख उत्पादक राज्यों उत्तर प्रदेश, महाराष्ट्र, कर्नाटक एवं तमिलनाडु के लिए विभिन्न श्रेणियों में बांटा गया था। उत्तर प्रदेश में अत्यधिक सघन गन्ना उत्पादक जिलों ने क्षेत्र और उत्पादकता के स्तर में सकारात्मक वृद्धि हुई है, लेकिन तीन उष्णकटिबंधीय राज्यों में मुख्य गन्ना उत्पादक जिलों ने पिछले दशकों के दौरान क्षेत्र और उत्पादकता के स्तर में गिरावट दर्ज किया है। उत्तर प्रदेश में, आठ जिलों ने गन्ना क्षेत्र और उत्पादकता दोनों स्तरों में सकारात्मक और महत्वपूर्ण वृद्धि दर्ज की है। महाराष्ट्र और कर्नाटक के तीन–तीन जिलों और तमिलनाडु के चार जिलों में गन्ना क्षेत्र और उत्पादकता के स्तर में नकारात्मक वृद्धि दर्ज की गई है।

- भारत दुनिया में हर साल 170–182 देशों को चीनी और कन्फेक्शनरी उत्पादों का निर्यात करता है। 2021 के दौरान भारत का चीनी और कन्फेक्शनरी निर्यात 3016 मिलियन अमेरिकी डॉलर का था, जो पिछले 5 वर्षों के दौरान प्रति वर्ष 41.42% बढ़ा है। भारतीय चीनी निर्यात के लिए शीर्ष 5 देश सूडान, इंडोनेशिया, सोमालिया, ईरान और श्रीलंका थे। इन 5 देशों में भारतीय चीनी निर्यात का 45.29 प्रतिशत हिस्सेदारी है, जबकि शीर्ष 10 देशों में कुल चीनी निर्यात का 68.66 प्रतिशत हिस्सेदारी है। यह दर्शाता है कि भारतीय चीनी निर्यात कुछ विकासशील देशों में अत्यधिक केंद्रित है प्रत्येक दक्षिण एशियाई देश के व्यापार प्रोफाइल के विश्लेषण से पता चलता है कि चीनी न तो कुल व्यापार के साथ–साथ समग्र कृषि व्यापार में एक प्रमुख आयात और न ही निर्यात वस्तु है। हालांकि, भारत को दक्षिण एशियाई देशों (आरसीए >1 के रूप में) को चीनी निर्यात के लिए आपूर्ति–पक्ष में तुलनात्मक लाभ था, जिसने चीनी निर्यात में तुलनात्मक लाभ भी प्राप्त किया। तीन दक्षिण एशियाई देश अर्थात श्रीलंका, बांग्लादेश और अफगानिस्तान भारतीय चीनी की मांग करने वाले शीर्ष 10 देशों में से हैं। इसलिए, देश की विशिष्ट चीनी मांग प्राथमिकताओं का विश्लेषण किया जाना चाहिए और दक्षिण अफ्रीका देशों को चीनी निर्यात बढ़ाने के लिए उपयुक्त नीति और रणनीति की आवश्यकता है।

बायोलॉजिकल कंट्रोल सेंटर, प्रवरनगर (महाराष्ट्र)

- व्हाइट ग्रब के खिलाफ *हेटेरोरहैबडाइटिस इंडिका* के क्षेत्र मूल्यांकन में एच. इंडिका– उपचरित भूखंड में 16.58% क्लंप मृत्यु दर दिखाई, जबकि अनुपचारित नियंत्रण में 35.89% थी। इस *एच. इंडिका–किल्ड व्हाइट ग्रब* ने गन्ने में फील्ड की स्थिति के तहत पर्याप्त संख्या में आईजे का उत्पादन किया।
- एन्टोमोपैथोजेनिक बैक्टीरिया आइसोलेट्स *पैनीबैसिलस* एसपी. और *बैसिलस* एसपी. को व्हाइट ग्रब *होलोट्रिचिया सेराटा* के खिलाफ कीटनाशक गतिविधि आशाजनक पाया गया, जिससे क्रमशः तीसरे– इंस्टार ग्रब में 60% और 40–60% मृत्यु दर हुई। *बैसिलस* एसपी. पृथक बीटी1 और बीटी2 की पहचान 16 एस आरआरएनए आंशिक अनुक्रमों द्वारा *बैसिलस थुरिंजिएंसिस* के रूप में की गई है, जिन्हें एनसीबीआई जीन बैंक में जमा किया गया है और क्रमशः, आईआईएसआरबीसीसीईबी01, (एसीसी संख्या OQ504327) और आईआईएसआरबीसीसीईबी02 (एसीसी संख्या OQ504330) के रूप में नामित किया गया है।
- गोंद बनाने वाले और सुक्रोज को नष्ट करने वाले जीवाणु पृथक्क 12 घंटे के टीकाकरण के बाद क्रमशः सुक्रोज को 28% और 22.5% तक नष्ट कर देते हैं। 16एस आरआरएनए आंशिक अनुक्रमों के आधार पर, सुक्रोज को नष्ट करने वाले जीवाणु पृथक्क नं. 2, 3, 4, 7, 10 और 11 की पहचान क्रमशः *क्लेबसिएलास्प, पैंटोएडिस्पर्सा, एंटरोबैक्टरस्प* (आईआईएसआरबीसीसीएसबी02, एसीसी नंबर व्फ504353) *लाइसिनीबैसिल एसपी., क्लेबसिएला एसपी.* (आईआईएसआरबीसीसीएसबी, एसीसी नंबर व्फ504350) और *पैंटोएग्लोमेरेंस* के रूप में की गई।
- गन्ने के भूरे धब्बे से संबंधित सर्कोस्पोरा प्रजाति ने 25 डिग्री सेल्सियस पर 20% V8 के साथ पूरक 25% हरी पत्ती के अर्क वाले संवर्धन माध्यम में अधिकतम वृद्धि और बीजाणु निर्माण दिखाया।
- समागम प्रकार की पहचान के लिए पीसीआर–आधारित परख ने संकेत दिया कि गन्ने के पोक्काबोएंग से जुड़े फ्यूजेरियम प्रजाति के सभी आइसोलेट्स में एमएटी –1 इडियोमॉर्फ मौजूद है।
- माइकोपैरासिटिक कवक के *इन विट्रो* बायोएसे ने यूरेडोस्पोर के अंकुरण में 91.85 ± 2.41% की कमी और 2.106 और 2.108 बीजाणु प्रति मिलीलीटर पर जंग के दानों के यूरेडोस्पोर में 72.51 ± 5.55% और 74.91 ± 4.64% परजीवीकरण दिखाया।
- व्हाइटफ्लाई *एलेरोलोबस बारोडेन्सिसनिम्फ* और प्यूपा में रिपोर्ट किए गए हाइमेनोप्टेरान परजीवी की पहचान 28 एस डी 2 सबयूनिट आंशिक अनुक्रम द्वारा हैब्रोब्राकॉन प्रजाति के रूप में की गई।

चुकंदर

- चुकंदर की किस्मों का बीज उत्पादन शुगरबीट ब्रीडिंग आउटपोस्ट, मुक्तेश्वर में किया गया, जबकि आईआईएसआर, लखनऊ में 149 जर्मप्लाज्म बनाए रखा गया। जीनप्रारूप एलकेसी 11, एलकेसी 2000 और एलकेसी एचबी ने पानी की सीमित परिस्थितियों में बेहतर प्रदर्शन किया, जबकि एलकेसी 2006 और एलएस 6 ने खारे पानी की परिस्थितियों में सबसे अच्छा प्रदर्शन किया। उच्च तापमान की स्थिति में एलएस 6 किस्म ने सबसे अच्छा प्रदर्शन किया। वायरल रोगों के साथ–साथ लीफ माइनर, मकड़ियों, भृंगों, माइजस, बिहार हेयरी कैटरपिलर और टिड्डों की मामूली घटनाओं के साथ–साथ सर्कोस्पोरा लीफ–स्पॉट रोग, फ्यूजेरियम येलो, स्क्लेरोटियम रूट रॉट का अधिक प्रकोप देखा गया। स्पोडोप्टेरा एसपीपी. (आर्मी वर्म) प्रमुख कीट था। एलकेसी 2020 के बाद एलकेसी 2010 ने सबसे अधिक इथेनॉल सामग्री का उत्पादन किया।

About the Institute

The ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow was established on February 16, 1952 by the erstwhile Indian Central Sugarcane Committee for conducting research on fundamental and applied aspects of sugarcane culture as well as to co-ordinate research work done on this crop in different states of the country. The Government of India took over the Institute from the Indian Central Sugarcane Committee on January 1, 1954, and thereafter, it was transferred to the Indian Council of Agricultural Research (ICAR), New Delhi on April 1, 1969. The Institute is located in Lucknow, the capital city of Uttar Pradesh and is conveniently situated at about 12 km from CCS Airport, Amausi and at about 5 km from Lucknow Railway Station. The climate of the area is sub-tropical semi-arid type. Monthly average maximum temperature during April to June ranges from 36°C to 40°C and minimum temperature during November to February ranges from 7°C to 11.5°C. The annual average rainfall is around 880 mm.

Vision

An efficient, globally competitive and vibrant sugarcane agriculture

Mission

Enhancement of sugarcane production, productivity, profitability and sustainability to meet future sugar and energy requirement of India

Mandate

(i) Basic, strategic and adaptive research on production and protection in sugarcane and breeding for sub-tropical region of the country

(ii) Coordination and monitoring of applied research on national and regional issues to develop improved varieties and technologies.

(iii) Dissemination of technologies and capacity building.

Issues and Strategies

To achieve the desired growth in area, productivity of sugarcane and recovery of sugar in different agro-ecological zones of the country and to extend appropriate information and technologies to the end users, the following issues and strategies have been identified that need to be pursued at:

Issues

- Low levels of cane yield and sugar recovery
- High cost of cane cultivation
- Decline in total factor productivity

Strategies

Increasing the level of cane yield and sugar recovery

a. Introgression of untapped genes in the parental gene pool

b. Enhancing selection efficiency through marker aided selection (MAS)

c. Improving sink strength and source efficiency

d. Enhancing productivity of ratoon cane

Reducing the cost of cane cultivation

a. Nutrient use efficiency through rhizospheric engineering and INM technology

b. Water use efficiency through micro- irrigation

c. Land use efficiency though companion cropping

d. Reducing cost of pesticide use in an eco-friendly manner through bio-intensive IPM and IDM

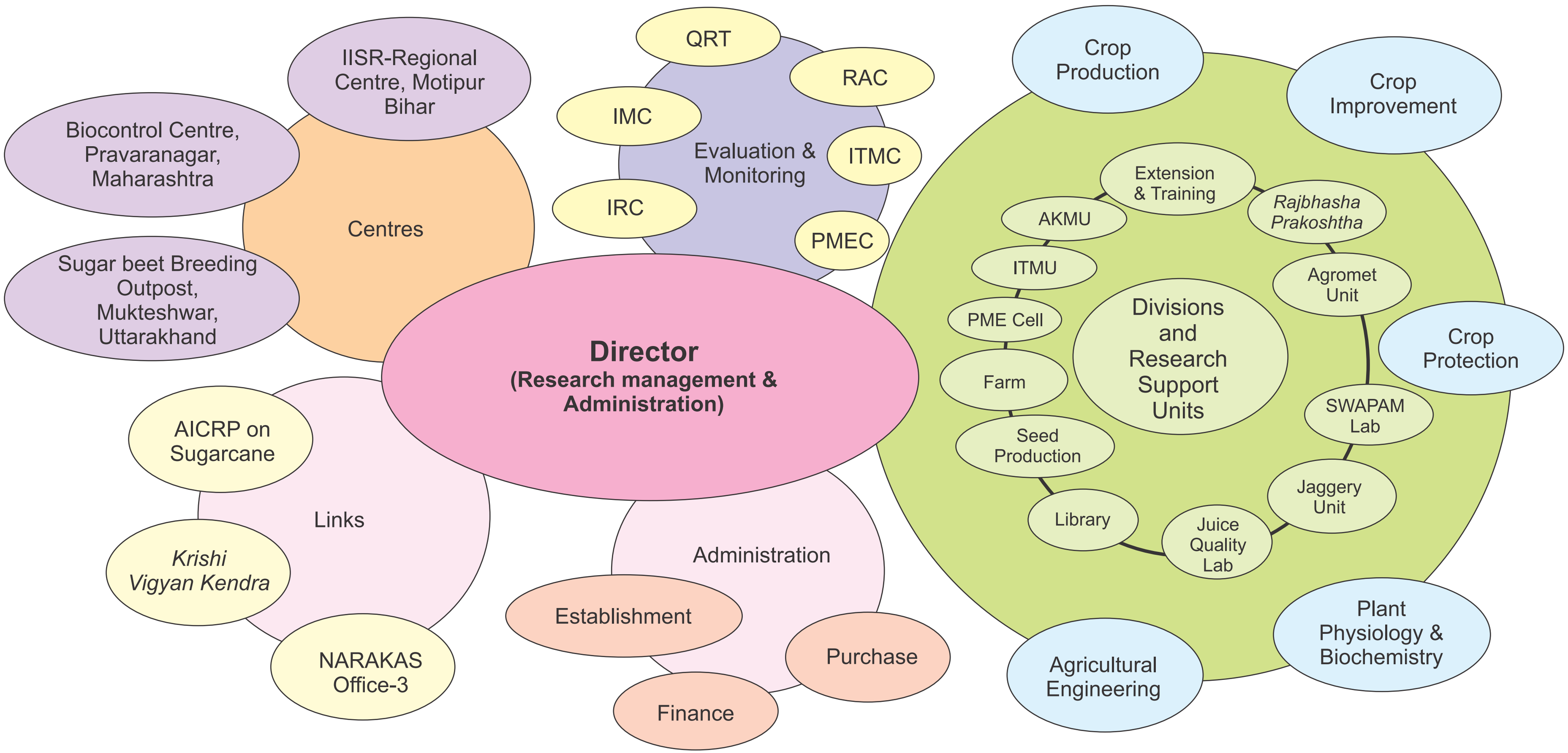
e. Mechanizing sugarcane farming

Arresting decline in total factor productivity

a. Soil biological and nutritional dynamism

b. Carbon sequestering through cropping system

ICAR-Indian Institute of Sugarcane Research, Lucknow



Organizational Structure

Budget 2022-23

Particulars	Plan (Rs. in lakh)	
	Revised Estimate	Expenditure as on December 31, 2022
ICAR-Indian Institute of Sugarcane Research, Lucknow	7144.00 including salary & pension	5603.52 including salary & pension
All India Coordinated Research Project on Sugarcane	962.00 including salary & pension	793.19 including salary & pension

Budget 2023-24

Particulars	Plan (Rs. in lakh)	
	Revised Estimate	Expenditure as on December 31, 2023
ICAR-Indian Institute of Sugarcane Research, Lucknow	7155.13 including salary & pension	5616.40 including salary & pension
All India Coordinated Research Project on Sugarcane	1452.54 including salary & pension	1452.54 including salary & pension

Staff Position

(As on December 31, 2023)

Category	Sanctioned	Filled	Vacant
RMP	**1**	**1**	**0**
Scientific			
Principal Scientist	7	2	5
Senior Scientist	14	12	2
Scientist	52	38	14
Total	**74**	**53**	**21**
Technical			
Category-I	77	25	52
Category-II	54	25	29
Category-III	3	1	2
Total	**134**	**51**	**83**
Administrative	**54**	**35**	**19**
Skilled Supporting Staff	**36**	**5**	**31**
Grand Total	**298**	**144**	**154**

CHAPTER 1

Genetic Improvement of Sugarcane for Higher Cane and Sugar Productivity

Technology development

Release and notification of sugarcane varieties

Two sugarcane varieties namely, CoLk 14201 (Early) and CoLk 15206 (Midlate) were released and notified by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops for commercial cultivation in North West Zone of India *(The Gazette of India notification S.O. 4222 (E) dated the 25 September, 2023)*. Another early maturing sugarcane variety i.e. CoLk 16466 has been released and notified by Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops (*The Gazette of India notification S.O. 4222 (E) dated the 25 September, 2023*) for commercial cultivation in North Central and North Eastern Zone of India (Table 1.1).

Table 1.1 Salient features of sugarcane varieties CoLk 14201, CoLk 15206 and CoLk 16466

Variety	Parentage	Maturity group	Cane yield (t/ha)	CCS yield (t/ha)	Sucrose % at harvest	Pol % cane at harvest	Recommended zone
CoLk 14201 (*IKSHU*-10)	Co 0238 GC	Early	91.34	11.39	18.11	13.69	North West zone
CoLk 15206 (*IKSHU*-14)	LG 95053 GC	Midlate	89.81	11.64	18.42	14.32	North West zone
CoLk 16466 (*IKSHU*-15)	BO 91 x Co 86002	Early	85.35	10.19	17.31	13.31	North Central & North Eastern zone

***Fig. 1.1** Field view of the plants and buds of CoLk 14201*

***Fig. 1.2** Field view of the plants and buds of CoLk 15206*

***Fig. 1.3** Field view of the plants and buds of CoLk 16466*

Identification for release of sugarcane varieties

The sugarcane variety CoLk 16202 (Early) was identified by the Varietal Identification Committee for its release in North West Zone of India during the Annual group meeting of All India Coordinated Research Project on Sugarcane held at Dr. RPCAU, Pusa on 26-27 October, 2023 (Table 1.2). Another sugarcane variety CoLk 16470 (Mid-late) was also identified by the Varietal Identification Committee for its release in North Central and North Eastern Zone of India during the Annual group meeting of All India Coordinated Research Project on Sugarcane held at Dr. RPCAU, Pusa on 26-27 October, 2023.

Table 1.2 Salient features of sugarcane varieties CoLk 16202 and CoLk 16470

Variety	Parentage	Maturity group	Cane yield (t/ha)	CCS yield (t/ha)	Sucrose % at harvest	Pol % cane at harvest	Recommended Zone
CoLk 16202 (*IKSHU*-16)	LG 95053 x CoLk 94184	Early	93.22	11.43	17.74	13.57	North West zone
CoLk 16470 (*IKSHU*-17)	CoS 8436 x CoSe 92423	Midlate	82.50	9.59	17.37	13.20	North Central & North Eastern zone

Registration of sugarcane varieties

Three sugarcane varieties namely, CoLk 15201 (*IKSHU*-11), CoLk 15207 (*IKSHU*-12) and CoLk 15466 (*IKSHU*-13) were submitted for registration under the Protection of Plant Variety and Farmers Right Act, 2001 for their protection (Table 1.3). The duly filled applications of the aforesaid varieties have been submitted to the Protection of Plant Variety and Farmers Right Authority, New Delhi.

Table 1.3 Salient features of sugarcane varieties CoLk 15201, CoLk 15207 and CoLk 15466.

Variety	Parentage	Maturity group	Cane yield (t/ha)	CCS yield (t/ha)	Sucrose % at harvest	Pol % cane at harvest	Recommended zone
CoLk 15201 (*IKSHU*-11)	CoS 8436 GC	Early	93.92	11.44	17.64	13.60	North West zone
CoLk 15207 (*IKSHU*-12)	Co 88039 GC	Mid-late	84.53	10.97	18.71	14.52	North West zone
CoLk 15466 (*IKSHU*-13)	CoS 8436 GC	Early	85.97	10.41	17.54	13.54	North Central & North Eastern zone

Sugarcane clones accepted for multi-location testing

Three early maturing sugarcane clones, *i.e.*, CoLk 23201 (LG 17222), CoLk 23202 (LG 19014) and CoLk 23203 (LG 16487) and three midlate maturing clones CoLk 23204 (LG 18410), CoLk 23205 (LG 18907) and CoLk 23206 (LG 15670) were accepted for multi-location testing in North West Zone of India during the Group Meeting of AICRP(S) 2023 organized at Dr. RPCAU, Pusa (Table 1.4).

Table 1.4 Salient features of the accepted clones

Clone	Parentage	Maturity group	Cane yield (t/ha)	CCS yield (t/ha)	Sucrose % at harvest	Red rot rating
CoLk 23201 (LG 17222)	LG 08422 x Co 89029	Early	99.88	12.97	18.52	MR
CoLk 23202 (LG 19014)	LG 95053 x BO 154	Early	98.24	12.78	18.48	MR
CoLk 23203 (LG 16487)	LG 05460 GC	Early	95.63	12.15	18.34	MR
CoLk 23204 (LG 18410)	Co 86002 x Co775	Mid-late	96.61	13.39	19.71	MR
CoLk 23205 (LG 18907)	CoLk 8102 GC	Mid-late	96.49	12.89	19.10	MR
CoLk 23206 (LG 15670)	LG 05434 GC	Mid-late	92.49	12.54	19.22	MR

Hybridization and seedling raising

A total of 29 bi-parental sugarcane crosses were made during the crossing season 2022. Out of these, 24 crosses were attempted at National Hybridization Garden, Coimbatore and 05 were attempted at National Distant Hybridization Facility (NDHF), Agali. In addition to that, fluff of 50 GCs was also requested from the Sugarcane Breeding Institute, Coimbatore. Fluff of these crosses will be sown in the glass/poly house for the raising of seedlings. Approximately, 14052 seedlings derived from 36 bi-parental crosses, 01 PC, and 14 GCs (from the crossing season 2021) were raised and transplanted in the field condition for their evaluation.

Selection in seedling (C_0) population

Based on the HR brix and other growth parameters, a total of 500 clones were selected from the seedling population. These selected clones have been planted as C_1 clones along with standard varieties for their further evaluation.

Evaluation of clonal generations

A total of 163 sugarcane clones were selected from C_1 population and promoted to the C_2 generation for their further evaluation. About 57 promising sugarcane clones were selected from C_2 population and promoted to the C_3 generation and also given for the red rot testing. Among these clones, the best promising ones were planted in replicated trials for their yield and quality evaluation. Based on the yield, quality and red rot ratings, best nine promising clones, i.e., LG 18016, LG 18032, LG 18071, LG 18078, LG 18085, LG 18384, LG 20519, LG 20579 and LG 20601 were included in the Station Trial (2023-24) for their evaluation.

Station Trial (2022-23)

Ten elite sugarcane genotypes, *viz.*, LG 15670, LG 16487, LG 17222, LG 18145, LG 18410, LG 18907, LG 19014, LG 19021, LG 19077 and LG 19120 along with six standard varieties (Co 0238, Co 05009, CoJ 64, CoS 767, CoPant 97222, Co 05011) were evaluated in Station Trial (2022-23) for their growth, yield and quality parameters (Table 1.5). The genotype, LG 17222 recorded the highest (99.88 t/ha) cane yield, which was significantly superior to the best standard and followed by the LG 18410 (96.61.67 t/ha) and LG 18907 (96.49 t/ha). Similarly, LG 17222 also recorded the highest CCS yield (14.29 t/ha) followed by the LG 16487 (13.79 t/ha) and LG 18410 (13.39 t/ha) at 360 days. The highest sucrose per cent at 360 days was recorded in LG 16487 (20.51%) followed by LG 17222 (20.35%) and LG 18410 (19.71%). However, at 300 days, the highest sucrose percent was recorded in LG 17222 (18.52%) followed by LG 19014 (18.48%). Among the standards, Co 0238 was found to be the best for all the parameters at both 300 and 360 days.

Table 1.5 Performance of elite sugarcane genotypes under Station Trial (2022-23)

Genotype	Cane yield (t/ha)	CCS yield at 360 days (t/ha)	Sucrose % at 360 days	Sucrose % at 300 days
LG 15670	92.49	12.54	19.22	18.03
LG 16487	95.63	13.79	20.51	18.34
LG 17222	99.88	14.29	20.35	18.52
LG 18145	69.77	8.89	18.25	17.73
LG 18410	96.61	13.39	19.71	18.30
LG 18907	96.49	12.89	19.10	17.58
LG 19014	98.24	13.36	19.40	18.48
LG 19021	65.13	8.92	19.59	18.34
LG 19077	65.83	8.93	19.55	17.61
LG 19120	64.68	8.43	18.77	17.50
CoJ 64	70.75	9.56	19.29	18.35
Co 0238	82.78	11.33	19.56	17.97

Co 05009	68.53	9.14	19.04	18.06
CoS 767	73.81	9.47	19.38	17.44
CoPant 97222	80.34	10.96	18.36	17.41
Co 05011	71.90	9.92	19.22	17.33
CD (0.05)	11.54	1.89	1.57	0.87
CV %	8.57	10.34	4.86	2.91

Evaluation of early sugarcane clones for North West Zone.

Initial Varietal Trial (Early)

A trial comprising of ten sugarcane genotypes i.e., CoS 19016, CoPb 19181, CoLk 19201, CoLk 19202, CoLk 19203, CoPb 19211, CoPb 19212, CoPant 19221, CoS 19231 and CoH 19261 and three standards i.e. CoJ 64, Co 0238 and Co 05009 was conducted and observations were recorded on various yield and quality parameters. CoLk 19201 recorded the highest cane yield (89.30 t/ha) followed by CoLk 19202 (85.62 t/ha) and CoH 19261 (85.35 t/ha). However, the highest CCS yield was recorded in CoH 19261 (10.90 t/ha) followed by CoS 19231(10.80 t/ha) and CoLk 19202 (10.75 t/ha). Highest sucrose content at harvest was recorded in CoS 19231 (18.35 %) followed by CoH 19261 (18.27 %). Among the standards, Co 0238 was found to be the best standard for both yield and quality parameters and recorded the highest cane yield (81.65 t/ha) and CCS yield (10.15 t/ha).

Advanced Varietal Trial I Plant (Early)

Four sugarcane clones *viz.,* CoS 17231, CoS 17232, CoLk 18202 and CoPb 18181 along with three standards CoJ 64, Co 0238 and Co 05009 were evaluated for yield and quality parameters. Among the test genotypes, CoLk 18202 recorded the highest cane yield (94.25 t/ha) and CCS yield (12.16 t/ha). The genotype, CoLk 18202 showed the highest sucrose percentage at harvest (18.48 %) followed by CoS 17231 (18.47 %). Among the standards, Co 0238 was the best check for cane yield (89.18 t/ha) and CCS yield (11.74 t/ha).

Seed Multiplication (Early)

The seed of six sugarcane genotypes *viz* Co 20016, CoLk 20201, CoLk 20202, CoLk 20203, CoPb 20211 and CoH 20261 has been multiplied for next year's IVT trial.

Evaluation of mid-late sugarcane clones for North West Zone.

Initial Varietal Trial (Mid-late)

Twelve sugarcane clones *viz.,* Co 19017, Co 19018, CoPb 19182, CoLk 19204, CoPb 19213, CoPb 19214, CoPant 19222, CoS 19232, CoS 19233, CoS 19234, CoS 19235 and CoH 19262, along with three standards *viz.,* CoS 767, CoPant 97222 and Co 05011 were evaluated for yield and quality parameters. The genotype CoS 19233 recorded the highest cane yield (109.90 t/ha) followed by CoLk 19204 (109.64 t/ha) and CoPb 19213 (108.36 t/ha). The genotype, CoLk 19204 showed the highest CCS yield (14.87 t/ha) followed by CoS 19233 (14.29 t/ha) and CoPb 19213 (13.50 t/ha). Among the test genotypes, CoH 19262 recorded the highest sucrose percentage at harvest (20.05 %) followed by Co 19017 (19.81%) and CoLk 19204 (19.47). Among the standard varieties, CoPant 97222 recorded the highest CCS yield (11.27 t/ha) followed Co 05011 and CoS 767.

Advanced Varietal Trial I Plant (Mid-late)

Six sugarcane genotypes viz., Co 18022, CoPb 18213, CoPb 18214, CoS 18231, CoS 18232 and CoS 18233 along with three standards CoS 767, CoPant 97222 and Co 05011 were evaluated for yield and quality parameters. CoPb 18213 recorded the highest cane yield (110.74 t/ha) followed by Co 18022 (101.61 t/ha) and CoS 18231 (98.20 t/ha). Similarly, CoPb 18213 exhibited the highest sucrose % at harvest (19.76 %) followed by CoS 18232 (19.32 %) and CoPb 18214 (19.12 %). Among the standard varieties, CoPant 97222 was found to be the best for cane yield (99.24 t/ha) and CCS yield (13.53 t/ha).

Advanced Varietal Trial II Plant (Mid-late)

Nine sugarcane genotypes viz., Co 17018, CoLk 17204, CoPb 17215, CoPant 17223, CoS 17234, CoS 17235, CoS 17236, CoH 17261 and CoH 17262 along with three standards CoS 767, CoPant 97222 and Co 05011 were evaluated for yield and quality parameters. CoS 17235 recorded the highest cane yield (95.08 t/ha) which was significantly superior to the best check. CoH 17262 exhibited the highest sucrose % at harvest (20.16 %) followed by CoLk 17204 (19.64 %) and CoH 17261 (19.51%). Among the standard varieties, CoPant 97222 was found to be the best for cane yield (81.75 t/ha) and CCS yield (11.65 t/ha).

Advanced Varietal Trial Ratoon (Mid-late)

Nine sugarcane genotypes viz., Co 17018, CoLk 17204, CoPb 17215, CoPant 17223, CoS 17234, CoS 17235, CoS 17236, CoH 17261 and CoH 17262 along with three standards CoS 767, CoPant 97222 and Co 05011were evaluated for their ratooning ability. The genotype CoS 17235 had shown highest cane yield (75.19 t/ha) and CCS yield (9.51 t/ha). Among the standard varieties, CoS 767 was found to be the best for cane yield (63.86 t/ha) and CoPant 97222 for CCS yield (7.60 t/ha).

Seed multiplication (Mid-late)

The seed of nine sugarcane genotypes *viz.*, Co 20017, Co 20018, CoLk 20204, CoLk 20205, CoPb 20181, CoPb 20212, CoS 20231, CoS 20232 and CoS 20234 has been multiplied for next year's IVT trial.

Defining ideotypes in sugarcane for moisture deficit conditions

At 90 days after planting (DAP), soil moisture levels in the upper soil layer (0-15 cm) were lower than those in the lower soil layer (15-30 cm). However, at 180 and 270 DAP, the soil moisture content in the upper soil layer surpassed that in the lower soil layer. Noteworthy significant differences were observed among sugarcane materials in terms of chlorophyll fluorescence, both during the drought stress period (90 DAP) and the subsequent recovery period (180 DAP). Ratooning was conducted in March 2022.

LG 18952 (with 18.63% and 16.26%) and LG 18955 (with 18.15% and 16.35%) displayed higher sucrose content, surpassing the checks CoSe 95422 (16.64% and 15.14%) and CoLk 94184 (17.08% and 16.01%) under both conditions. In terms of Brix levels, LG 18952 exhibited superiority with values of 19.65 and 18.58 and LG 18955 with 19.28 and 18.60, outperforming the checks CoSe 95422 (17.51 and 18.43) and CoLk 94184 (19.21 and 18.03) under both irrigated and drought conditions. Furthermore, the purity percentage of LG 18952 (91.8% and 84.51%) and LG 18955 (92.13% and 84.90%), demonstrated superiority compared to the checks CoSe 95422 and CoLk 94184 in irrigated and drought conditions. Meanwhile, the highest single cane weight was recorded in LG 18952 (1.48 and 1.30 Kgs) and LG 18955 (1.40 and 1.55 kgs) against CoLk 94184 (1.09 and 0.99 kgs) and CoSe 95422 (1.27 and 0.93 kgs) under irrigated and drought conditions.

Population improvement and development of sugarcane genetic stocks for high sugar accumulation potential for sub-tropical India

The project aims for population improvement for high sugar accumulation potential in the sub-tropical sugarcane genotypes and to develop high sugar sugarcane genetic stocks. One mid-late maturing sugarcane variety CoLk 15206 (*IKSHU*-14) was released and notified for commercial cultivation in the north-west sugarcane growing zone of the country. Three promising clones CoLk 19201 (early maturing) and CoLk 20203 (early maturing) and CoLk 20205 (mid-late maturing) are being tested in the multi-location trials of AICRP (Sugarcane). Two promising sugarcane clones CoLk 23203 (early maturing) and CoLk 23206 (mid-late maturing) were accepted for testing in the multi-location trials under AICRP (Sugarcane) in 2023. One promising sugarcane clone LG 16471 is being evaluated in the divisional station trial for economically important traits. Two high sugar genetic stocks LG 15533 and LG 16581 with sucrose % juice values around 20.0 % in January, have been included in NHG at ICAR-SBI, Coimbatore after quarantine screening, for use as parental clones in crossing programme.

The high sugar genotypes being evaluated in the clonal stages exhibited variation with respect to the sucrose content and other traits like stalk length, stalk girth, number of millable canes and single cane weight. The juice analysis carried out in the month of January-February 2023 showed four genotypes from the advanced clonal stage having sucrose % juice of 20% or more (Table 1.6) with satisfactory purity. These clones had satisfactory morphological attributes and these are being evaluated further for their suitability as early maturing varietal candidates. The other promising clones were advanced to the next stage for further evaluation. An evaluation of the genotypes in the clonal stages indicated that, the crosses involving LG 01118, a high sugar genotype developed in the second cycle of mating and selection, gave a good number of progenies with sucrose% in juice values 19-20%. In the red rot screening using the prevalent races of *C. falcatum*, the progenies from LG 01118 gave a comparatively higher number of progenies with Resistant/Moderately Resistant reaction.

A part of the left over fluff from 2022 crossings that were sown in November 2022 showed satisfactory germination in the different crosses. The crosses involving the clones LG 14564, LG 08422, LG 01200, LG 01118, LG 01030 exhibited good germination (>50%). Hand refractometer brix readings recorded during November 2023 in the seedlings transplanted to field indicated that approximately 8 % of the seedlings had a mean HR brix values more than 20 (°Bx) in January. The crosses attempted during the crossing season of 2023 included eight crosses involving *S. officinarum* clones carried out at Distant Hybridization Facility, ICAR-SBI RC, Agali.

Table 1.6 Promising sugarcane clones with high sugar accumulation potential

Genotype	Parentage	Mean sucrose % in juice (Jan-Feb 2023)
LG 15431	LG 07501 GC	20.14
LG 15566	LG 07408 GC	20.34
LG 15563	LG 07408 GC	20.17
LG 16520	LG 08422 x LG 07482	20.15

Mapping of loci linked to sugar content in sugarcane

The project aims to identify and map the loci linked to sugar content related traits in sugarcane. Phenotyping studies of the genotypes in the selfed population gave a similar pattern with respect to the sucrose content as if earlier years. Genotyping of 180 genotypes in the selfed population using already reported and a few novel primer sequences identified more than 60% polymorphic sequences. The results obtained will be used for analyzing the associations between the sugar content and the markers.

Profiling and prediction of small RNA transcriptome in red-rot challenged sugarcane

From unmapped reads between the range 18-30 nt (total 13070817) from small RNA libraries of BO 91 and CoJ 64 control and red rot inoculated samples respectively, 472 novel miRNAs were identified. Out of these, 203 and 102 miRNA showed differential expression in CoJ 64 and BO 91 control vs. red rot inoculated samples, whereas, 277 and 254 miRNA expressed differentially in BO 91 vs. CoJ 64 and CoJ 64 vs. BO 91 red rot inoculated samples. GO enrichment demonstrated that differentially expressed genes in both the varieties were mainly associated with cellular and metabolic processes. Their molecular functions were mainly related to binding and catalytic activity along with some disease resistance genes. The significantly enriched KEGG pathway of predicted target genes were related to pathways of stress response, hormone and signal transduction, protein synthesis and transcription pathway, disease resistance, cell division and metabolism. RT-qPCR was used to establish the relation between the differentially expressed miRNAs and the respective target gene transcripts.

Investigating the differentially expressed sugarcane proteins in red rot susceptible and tolerant sugarcane cultivars during *C. falcatum* infection

Using NanoLCMS/MS based proteomics analysis of *C. falcatum*, we identified eighteen proteins implicated in MAPK signalling pathway in *C. falcatum*. Mitogen-activated protein kinase (MAPK) signalling pathway plays pivotal role in coordinating the process of pathogenesis. Twelve of the MAPK proteins were the part of core MAPK signalling pathway, whereas the remaining proteins were indirectly implicated in MAPK signalling. A large number of these MAPK proteins were induced in *C. falcatum* samples cultured with host sugarcane stalks. String association networks of MAPK proteins revealed strong association with numerous other proteins involved in the process of pathogenesis/virulence.

Further, NanoLCMS/MS based investigation of sugarcane proteome revealed occurrence of 21 catalases in red rot resistant (BO 91) and susceptible (CoJ 64) cultivars of sugarcane. Catalases are heme-containing enzymes, associated with the internal and external extremities of plants like biotic and abiotic stresses. The resistant (BO 91) cultivar had predominantly more number and enhanced abundance of catalase proteins, compared to susceptible (CoJ 64) cultivar. Peptide abundance of ten catalases, common in both the cultivars of sugarcane, was largely induced by *C. falcatum* inoculation.

Transcriptomics based identification of host and pathogen genes involved in red rot disease of sugarcane and their validation.

In sugarcane, qRT-PCR-based real time expression analysis of selected six catalase genes corresponding to identified proteins, was also performed to substantiate the findings of proteomics. The results of catalase gene expression corroborated with the findings of proteomics to a large extent. Further, real-time expression analysis (qRT-PCR) was performed to validate the findings of proteomics for selected MAPK genes in *C. falcatum*. The expression of core MAPK pathway genes (MAPKKK-NSY1, MAPK 17-MAPK17, MAPKKK 5-MAPKKK5, MAPK-HOG1B, MAPKKK-MCK1/STE11, MAPK-MST50/STE50, MAPKK-SEK1, MAPKK-MEK1/MST7/STE7, MAPKK-MKK2/STE7, MAPKKK-MST11/STE11, MAPK 5-MPK5, and MAPK-MPK-C) corroborated the results of proteomics to a large extent. MAPK cascades are three-tiered PK modules that are present in all eukaryotic organisms and function in succession to transmit a variety of cellular signals. The MAP kinase kinase kinase (MAPKKK) phosphorylates the MAP kinase kinase (MAPKK), which in turn activates the MAPK by dual phosphorylation of a pair of conserved threonine and tyrosine residues (Fig. 4). In the present study, we

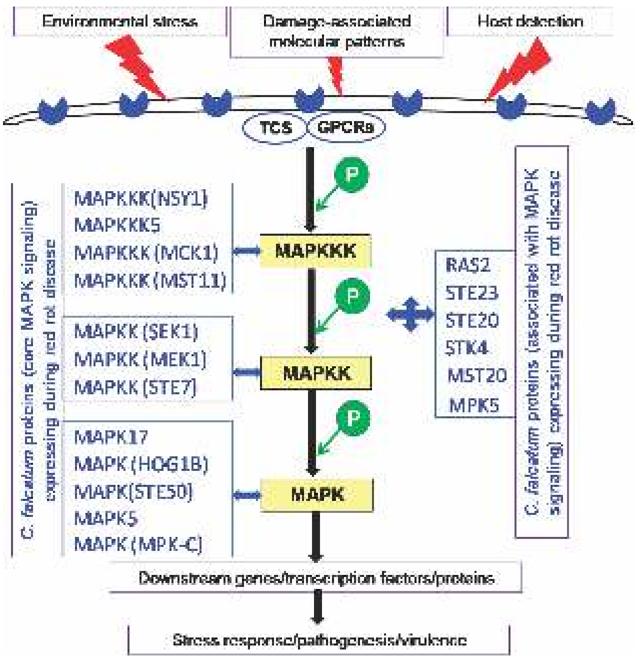


***Fig. 1.4** Schematic representation of fungal MAPK (mitogen-activated protein kinase) signaling pathway along with C. falcatum proteins expressed during sugarcane infestation. External stimuli/signals (stress/host detection/etc.) are perceived either through two-component signal transduction (TCS) or through G-proteins coupled receptors (GPCRs). These receptors phosphorylate MAPKKKs (MAP kinase kinase kinases), which in turn phosphorylate MAPKKs (kinase kinases), which further phosphorylate MAPKs. The activated MAPKs trigger the expression of genes/transcription factors/proteins responsible for stress response/pathogenesis/virulence/etc., in fungi.*

recognized predominance of MAP kinases implicated in MAPK signaling pathway including four MAPKKKs, three MAPKKs, and five MAPKs in *C. falcatum* samples cultured with sugarcane stalks.

Production of disease-free and genetically pure seed cane through micropropagation

Virus indexed mother stock of the sugarcane varieties from IISR are being maintained. Virus indexed mother stock culture of sugarcane variety CoLk 14201 were supplied to UP Cooperative sugar Mills Federation. *In vitro* cultures of new sugarcane varieties, *viz.*, CoLk 15201, CoLk 15207 CoLk 15466, and CoLk 14201 were established and multiplied through enhanced axillary shoot proliferation using apical shoot explants. Shoot initiation was achieved on Murashige and Skoog's medium supplemented with 4.44 µM benzyladenine (BA) and 4.6 µM kinetin (Kin) + 3% sucrose. The maximum shoot proliferation per explant with 100% shoot regeneration frequency was obtained on MS medium supplemented with 2.22 µM BA + 2.3 µM Kin + 26.8 µM NAA + 3% sucrose. Vigorous rooting was obtained on MS medium containing 26.8 µM NAA and 5% sucrose. Approximately 5000 plantlets of *in vitro* multiplied sugarcane varieties CoLk 09204 and CoLk 14201 from previous year were acclimatized and transferred to field. In addition, ~10000 plants of variety CoLk 14201 have been acclimatized in mist chamber which would be transferred to field in spring 2024.

Accredited Test Laboratory under National Certification System for Tissue Culture-raised Plants (DBT, New Delhi)

An Accredited Test Laboratory (ATL) for genetic fidelity and virus indexing of tissue culture raised plants is under operation at IISR, Lucknow with the financial support from Department of Biotechnology (DBT), New Delhi under National Certification System for Tissue Culture-raised Plants (NCS-TCP) program. The aim of ATL is to support the tissue culture production units for testing of mother stock and TC plants to ensure genetically uniform and virus-free quality planting materials to the farmers. During the reporting period, a total of 31645 samples have been tested, out of which 27605 samples were of banana, 270 samples were of sugarcane and 3970 samples were of potato. Of the total samples, 27605 samples of banana tested for genetic fidelity translated to quality certification of ~3 crore tissue culture plantlets, for which, test reports were generated by ATL and certificate of quality were issued by DBT. The testing included virus indexing of sugarcane for Sugarcane mosaic virus (SCMV), Sugarcane yellow leaf virus (ScYLV), Sugarcane bacilliform virus (SCBV), and phytoplasma, banana samples for Banana bract mosaic virus (BBrMv), Cucumber mosaic virus (CMV), Banana bunchy top virus (BBTV), and Banana streak virus (BSV)] and virus indexing in potato for PVX, PVY, PVA, PVM, PVS, PLRV, PALCV, GBNV and PSTVd.

Identification of alternate splicing events and premature stop codons associated with early sucrose accumulation in sugarcane

Sucrose is the prime product of sugarcane and a significant variation has been observed among different sugarcane genotypes for the time taken to initiate sucrose accumulation. High sucrose accumulation in sugarcane at early crop phase is one of the most desirable traits, since it can help in reducing its long growth cycle. RNA-seq libraries of two extreme bulks from a segregating full-sib population and its parents were used to identify highly significant, alternate splicing (AS) events and premature stop codons (PMC) associated with early sucrose accumulation. An important differential AS event was identified within the β-subunit of pyrophosphate-fructose 6-phosphate 1-phosphotransferase (PFP) which plays a key role in carbon partitioning in sugarcane. Premature stop codons that could result in truncated proteins were also detected in genes coding for aquaporin, aldolase, cytochrome C-oxidase, ribophorin and plant plasma membrane intrinsic proteins. A major proportion of these AS events and premature stop codons was validated for their differential enrichment in an independent set of sugarcane varieties having high and low sucrose content.

GBS based association mapping and prediction for red rot resistance in sugarcane

Genome wide association mapping was carried out for resistance to three races of red rot pathogen (CF01, CF08 and CF09) using a panel of 174 sugarcane varieties genotyped through GBS (ApeKI) and highly significant SNPs (FDR 0.01) associated with the trait identified. Following this, genomic prediction for red rot resistance was carried out using the panel of 174 varieties as training population based on SNP calling(GATK4), LD-kNNi imputation (TASSEL v.5), and gBLUP prediction (GAPIT v.3). A set of 144 F1 (MS 68/47 X CoV 92102) clones was used as testing population and genotyped through GBS for determining their predicted red rot resistance values. A set of 10 F1 clones with high prediction values for red rot resistance and sucrose content were used as parental lines and further used for general cross. The progeny of general cross is being evaluated for sucrose content and red rot resistance.

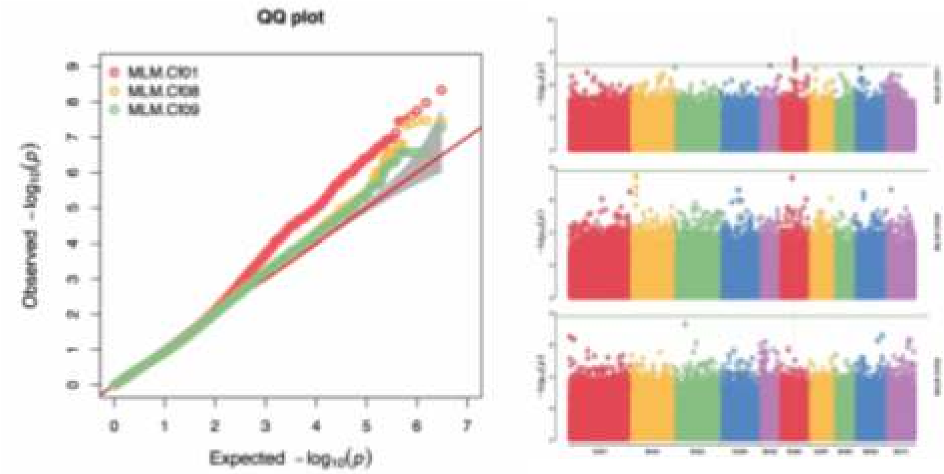


*Fig. 1.5 QQ and Manhattan plot showing significant markers for resistance to the three races of **C. falcatum** (CF01, CF08, CF09).*

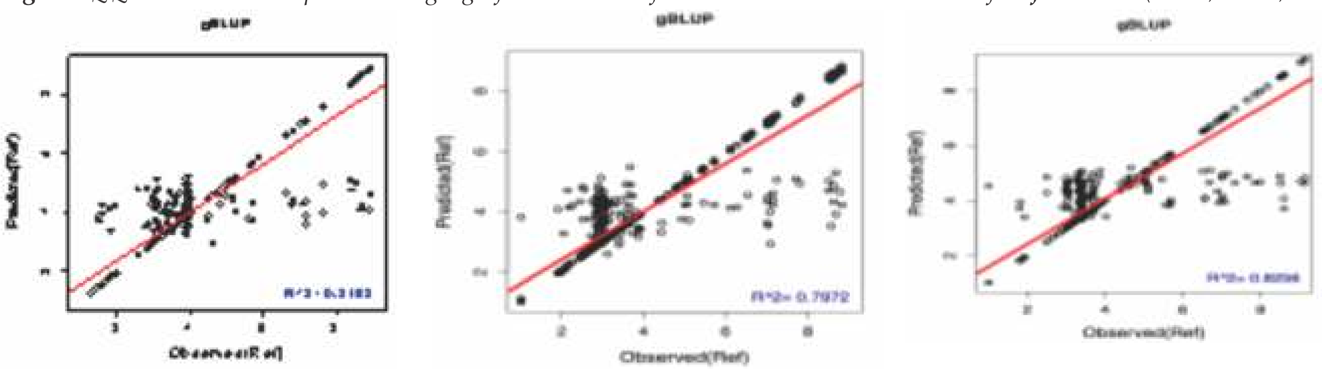


Fig. 1.6 Genomic prediction of resistance reaction values vs observed resistance reaction values of the 174 individuals of training population

Central Sector Scheme for Protection of Plant Varieties and Farmers' Rights Authority

This year, a total of 165 reference varieties of sugarcane were maintained in DUS field. This reference collection includes all the identified, released and notified varieties from CVRC, varieties released from states and clones from Advanced Varietal Trials of AICRP(S) available with different research organizations working on sugarcane. DUS characters were recorded on 150 varieties in reference collection as per the DUS Testing guidelines. Five 'New' and four Farmers' Varieties are presently under DUS Testing.

Seed production in agricultural crops (ICAR Seed Project)

During the year 2022-23, approximately 10430 quintals of seed cane was produced (Table 7). The lifting of seed cane was excellent. Under Seed Cane Awareness, seed of newly released varieties from IISR, Lucknow were distributed to farmers and several sugar industries for making the sugarcane growers aware about the role of new varieties and the quality seed cane in enhancing the yield and production. Field Days to popularize recently notified varieties were organized at the Institute. Awareness for morphological identification of varieties with DUS characters under field condition was also taken-up with development staff and farmers.

Table 1.7 Seed cane availability for the crop season 2024-25.

Sl. No.	Variety	Maturity group	Total expected quantity available (Quintal)
1	CoLk 15201	Early	**1080**
2	CoLk 14201	Early	**3830**
3	CoLk 11203	Early	**1630**
4	CoLk 9709	Early	**160**
5	CoLk 15466	Early	**660**
6	CoLk 12207	Early	**460**
7	CoLk 15207	Mid-late	**870**
8	CoLk 14204	Mid-late	**1000**
9	CoLk 15206	Mid-late	**320**
10	CoLk 12209	Mid-late	**70**
11	CoLk 11206	Mid-late	**70**
12	CoLk 09204	Mid-late	**280**
	Total		**10430**

Bihar Sugarcane Breeder Seed Production Program

This programme namely Bihar Sugarcane Breeder Seed Production Programme funded by Sugarcane Industries Department (SID), Patna started during 2019-20 and this year is the last year as per signed MoU between SID, Patna and ICAR-IISR, Lucknow. During the season of 2022-23, a total of 18,676.37 quintals (q) of breeder seeds were produced across 29 hectares, encompassing five distinct varieties in four key centres, with IISR RC, Motipur, being one of them (Table 8). Notably, IISR RC, Motipur, achieved a seed yield exceeding 80 tons per hectare in the preceding year. The state of Bihar experienced erratic and intense rainfall patterns in the past two years, significantly impacting the sugarcane harvest. This natural calamity has also affected the ongoing breeder seed production program. In response to these challenges, various agencies in Bihar have received the breeder seeds to sustain the production of foundation seeds. For the upcoming season of 2023-2024, breeder seed production is planned on a total of 35 hectares distributed among four different centres. These centres include IISR Regional Centre, Motipur; New Swadesi Sugar Mills, Narkatiaganj, Harinagar Sugar Mills, Harinagar and Tirupati Sugars Ltd., Bagaha. The objective is to ensure the continued production of high-quality breeder seeds. This year two newly released varieties *viz.*, CoLk 12207 and CoLk 12209 were also included in seed chain for producing breeder seed under this programme.

Table 1.8 Breeder Seed production at four centres with five cane varieties during 2022-23.

Sl No.	Varieties	Centres			
		Motipur	Hari Nagar	Bagha	Narkatiyaganj
1	**CoLk 94184**	811.98	-	-	538.4
2	**CoP 9301**	305.45	2110.0	946.39	2009.4
3	**Co 0118**	1683.22	4098.81	2211.24	1935.2
4	**Co 0238**	-	-	-	1614.55
5	**CoP 16437 (RG1)**	411.73			-
Total	3212.38	6208.81	3157.63	6097.55	
Grand total	**18676.37**				

Furthermore, monitoring of breeder seed plots was performed by a team of scientists from IISR, Lucknow along with representatives from the Sugarcane and

Seed Certification Department of Bihar. The team members visited IISR Regional Center, Motipur, NSSM, Narkatiyaganj, HSM, Harinagar and TSL, Bagha for monitoring of Breeder seed plots from 5th to 7th December, 2023. The team was happy with the good results and appreciated the performance.

CHAPTER 2

Natural Resource Management

Diversification of sugarcane based cropping system with medicinal and aromatic plants in sub-tropical India

A fixed field experiment 'Diversification of sugarcane-based cropping system with medicinal and aromatic plants in sub-tropical India' with an objective to identify the most remunerative sugarcane-based cropping system in sub-tropical India was initiated during June 2019. The experiment consisted of ten treatments with three replications. Second cycle of experiment was carried out during *kharif* and *rabi* seasons of 2022-23. Rice, tulsi, marigold and *kalmegh* were grown as per treatment during *kharif* season. Wheat, wild marigold, Stevia and sugarcane (autumn with wild marigold) were planted during Rabi season and harvested during the spring. Further the succeeding crops such as sugarcane have been planted in the same field as per the treatments. The highest rice equivalent yield (73.5 q/ha) of *tulsi* was recorded under (tulsi-stevia- sugarcane (spring) - sugarcane ratoon-mint treatments during *Kharif* season. Similarly, the maximum wheat equivalent yield (109.7 q/ha) of wild marigold was recorded under the system tulsi-wild marigold (two cut) - sugarcane (spring) - sugarcane ratoon-mint during *rabi* seasons.

Developing Sugarcane Based Integrated Farming System Model for Small Farm Holders for Sub-tropical India

Integrated farming system is an important principle for achieving the goal of higher yields of different component crops and enterprises, livelihood security, soil health management, nutritional security, by-product recycling, eco-friendly agri-system and employment generation throughout the year by adapting principles of the sustainable agriculture. Keeping above points, ICAR-IISR, Lucknow is maintaining a Sugarcane Based Integrated Farming System model on its main farm on long term basis. The model consists of different components *viz*., Agriculture (Sugarcane), Vegetables, Horticulture, Backyard Poultry, Fisheries, Vermicomposting and dairy (cow) to demonstrate sugarcane based integrated farming system models for marginal and small farm holders in sub-tropics of India. Allocation of farm land to each component are kept in such a way that may fulfil the minimum essential annual requirements for food, vegetables, fruits, fish, egg, chicken etc. of a household having 7 members and overall improvement in their livelihood. Impacts of different treatments on yield, profitability, employment generation, product (waste) recycling parameters were observed. During the period reported, most profitable enterprise were sugarcane + Vegetables + Horticulture + Backyard Poultry + Fisheries + Vermicomposting + Dairy (cow). The results clearly indicated that autumn sugarcane based integrated farming system as Sugarcane + Vegetables + Horticulture + Backyard Poultry + Fisheries +Vermicomposting + Dairy (cow) fetched net income

Table 2.1 Productivity and profitability of different components of the cropping/farming system integrated with sugarcane (autumn planted sugarcane)

Sr. No.	Cropping/Farming systems	Cost of Production (Rs/ha)	Gross Income (Rs/ha)	Net Income (Rs/ha)	Income from component crop/ enterprise (Rs/ha) or enterprises/unit
1.	Sugarcane (Sole) CoLk14201	268,000	595,125	327,125	-
2.	Sugarcane + Vegetables	395,500	925,145	529,645	202,520
3.	Sugarcane + Vegetables + Horticulture + Backyard poultry	445,950	11,45,925	699,975	327,850
4.	Sugarcane + Vegetables + Horticulture + Backyard Poultry + Fisheries + Vermicomposting + Dairy(cow)	565,350	13,45,515	780,165	453,040

Table 2.2 Productivity and profitability of different components of the cropping/farming system integrated with sugarcane (spring planted sugarcane)

Sr. No.	Cropping/Farming systems	Cost of Production (Rs/ha.)	Gross Income (Rs/ha.)	Net Income (Rs/ha.)	Income from component crop/ enterprise (Rs/ha.) or enterprises /unit
1.	Sugarcane (Sole) CoLk 14201	265,000	5,75,295	310,295	-
2.	Sugarcane + Vegetables	385,500	9,00,236	514,736	204,441
3.	Sugarcane + Vegetables + Horticulture + Backyard poultry	428,950	11,25,122	696,172	385,877
4.	Sugarcane + Vegetables + Horticulture + Backyard Poultry+ Fisheries + vermicomposting +dairy(cow)	560,350	13,21,626	761,276	450,981

of Rs.7,80,165/ha. The system accrued an additional income of Rs. 4, 53,040/ha over that with sole sugarcane. For spring sugarcane based integrated farming system as Sugarcane + Vegetables + Horticulture + Backyard Poultry+ Fisheries +Vermicomposting + Dairy (cow) fetched net income Rs.7,61,276 /ha compared to that of Rs. 4,50,981/ha earned with sole sugarcane cropping.

Nano-assisted urea coating for improving nitrogen use efficiency of sugarcane crop

The nano coating material developed from jute fibre, silica and protein was used for coating of the urea. This coated urea showed the slow release characteristics than the normal market available neem-coated urea. From this coated product a pot experiment was conducted in sugarcane crop to evaluate the doses and performance of the product on the cane productivity. The cane height, girth and cane weight were significantly affected by different treatments. There was more plant height, cane girth and per cane weight with the use of 100 % RDN through nano coated urea over 100 % RDN of market urea. No of tillers and millable cane/pot were not affected by different treatments (Table 3).

The non-significant differences in millable cane and per cane weight in 100 % RDN with neem coated urea and 50 % of RDN with nano coated urea clearly revealed that with the use of 50 % reduced doses of N with nano coated urea either in two or three splits can give equal number of millable canes obtained using 100% recommended doses of N with neem coated urea.

Table 2.3 Effect of different treatments on growth and yield of sugarcane

Treatment	Tillers/pot	Height (cm)	Girth (mm)	Millable	Cane weight
1	5.67	156.78	21.27	3.67	1.18
2	5.67	148.78	20.48	3.33	1.16
3	5.33	145.61	19.92	3.00	1.11
4	5.00	143.25	21.15	3.00	1.13
5	4.67	143.02	21.12	2.67	1.11
6	4.67	139.10	19.25	2.67	1.09
7	4.67	123.69	18.93	2.67	0.98
8	4.33	119.33	18.83	2.33	0.96
9	4.00	120.50	18.77	2.33	0.96
10	5.33	139.10	20.62	3.33	1.05
CD at 5%	NS	11.61	1.72	NS	0.12

Table 2.4 Nutrient uptake at 90 days stage (g/plant)

Treatment	N	P	K
T1. 100 % N through Nano urea in 3 split applications (1/2 Basal +1/4 tillering + 1/4 pre-monsoon)	0.74	0.22	3.80
T2. 100 % N through Nano urea in 2 split applications (1/2 Basal + 1/2 at tillering stage)	0.66	0.20	3.12
T3. 100 % N through Nano urea as a basal	0.62	0.16	2.88
T4. 75 % N through Nano urea in 3 split applications (1/2 Basal+1/4 tillering + 1/4 pre-monsoon)	0.58	0.15	2.38
T5. 75 % N through Nano urea in 2 split application (1/2 Basal + 1/2 at tillering stage)	0.53	0.14	2.19
T6. 75 % N through Nano urea as a basal	0.50	0.14	1.87
T7. 50 % N through Nano urea in 3 split application (1/2 Basal+1/4tillering + 1/4 pre-monsoon)	0.46	0.13	1.83
T8. 50 % N through Nano urea in 2 split applications (1/2 Basal + 1/2 at tillering stage)	0.46	0.11	1.66
T9. 50 % N through Nano urea as a basal	0.45	0.10	1.30
T10. 100 % N through Neem coated urea in 3 split applications (1/2 Basal+1/4 tillering + 1/4 pre-monsoon) (check treatment)	0.65	0.18	3.34

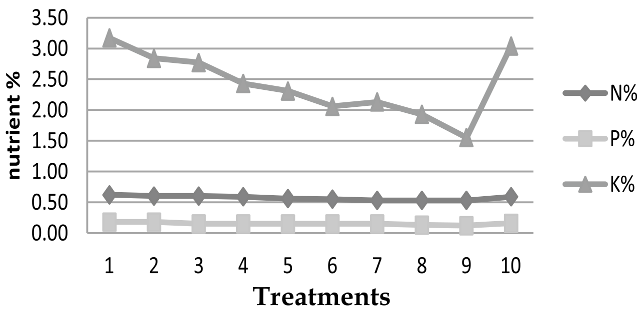


***Fig 2.1** Effect different treatments on nutrient content in plant*

Nutrient uptake was affected by different treatments (Table 2.4). The N uptake ranged from 0.45 - 0.74 g/plant, P ranged from 0.10 - 0.22 and K varied from 1.30 to 3.80 g/plant under different treatments. On an average the 100 % RDF of nano coated urea application was found best among all as far as NPK uptake was concerned. Similar was the case of nutrient content in plant (Fig 2.1) where higher nutrient uptake was recorded with 100 % nano coated urea application over neem urea showed that the slow release nitrogen was taken up by the plant in most efficient manner.

Brix % varied from 18.35 -20.41; sucrose % ranged from 16.39 - 18.48 and purity coefficient varied from 87.58 - 91.25 under different treatments (Fig 2). But juice quality parameters viz. brix %, sucrose % and purity coefficient were not affected significantly among different treatments.

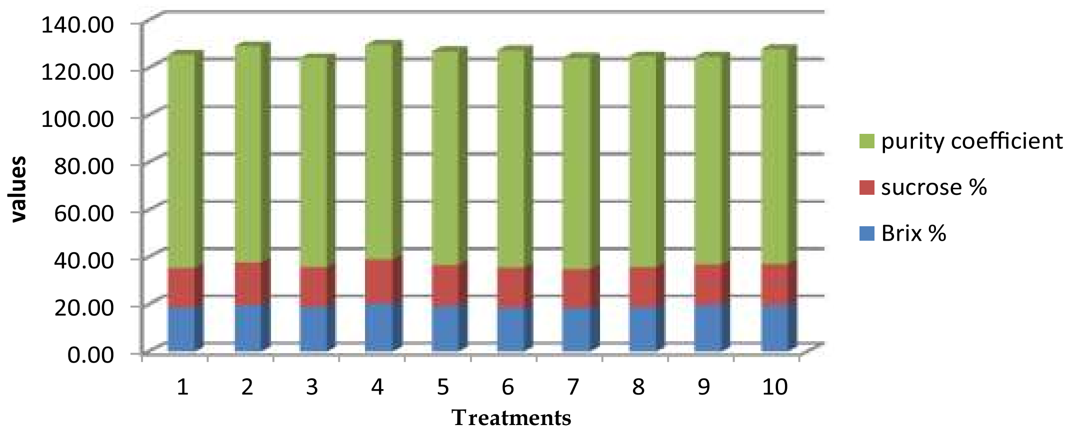


***Fig 2.2** Effect of different treatments on juice quality parameters*

Improved agronomic interventions for enhancing productivity of sugarcane (*Saccharum officinarum* L.) ratoon crop

Effect of date of ratoon initiation and STCR based nutrient application on sugarcane ratoon:

The highest tiller count at 150, 180 and 210 days after ratoon initiation (DARI) was observed in the February-initiated ratoon crop, followed by March, April, and May-initiated ratoons (Table 2.5). Concerning plant population, the February-initiated ratoon exhibited significantly higher numbers than April and May-initiated ratoons but was similar to those initiated in March. The least number of tillers was recorded in the May-initiated ratoon, though statistically comparable to March and April.

The rate of fertilizer application also influenced plant stand in the field. At 150 DARI, slightly higher plant counts were found in the combined application of FYM and NPK, although this difference was not statistically significant at remaining growth stages. The highest plant population was recorded in the treatment applied with nutrients and without FYM, remaining at par with the application of NPK and FYM treatment. Shoots were the result of the overall tiller population in the field, with the highest numbers observed in the combined application of NPK and FYM, statistically superior to only recommended NPK, and similar to NPK using Soil Test Crop Response (STCR) and without FYM.

Table 2.5 Effect of date of ratoon initiation and STCR based nutrient application on growth of ratoon

Time of ratoon initiation	Tiller count (ha)			
	150 DARI	180 DARI	210 DARI	Shoot Count
February	147242.8	169382.7	177530.9	144197.5
March	141070.0	164444.5	171687.3	140905.3
April	130123.5	144197.5	142716.1	130946.5
May	128642.0	131604.5	131687.3	125020.6
SE(m)	3893.7	10040.0	11150.2	4017.9
CD (p =0.05)	13735.8	35418.3	39334	14174.1
Nutrient management				
Recommended NPK	127716.1	152407.4	157037.0	125061.7
NPK through using STCR Without IPNS	139691.4	162345.7	160555.5	139629.6
NPK through using STCR With IPNS	142901.2	161975.3	167592.6	141111.1
SE(m)	4249.7	2574.1	8093.8	2394.7
CD (p =0.05)	NS	7783.6	NS	7241.2

Growth parameters play a pivotal role as they eventually translate into yield parameters and, ultimately, yield itself. The timing of ratoon initiation significantly impacts cane length, cane girth, cane weight, and number of millable cane (NMC), thereby influencing overall yield. The highest cane length, measuring 196.33 cm, was recorded in the February-initiated ratoon crop, demonstrating a significant increase compared to April and May ratoon crops. Specifically, the February ratoon crop exhibited 14.3%, 9.4%, and 5.8% greater cane length than the March, April, and May-initiated ratoon, respectively. Two other crucial yield attributing characteristics, thickness, and weight, were also documented. The February-initiated ratoon crop produced the highest thickness and weight, while the least was observed in the May ratoon crop. Statistically, superior cane thickness was noted in the February ratoon crop, reflecting a 16.3%, 15.7%, and 7.9% increase compared to March, April, and May-initiated ratoon crops, respectively. NMC was influenced by the timing of ratoon initiation, with February month ratoon recording 14.7, 9.8, and 3.5% more millable canes than ratoon crop initiated in May, April and March, respectively.

Ratoon cane yield was recorded highest with February ratoon crop, significantly surpassing April and May ratoon crops. The increase in cane yield was notable, with a 16.8, 15.4, and 5.9 % rise in February, March, and April compared to May-initiated ratoon crops, respectively. This disparity may be attributed to superior attributing characteristics in the February ratoon crop, showcasing a gradual reduction with advanced initiation months. It's noteworthy that even the May-initiated ratoon crop exceeded the national average ratoon productivity by 22 t/ha, which typically ranges from 45-50 t/ha.

The application of nutrients, whether based on blanket recommendations or a combination of Soil Test Crop Response (STCR) and Integrated Plant Nutrient System (IPNS) with or without Farmyard Manure (FYM), showed limited impact on cane weight. However, there was a discernible influence on cane length and girth. The most significant effect on cane length and weight was observed with the application of NPK using STCR and IPNS. Similar trends were noted in recommended NPK and NPK using STCR without FYM, where significantly higher length and weight were recorded compared to blanket recommendation. Specifically, in the application of NPK using STCR and IPNS, there was a 15.4% and 5.2% increase in length compared to blanket recommendation and NPK using STCR without FYM, respectively. These trends were consistent in cane girth as well.

Table 2.6 Effect of month of ratoon initiation on single cane parameters and cane yield of ratoon

Time of ratoon initiation	Length (cm)	Girth (mm)	Weight (kg)	NMC (ha)	Yield(t/ha)
February	196.33	23.55	0.822	130535.0	84.69
March	188.00	23.44	0.787	125020.6	83.70
April	181.78	21.86	0.677	117777.8	76.79
May	171.78	20.25	0.596	113827.2	72.51
SE(m)	3.81	0.57	0.059	3114.9	2.17
CD (*p* =0.05)	13.44	1.99	NS	10988.5	7.66
Nutrient management					
Recommended NPK	170.25	21.37	0.682	115061.7	75.86
NPK through using STCR Without IPNS	186.75	22.02	0.703	122777.8	81.54
NPK through using STCR With IPNS	196.42	23.43	0.777	127530.9	80.86
SE(m)	3.57	0.28	0.027	2327.0	1.52
CD (*p* =0.05)	10.78	0.85	NS	7036.5	4.56

Weed control is a crucial factor influencing yield outcomes. Among all the months of ratoon initiation, February recorded the highest yield, with T3 treatments producing the maximum yield. This result was statistically similar to T2, T4, and T10 treatments. In contrast, ratoon crops initiated in March, April, and May demonstrated statistically superior results with T4 treatments compared to all other herbicidal treatments. Specifically, the March, April, and May-initiated ratoon crops yielded 16.2%, 16.4%, and 18.9% more in T4 treatment than the control treatments. Based on the aforementioned observations, it can be inferred that ratoon initiation in February resulted in better performance than crops initiated in March, April, and May. Even with the implementation of optimal agronomic practices, including effective weed and nutrient management using Farmyard Manure (FYM), significant improvements in yield were observed, extending the positive impact up to May-initiated ratoons.

Table 2.7 Effect of weed control measures and date of ratoon initiation on cane yield of ratoon crop

Sr. No.	Treatment	Yield (t/ha)			
		February	March	April	May
1	T1- Control	76.8	74.8	65.7	61.9
2	T2- Flumioxazin 50 100g/ha (Pre) *fb* trash mulching	84.9	79.0	71.1	68.4
3	T3- Flumioxazin 100 g/ha *fb* 2,4-D 725 g/ha + Halosulfuron 67.5 g/ha (Post)*	88.1	78.8	70.9	66.4
4	T4 - Atrazine 2000g/ha(Pre) *fb* Ametryn 1500 g/ha + 2,4-D 725 g/ha (Post)*	86.9	86.9	76.5	73.6
5	T5 -Ametryn 1500 g/ha (Pre) *fb* SL 160 60 g/ha (Post)*	82.5	81.2	71.1	66.4
6	T6- Trash mulching alone@ 10 t/ha	80.5	78.8	69.9	62.9
7	T7- Metribuzine 750 g/ha (Pre) *fb* Trash mulching	83.2	78.3	71.4	66.9
8	T8- Trash mulching (10 t/ha) *fb* 2,4-D 725 g/ha + Ametryn 1500 g/ha (Post)*	81.5	80.0	71.9	67.9
9	T9 -Trash mulching *fb* 2,4-D 725 g/ha + halosulfuron 67.5 g/ha (Post)*	837	81.2	74.1	71.9
10	T10 -Hand weeding (30, 60 and 90 Days After Ratoon Initiation)	84.4	86.2	76.1	71.6
	SE(m)	2.0	1.5	1.6	2.4
	CD(p=0.05)	4.2	4.3	4.6	7.0

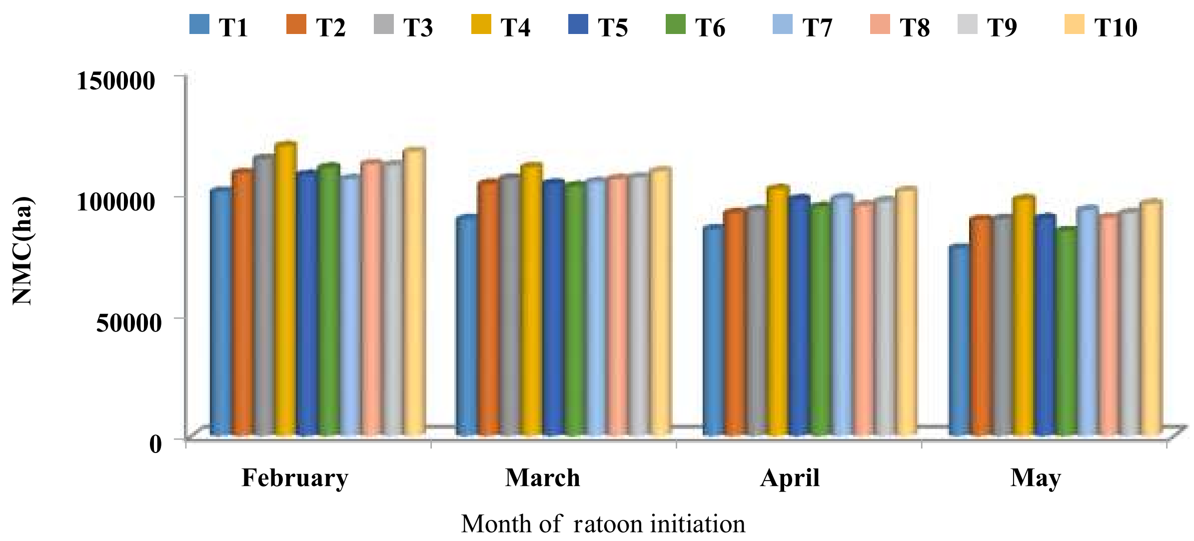


Figure 2.3 Effect of weed control measures and month of ratoon initiation on NMC of ratoon crops

Assessing nutritional management approach for enhanced cane and sugar productivity of multiple ratoons initiated under variable dates

The data (Table 2.8) revealed that maximum sprouting, tiller production, number of millable canes, cane length, cane diameter, cane yield and commercial cane sugar was recorded in sugarcane ratoon initiated on 15th February. Ratoon initiated on 15th February was significantly superior over ratoon initiated on 15th December of previous year in all the growth and yield parameters. As far nutrient management, all the treatments were significantly superior over control on production of NMC, cane yield and CCS t/ha. Sugarcane yield increased by 25.78 percent in February initiated ratoon over December initiated ratoon (68.52 t/ha).

Table 2.8 Effect of date of ratoon initiation and nutritional management approach on tiller production, NMC, height of plant, cane diameter, cane yield and CCS

Treatment	Sprout (%)	Tillers ('000/ha)	NMC ('000/ha)	Cane length (cm)	Cane diameter (cm)	Cane yield (t/ha)	CCS (t/ha)
Dates of sugarcane ratoon initiation							
D_1	84.42	182.01	88.63	223.43	2.29	68.52	7.92
D_2	92.63	218.71	104.55	234.36	2.37	86.19	10.94
CD (p =0.05)	3.08	8.04	5.95	10.61	NS	5.23	0.86
Nutritional management approach							
N_1	86.19	196.68	90.02	223.54	2.30	72.31	8.52
N_2	87.73	198.32	94.30	226.79	2.32	75.48	9.09
N_3	88.19	199.54	95.88	228.71	2.33	77.00	9.65
N_4	89.99	202.98	100.24	231.62	2.35	79.89	9.87
N_5	90.54	204.27	102.51	233.82	2.36	82.11	10.01
CD (p= 0.05)	1.80	3.31	2.27	4.26	0.03	1.41	0.78

Improving soil health and ratoon productivity through application of microbial consortia

A field experiment was initiated during 2019-20 to assess the effect of various microbial cultures on ratoon cane productivity and soil quality parameters in multi-ratooning system. The third ratoon crop was initiated on 7th February 2022, and treatments were allocated as per the protocol. Nutrient application at 75% RDF recorded the significantly highest cane yield (67.8 t/ha) and sugar yield (7.43 t/ha) compared to 50% RDF (63 t/ha) and FYM application @ 15 t/ha (62.2 t/ha) (Table 9). The 75% RDF combined with microbial consortia superseded the cane yield and sugar yield compared to 100% RDF, following a similar pattern as in the first and second ratoon crops. Microbial consortia M_1 (67.6 t/ha) and M_2(66.1 t/ha) being at par produced higher cane yield but was significantly better over M_3 (62.9 t/ha) and M_4 (60.3 t/ha). Use of RDF at 100% significantly increased the ratoon yield by 24 % over absolute control (50.2 t/ha). Microbial consortia did not affect NMC and sucrose (%) in juice.

Use of microbial consortia significantly affected the soil organic carbon at harvest and was recorded highest in M_1 (0.98%) closely followed by M_2 (0.96%) and least in M_4 (0.88). M_1 and M_2 registered higher values of organic carbon compared to that with the recommended dose of fertilizers (100%) without applying microbial consortia. On an average, the third ratoon cane yield declined by 16.2 and 27.4% compared to the second (76.7 t/ha) and first (88.6 t/ha) ratoon crop, respectively. Results revealed that in the third ratoon crop, application of microbial consortia with 75% RDF improved cane and sugar yield by 8.8 and 13 % compared to the recommended dose of fertilizers (100%) without microbial consortia (62.3 and 6.57 t/ha).

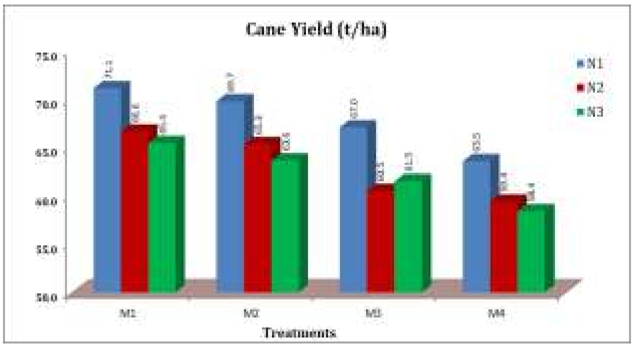


Fig 2.4 Comparative Yield Performance of Ratoon Crop

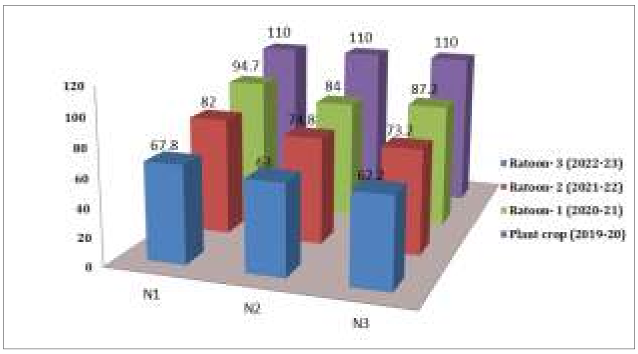


Fig 2.5 3rd Ratoon Cane Yield as Influenced by Nitrogen Management and Microbial Treatments During 2022-23

Table 2.9 Growth, yield and quality attributes of third ratoon crop as influenced by nitrogen management and microbial treatments (2022-2023)

	Cane height (cm)	Cane diameter (cm)	Single cane Wt. (kg)	Yield (t/ha)	NMC (000/ha)	Sugar yield (t/ha)	Sucrose %	LAI			Photosynthetic rate (µmol m^{-2} s^{-1})		
								Tillering stage	Grand growth stage	Harvesting stage	Tillering stage	Grand growth stage	Harvesting stage
Nutrient Management													
N_1 (RDF - 75%) 150 kg N+ 45kg P_2O_5 + 45kg K_2O + 18.75 kg $ZnSO_4$ + 30 kg S +7.5kg $FeSO_4$)	198	2.34	0.81	67.8	89.8	7.43	16.06	1.62	1.38	1.65	17.80	13.55	9.01
N_2 (RDF-50%) 100kg N + 30 kg P_2O_5 + 30 kg K_2O + 12.25 kg $ZnSO_4$ +20 kg S + 5kg $FeSO_4$)	183	2.15	0.77	63.0	86.3	6.66	15.58	1.16	1.07	1.25	12.28	10.24	7.17
N_3 (Organic - FYM @ 15t/ha)	181	2.14	0.76	62.2	84.9	6.56	15.53	1.14	1.05	1.18	11.25	10.25	6.71
CD	**13.30**	**0.09**	**0.02**	**4.62**	**NS**	**0.54**	**NS**	**0.23**	**0.26**	**0.36**	**4.97**	**NS**	**NS**
SE (m)	**4.51**	**0.03**	**0.007**	**1.56**	**2.57**	**0.18**	**0.158**	**0.08**	**0.09**	**0.12**	**1.68**	**1.09**	**0.95**
Microbial Consortia													
M_1 (Microbial culture of P + K+ Zn+ S+ Fe)	197	2.31	0.84	67.7	85.8	7.44	16.08	1.69	1.37	1.67	18.45	13.58	9.45
M_2-(Microbial culture of P+ K+ Zn+ S)	192	2.29	0.81	66.2	85.9	7.12	15.84	1.43	1.23	1.42	14.36	12.50	7.95
M_3.(Microbial culture of +P+ K+ Zn)	185	2.15	0.75	63.0	88.8	6.68	15.60	1.18	1.14	1.31	12.56	9.95	7.14
M_4 (Microbial culture of P+ K)	175	2.09	0.73	60.4	87.7	6.29	15.38	0.92	0.93	1.05	9.74	9.34	5.97
CD	**15.36**	**0.11**	**0.03**	**5.33**	**NS**	**0.62**	**NS**	**0.27**	**0.30**	**0.42**	**5.74**	**NS**	**NS**
SE(m)	**5.20**	0.04	**0.008**	**1.81**	**2.96**	**0.21**	**0.183**	**0.09**	**0.10**	**0.141**	**1.94**	**1.26**	**1.10**
Contro-1 (no Nutrients)	167.00	1.89	0.52	50.20	84.5	5.23	15.23	0.72	0.77	0.71	8.83	3.55	4.55
Contro-2 (100% RDF)	178.33	2.12	0.61	62.30	87.4	6.57	15.51	1.08	1.06	1.26	10.96	9.41	7.22
CD	**NS**	**0.177**	**0.05**	**9.31**	**NS**	**1.064**	**NS**	**0.429**	**NS**	**0.673**	**NS**	**6.051**	**NS**
SE(m)	**9.253**	**0.061**	**0.02**	**3.18**	**5.36**	**0.364**	**0.293**	**0.147**	**0.173**	**0.23**	**3.269**	**2.07**	**1.97**

Developing scientific aids for site specific nutrient management through variable mapping of soil properties in sugarcane growing soils

Study was conducted in Indo-Gangetic plain to develop scientific aids for site specific nutrient management through variable mapping of soil properties. The Institute research farm *Kharika* was selected for the study. The study area was geo-referenced and the entire farm area was divided in 50 x 50 meter grids for collection of grid based soil samples. The central point of each grid was considered as soil sample collection point. A total of 212 grid based soil samples were collected from the surface (106) and sub-surface (106) soil layers (0-15 and 15-30 cm soil depth, respectively) and analysed for various physico-chemical soil properties in the laboratory. Soil organic carbon exhibited significantly positive correlation with available nitrogen, phosphorus, copper, iron and manganese. However, soil pH showed significant negative correlation with available nitrogen, zinc, copper, iron and manganese. The data pertaining to various soil properties obtained through analysing the surface soil samples were used for geo-statistical analysis.

The results of geo-statistical analysis revealed that semivariogram model Stable was found best-fit for soil pH, available phosphorus and available potassium; Hole-effect for electrical conductivity; Gaussian for soil organic carbon; J-Bessel for available nitrogen, zinc, iron and manganese; Rational-quadratic for available sulphur and Circular for copper. The geo-statistical analysis based best-fit semivariogram models were selected for development of spatial distribution maps of soil properties. Based on this technique, the spatial distribution maps were developed for soil pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, sulphur, zinc, copper, iron and manganese for implementation of site-specific nutrient management at *Kharika* research farm of IISR, Lucknow.

Effect of silicon nutrition on growth, yield, juice and soil quality of sugarcane in sub-tropics

The field experiment was conducted with the objective to find out the suitable source and optimum dose of silicon for enhancing sugarcane productivity. The experiment consisted of 10 treatments viz. T_1 - Control (no silicon application), T_2 - Silicon @ 200 kg/ha through bagasse ash, T_3 - Silicon @ 400 kg/ha through bagasse ash, T_4 - Silicon @ 600 kg/ha through bagasse ash, T_5 - Silicon @ 800 kg/ha through bagasse ash, T_6 - Silicon @ 200 kg/ha through diatomaceous earth, T_7 - Silicon @ 400 kg/ha through diatomaceous earth, T_8 - Silicon @ 600 kg/ha through diatomaceous earth, T_9 - Silicon @ 800 kg/ha through diatomaceous earth and T_{10} - Foliar spray of 2.5 % Potassium silicate at 60, 90 and 120 DAP. The experiment was laid out in Randomized Block Design with three replications. The experimental crop (2nd cycle plant crop) was planted on 25.02.2021 with a row to row spacing of 75 cm using sugarcane mid-late variety CoLk 09204. The three-bud treated setts were used to plant the crop at proper soil moisture.

Performance of plant crop as influenced under various treatments was assessed and after its harvest ratoon was initiated in March 2022. The data recorded on ratoon sugarcane tillering, NMC, cane length and cane yield indicated significant variations among the treatments (Table 10). Application of silicon @ 400 kg/ha resulted into significant improvement in yield attributes and yield of ratoon sugarcane crop. Application of silicon either through diatomaceous earth or bagasse ash exhibited similar response on sugarcane ratoon but significantly superior to foliar spray of potassium silicate and control.

Management of Bio-resources for Enhancing Sugarcane Productivity and Soil Health

Application of chitosan in agriculture is recently in vogue for growth improvement, fungicidal activity and as seed coating agent. Chitosan has a direct effect on treated plants and induces a series of defence reactions. Furthermore, Chitosan and its derivatives have outstanding antibacterial, antiviral, antifungal, and abiotic stress tolerance properties, including drought and salt tolerance. This is in conjunction with the other characteristics of chitosan, such as its low toxicity towards mammalian cells. Biocompatibility and natural occurrence have attracted interest in recent years in research and development aimed at widening the scope of chitosan. There are so many bio-resources, *viz*., nitrogen-fixing bacteria, PSB, and potassium solubilizing bacteria, and hence their role is already proven for crop production. Plant growth regulators like GA-3 have also been proven for role in crop growth and development. Therefore, the present study was undertaken to work out the efficacy of oligo chitosan (Bio stimulator) and other bio-resources and their integration for improving sugarcane productivity and soil health. The experiment was conducted with the 12 different treatment combinations viz, T1: 100% N, P, K (Control), T2: 75%

Table 2.10 Number of tillers, NMC, cane length and cane yield as influenced by source and dose of silicon (1st ratoon of 2nd cycle plant crop)

Treatment	Tiller no. (000/ha)	NMC (000/ha)	Cane length (cm)	Yield (t/ha)
Control (No silicon application)	158.34	89.54	219.78	71.30
Silicon @ 200 kg/ha through bagasse ash	175.45	96.81	231.23	78.16
Silicon @ 400 kg/ha through bagasse ash	200.37	102.22	243.31	82.93
Silicon @ 600 kg/ha through bagasse ash,	211.12	103.81	249.15	84.42
Silicon @ 800 kg/ha through bagasse ash	223.25	105.02	252.67	85.66
Silicon @ 200 kg/ha through diatomaceous earth	178.78	98.31	233.75	79.43
Silicon @ 400 kg/ha through diatomaceous earth	207.63	103.85	246.25	84.35
Silicon @ 600 kg/ha through diatomaceous earth	218.61	105.15	251.70	85.58
Silicon @ 800 kg/ha through diatomaceous earth	230.12	106.06	255.54	86.77
Foliar spray of 2.5 % Potassium silicate at 60, 90 and 120 DAP	179.94	98.27	235.03	79.60
SEm ±	4.12	1.70	3.68	1.55
CD (p = 0.05)	12.32	5.07	11.01	4.63

N, P, K (Control), T3: T1 + Use of Bio stimulator derivative-drenching @ 2.5 ml/L of water *, T4: T3 + drenching with *Gluconacetobacter diazotrophicus*, T5: T4 + drenching with *Bacillus subtilis*, T6: T5 + drenching with *Bacillus cerelus*, T7: T6 + foliar application of GA3 @ 35 ppm at 90, 120 and 150 DAP, T8: T2 + Use of Bio stimulator derivative-drenching @ 2.5 ml/l of water*, T9: T8 + drenching with *Gluconacetobacter diazotrophicus*, T10: T9 + drenching with *Bacillus subtilis*, T11: T10 + drenching with *Bacillus cerelus*, T12: T11 + foliar application of GA3 @ 35 ppm at 90, 120 and 150 DAP. The design of the experiment was RBD with three replications.

Results indicated that treatment T7 (100% N, P, K. + drenching with Bio stimulator derivative@ 2.5 ml/L of water + drenching with *Gluconoacetobacter diazotrophicus* + drenching with *Bacillus subtilis* and *Bacillus cerelus* and foliar application of GA-3 @ 35 ppm at 90,120 and 150DAP) have been found significantly the best for cane yield (73.64 t/ha) over other treatment combinations followed by T11 (72.34 t/ha) and T9 (71.92 t/ha.). The number of tillers, NMC, cane weight and other growth parameters followed the similar trend. The initial soil analysis was also done for chemical and biological properties of soil and values for 0-15 cm depth were; Organic Carbon 0.59%, pH 7.73, N-254.01 kg/ha, P_2O_5-29.12 kg/ha, K_2O-202.16 kg/ha. For sub-soil (15-30 cm depth) the values were; Organic Carbon 0.37%, pH 7.87, ECe 0.37 dS/m, N 205.93 kg/ha, P_2O_5 18.39 kg/ha, K_2O 188.94 kg/ha. The biological analysis report of these samples are bacteria-8.8*106, actinomyces-3.74*10 4, fungi-9.31*10 4.

Enhancing water productivity of sugarcane production system by regulating irrigation regimes and field moisture management

A field experiment to assess the influence of IW/CPE based irrigation regime and field moisture management practices on sugarcane growth and yield, water productivity and water footprint was initiated in February 2021. During the year (2022-23) performance of spring planted sugarcane crop and first ratoon crop as influenced under various treatments was assessed. Sugarcane crop was planted with the help of sugarcane trench planter on 8th March 2022 after Laser levelling of the experimental field and pre sowing irrigation and was harvested in February 2023. The first ratoon crop was initiated on 16th March 2022 and harvesting was done on 30th January 2022. Both the experimental fields consisted of plots (7x6 m) with four paired row of sugarcane in 150:30 configuration and trenches so formed remained intact for applying irrigation treatments till the onset of monsoon. Earthing up during rainy season resulted in trench formation in the inter-row spaces that were used for post-monsoon irrigation treatments. The crop was given a general irrigation 30 DAP and thereafter irrigation scheduling was adopted as per the technical programme. The experiment consisted of maintaining irrigation regimes (03) based on IW/ CPE ratio 1.0, 0.8 and 0.6 with irrigation depth of 75 mm. Six moisture management practices viz., flood irrigation without mulch (M1), Flood irrigation with mulch (M2), trench irrigation without mulch (M3), trench irrigation with mulch (M4), alternate trench irrigation without mulch (M5) and alternate trench irrigation with mulch (M6) were taken. Quantity of water applied to every plot for each irrigation was measured with the help of water meter. Irrigation regimes were laid to main plots and moisture management practices to sub-plots. Strip plot design with 03 replications was adopted.

Data recorded and analysed during the year indicate:

Plant crop

1. Irrigation regimes exerted significant influence over growth and yield of sugarcane. The number of tillers (140 DAP), number of millable canes, average cane weight, cane length and cane yield were recorded significantly higher with IW: CPE ratio being 1.0 and 0.8 over those recorded with IW: CPE ratio being 0.6.
2. Irrigation in trenches (90.69 t/ha) or in the alternate trenches (89.33 t/ha) harvested statistically at par cane yield as with flood irrigation (85.69 t/ha).
3. Sugarcane juice quality was not influenced by irrigation regimes or the methods of irrigation.
4. As far water productivity under different irrigation regimes, the best (193.01 L/kg) was recorded with IW: CPE ratio 0.8 against 200.89 L/kg under IW: CPE ration 0.6 and 207.54 L/kg with IW: CPE ratio 1.0. However, the water productivity of the applied irrigation water was found best under IW: CPE ratio 0.6 (72.30 L/kg) followed by the ratio 0.8 (79.66 L/kg).
5. The water footprint of sugarcane plant crop cultivation ranged between 118.23 L/kg and 134.13 L/kg for different irrigation regimes wherein IW: CPE ratio 0.8 recorded the minimum water footprint. Among methods of irrigation, the trench irrigation generated the lowest water footprint (122.71 L/kg).
6. Partitioning of water footprint among green, blue and grey components revealed that rains contribute about 75-78% to total water footprint and the crop depends on irrigation water only for 12-15% of its water requirement.

First ratoon crop

1. Different irrigation regimes and methods of irrigation significantly affected the growth of sugarcane ratoon crop as evident from the tiller count, NMC, average cane weight and cane length. The highest ratoon yield was harvested under the irrigation regime with IW: CPE ratio 0.8 statistically similar to that recorded with IW: CPE ration 1.0. Irrigation methods could not exert significant effect over ratoon yield.
2. Irrigation by skipping alternate trenches in ratoon crop caused significant reduction in the juice quality of ratoon crop.
3. The best irrigation water productivity in ratoon cultivation was found under the irrigation regime having IW: CPE ratio 0.6 (83.20 L/kg) followed by IW: CPE ratio 0.8 (91.35 L/kg). Among irrigation methods the skip trench irrigation recorded the best water productivity (50.82 L/kg) followed by irrigating all the trenches (66.16 L/kg).
4. Water footprint of sugarcane first ratoon crop ranged between 127.02 and 148.34 L/kg. Partitioning among green, blue and grey components revealed that ratoon gets about 61% contribution from the rains and depends on irrigation only for 25% of its crop water needs.

Table 2.11 Effect of irrigation regime and water application methods on sugarcane ratoon (first) growth

Treatment	Initial tiller count ('000/ha)	Tiller count 140 DARI ('000/ha)	NMC ('000/ha)	Average cane length (cm)
Irrigation regime (IW:CPE ratio)				
1.0	122.24	104.58	81.72	252.77
0.8	118.71	118.14	88.31	238.33
0.6	114.94	117.85	75.11	214.27
CD (p =0.05)	NS	07.23	6.35	16.37

Irrigation method				
Flooding	108.77	86.47	81.92	226.88
Flooding with mulch	113.99	118.49	84.09	222.44
Trench irrigation	126.55	125.95	83.80	248.33
Trench irrigation with mulch	122.42	113.54	93.40	236.66
Skip trench irrigation	125.39	130.82	72.82	237.77
Skip trench with mulch	114.6	105.89	74.25	238.66
CD (*p* =0.05)	NS	14.52	12.58	14.57

Table 2.12 Effect of irrigation regime and water application methods on sugarcane ratoon yield and quality

Treatment	Average cane weight (kg)	Average cane girth (mm)	Cane yield (t/ha)	Sucrose (%)
Irrigation regime (IW:CPE ratio)				
1.0	1.033	25.30	79.08	17.62
0.8	0.903	24.32	82.10	17.87
0.6	0.947	23.62	72.11	17.45
CD (*p* =0.05)	0.052	NS	7.29	NS
Irrigation method				
Flooding	0.909	23.70	78.41	17.71
Flooding with mulch	1.010	24.04	76.82	17.67
Trench irrigation	0.991	24.85	78.85	18.04
Trench irrigation with mulch	0.891	24.23	80.45	17.82
Skip trench irrigation	0.949	24.35	75.34	18.25
Skip trench with mulch	1.009	25.27	76.64	17.81
CD (*p* =0.05)	0.092	NS	NS	NS

Table 2.13 Effect of irrigation regime and water application methods on quantity of water used and water productivity of sugarcane ratoon

Treatment	Irrigation water (mm)	Rain (mm)	Total water (mm)	Total Water productivity (m^3/ton)	Irrigation water productivity (m^3/ton)	Irr. Water productivity (Rs/m^3)
Irrigation regime (IW:CPE ratio)						
1.0	825	1067	1892	239.00	104.32	32.59
0.8	750	1067	1817	221.31	91.35	37.21
0.6	600	1067	1667	231.17	83.20	40.86
CD (P=0.05)	-	-	-	-	-	-
Irrigation method						
Flooding	720.66	1067	1787.66	227.98	91.90	36.99
Flooding with mulch	705.66	1067	1772.66	230.75	91.85	37.01
Trench irrigation	539.33	1067	1606.33	203.71	68.39	49.70
Trench irrigation with mulch	514.33	1067	1581.33	196.56	63.93	53.18

Skip trench irrigation	384.66	1067	1451.66	192.68	51.03	66.59
Skip trench with mulch	388	1067	1455	189.84	50.62	67.15
CD (P=0.05)	-	-	-	-	-	-

Table 2.14 Water footprint of sugarcane first ratoon as influenced by irrigation regime and water application method

Treatment	Green water footprint (m^3/ton)	Blue water footprint (m^3/ton)	Grey water footprint (m^3/ton)	Total water footprint (m^3/ton)
Irrigation regime (IW:CPE ratio)				
1.0	85.31	34.39	18.99	138.69
0.8	78.89	29.83	18.3	127.02
0.6	82.91	44.6	20.83	148.34
CD (P=0.05)	-	-	-	-
Irrigation method				
Flooding	81.88	36.27	19.29	137.44
Flooding with mulch	83.41	36.67	19.42	139.5
Trench irrigation	80.63	35.68	19.06	135.37
Trench irrigation with mulch	79.44	34.88	18.66	132.98
Skip trench irrigation	84.94	37.43	20	142.37
Skip trench with mulch	83.41	36.69	19.61	139.71
CD (P=0.05)	-	-		-

Table 2.15 Effect of irrigation regime and water application methods on sugarcane plant crop (second year) growth

Treatment	Germination %	Tiller count 140 DARI ('000/ha)	NMC ('000/ha)	Average cane length (cm)
Irrigation regime (IW:CPE ratio)				
1.0	32.62	180.55	119.57	237.27
0.8	37.31	167.88	113.94	232.38
0.6	40.52	164.10	111.49	225.73
CD (p =0.05)	NS	8.52	7.52	7.21
Irrigation method				
Flooding	37.16	181.16	118.15	235.84
Flooding with mulch	36.89	167.51	116.25	238.35
Trench irrigation	36.13	175.39	118.57	224.17
Trench irrigation with mulch	36.12	156.42	111.23	231.97
Skip trench irrigation	36.24	177.24	114.73	232.84
Skip trench with mulch	38.37	167.35	111.06	227.60
CD (p =0.05)	NS	18.32	NS	9.32

Table 2.16 Effect of irrigation regime and water application methods on sugarcane plant crop (second year) yield and quality

Treatment	Average cane weight (kg)	Average cane girth (mm)	Cane yield (t/ha)	Sucrose (%)
Irrigation regime (IW:CPE ratio)				
1.0	1.078	23.88	91.16	17.98
0.8	1.077	23.98	94.14	17.99
0.6	0.994	23.65	82.98	17.68
CD (p =0.05)	NS	NS	7.36	NS
Irrigation method				
Flooding	1.048	23.41	89.84	17.71
Flooding with mulch	1.069	24.56	86.66	17.67
Trench irrigation	1.060	23.69	90.15	18.04
Trench irrigation with mulch	1.062	23.59	91.24	17.82
Skip trench irrigation	1.020	24.30	88.04	18.25
Skip trench with mulch	1.040	23.47	90.63	17.81
CD (p=0.05)	NS	NS	NS	NS

Table 2.17 Effect of irrigation regime and water application methods on quantity of water used and water productivity of sugarcane plant crop (Second)

Treatment	Irrigation water (mm)	Rain (mm)	Total water (mm)	Total Water productivity (m^3/ton)	Irrigation water productivity (m^3/ton)	Irrigation Water productivity (Rs/m^3)
Irrigation regime (IW:CPE ratio)						
1.0	825	1067	1892	207.54	90.50	37.56
0.8	750	1067	1817	193.01	79.66	42.67
0.6	600	1067	1667	200.89	72.30	47.02
CD (P=0.05)	-	-	-	-	-	-
Irrigation method						
Flooding	720.66	1067	1787.66	198.98	80.21	42.38
Flooding with mulch	705.66	1067	1772.66	204.55	81.42	41.75
Trench irrigation	539.33	1067	1606.33	178.18	59.82	56.83
Trench irrigation with mulch	514.33	1067	1581.33	173.33	56.37	60.31
Skip trench irrigation	384.66	1067	1451.66	164.88	43.69	77.81
Skip trench with mulch	388	1067	1455	160.54	42.81	79.41
CD (P=0.05)	-	-	-	-	-	-

Table 2.18 Water footprint of sugarcane plant crop (second) as influenced by irrigation regime and water application method

Treatment	Green water footprint (m^3/ton)	Blue water footprint (m^3/ton)	Grey water footprint (m^3/ton)	Total water footprint (m^3/ton)
Irrigation regime (IW:CPE ratio)				
1.0	88.31	17.33	16.45	122.09
0.8	85.52	16.78	15.93	118.23
0.6	97.02	19.04	18.07	134.13
CD (P=0.05)	-	-	-	-
Irrigation method				
Flooding	89.61	17.58	16.69	123.88
Flooding with mulch	92.90	18.23	17.30	128.43
Trench irrigation	89.30	17.52	16.63	123.45
Trench irrigation with mulch	88.23	17.31	16.44	121.98
Skip trench irrigation	91.44	17.94	17.03	126.41
Skip trench with mulch	88.83	17.43	16.55	122.81
CD (P=0.05)	-	-	-	-

Precision nutrient management through rescheduling time of application for widely spaced sugarcane plant-ratoon systema

A field experiment was initiated during second week of February, 2020 with objective to assess the effect of split application of N & K till advanced crop growth stages on nutrient use efficiency, crop growth, yield and quality for widely planted sugarcane plant-ratoon system. The second plant crop was planted on 3rd March 2022 with recommended package of practices. Band placement method recorded significantly higher cane yield (80.8 t/ha) and commercial cane sugar in second plant (9.60 t/ha) crop as compared to broadcasting method (75.4 and 8.79 t/ha). This method maintained similar order of performance in terms of other yield attributes with the result that band placement produced the highest cane diameter (2.20 cm), cane length (280 cm), and single cane weight (1.04 kg) (Table 19). Significantly higher single cane weight resulted in higher cane and sugar yield under band placement method. Five Splitting of N and K produced higher cane yield (82.0 t/ha) being at par with six (80.4 t/ha) and seven (79.6 t/ha) splitting. Splitting of N and K also affected yield attributes significantly. Significantly highest sucrose (%) was recorded with five splitting (17.30) compared to six, seven and three splitting (RDF) of N and K. Band placement of fertilizers increased the yield by 7 % over broadcasting method. Five Splitting of N & K nutrient significantly improved cane and sugar yield compared to three splitting as conventional method.

Table 2.19 Yield, and quality attributes as influenced by nutrient management in sugarcane plant crop

	Cane length (cm)	Cane Diameter (cm)	Single Cane Wt. (kg)	NMC (000/ha)	Yield (t/ha)	CCS (t/ha)	Corrected Brix	Sucrose (%)
							At 12 month	
Method of Application								
M1- Broadcasting	269	2.18	0.971	77.9	75.4	8.79	18.44	16.64
M2- Band placement	280	2.20	1.04	78.0	80.8	9.60	18.67	16.97
CD	**NS**	**NS**	**0.06**	**N/A**	**4.95**	**0.58**	**NS**	**0.31**
SE(m)	**5.733**	**0.05**	**0.021**	**1.833**	**1.616**	**0.19**	**0.100**	**0.103**

Nutrient Management								
S1- RDN + RDK in five splits	287	2.27	1.098	74.9	82.0	9.93	19.05	17.30
S2- RDN + RDK in Six splits	270	2.15	0.981	81.9	80.4	9.34	18.39	16.61
S3- RDN + RDK in seven splits	272	2.18	0.96	82.9	79.6	9.26	18.44	16.67
S4- RDF and Schedule of nutrient applications (45 and 90 DAP)	270	2.16	0.983	72.0	70.5	8.25	18.35	16.65
CD	**NS**	**NS**	**0.09**	**7.94**	**7.00**	**0.82**	**0.435**	**0.444**
SE(m)	**8.108**	**0.06**	**0.029**	**2.592**	**2.285**	**0.27**	**0.142**	**0.145**

Enhancing crop productivity and profitability of autumn sugarcane planted in wide row spacing through high-value intercrops

A field experiment was initiated during the autumn season at the Research farm Kharika, of the institute, with an objective to enhance the crop productivity and profitability of autumn sugarcane planted in wide row spacing through high value intercrops without jeopardizing crop growth and development. The experiment comprising twelve treatment combinations was laid out in RBD with three replications under three wide row spacing (90, 120, 150 cm) and three intercrops (maize/ cowpea, garlic/okra and fenugreek/onion in plant/ratoon cropping system). The sugarcane variety was Co 0238. During the reporting period the ratoon crop II was harvested and yield attributes were recorded and subsequent residual effect of treatments were observed in the field. Also studies on soil fertility and microbial count was made after harvest of crop cycle.

- Autumn sugarcane ratoon crop, the number of millable cane (NMC) and sugarcane yield were higher in 90 cm and 120 cm row spacing (mean NMC-88.89 thousand/ha, mean cane yield- 161.27 t/ha and 70.31 thousand/ha, 127.11 t/ha, respectively) in sugarcane sole crop as compared to 150 cm row spacing (mean NMC-55.92 thousand/ha, mean cane yield-96.96 t/ha).
- Among the sugarcane ratoon + intercropping residual treatment, the highest cane yield in 90 cm row spacing was found in sugarcane ratoon + cowpea (165.62 t/ha) followed by cane yield in sugarcane ratoon + onion (163.87 t/ha) and sugarcane ratoon + okra (143.20 t/ha) of intercropping system.
- The single cane weight was in the range of 1.16 to 1.62 kg, having cane length of 230.3 to 294.0 cm and an average cane diameter of 2.66 to 3.03 cm.
- Sugarcane ratoon sole at 90 cm row spacing fetched the highest net income of Rs. 524232 / ha, (B: C ratio of 5.61) followed by sugarcane ratoon at 90 cm row spacing + maize / cowpea treatment with net income of Rs. 499737 / ha, (B: C ratio of 5.42) and sugarcane ratoon at 90 cm row spacing + fenugreek / onion residue with net income of Rs. 493415 / ha, (B: C ratio of 5.37).
- The results after post harvest soil analysis showed that the soil pH, EC, organic carbon (OC), available nitrogen (AN), available phosphorus (AP), available potassium (AK) were higher under various sugarcane based intercropping system than initial values.
- In contrast, micronutrients like Zn, Cu, Fe, Mn values were decreased under various sugarcane based intercropping system than initial values.
- There was gradual increase of bacterial and fungi population in sugarcane intercropping system. The mean bacteria numbers in all intercropping system ranged from 32.10 x 10^5 cfu g^{-1} soil to 38.33 x 10^5 cfu g^{-1} soil. The population of fungi recorded lower and it ranged from 4.43 x 10^3 cfu g^{-1} soil to 6.03 x 10^3 cfu g^{-1} soil as compared to bacteria population. The lower population of actinomycetes was recorded 23.43 x 10^5 cfu g^{-1} soil in sugarcane + garlic /okra intercropping, 23.47 x 10^5 cfu g^{-1} soil in sugarcane + fenugreek /onion and 23.23 x 10^5 cfu g^{-1} soil in sugarcane sole as compared

to sugarcane + maize /cowpea (25.13 x 10 ^{5} cfu g^{-1} soil).

Overall, intercropping with sugarcane increased the crop productivity by regulating soil fertility and microbial dynamics in the rhizosphere of sugarcane.

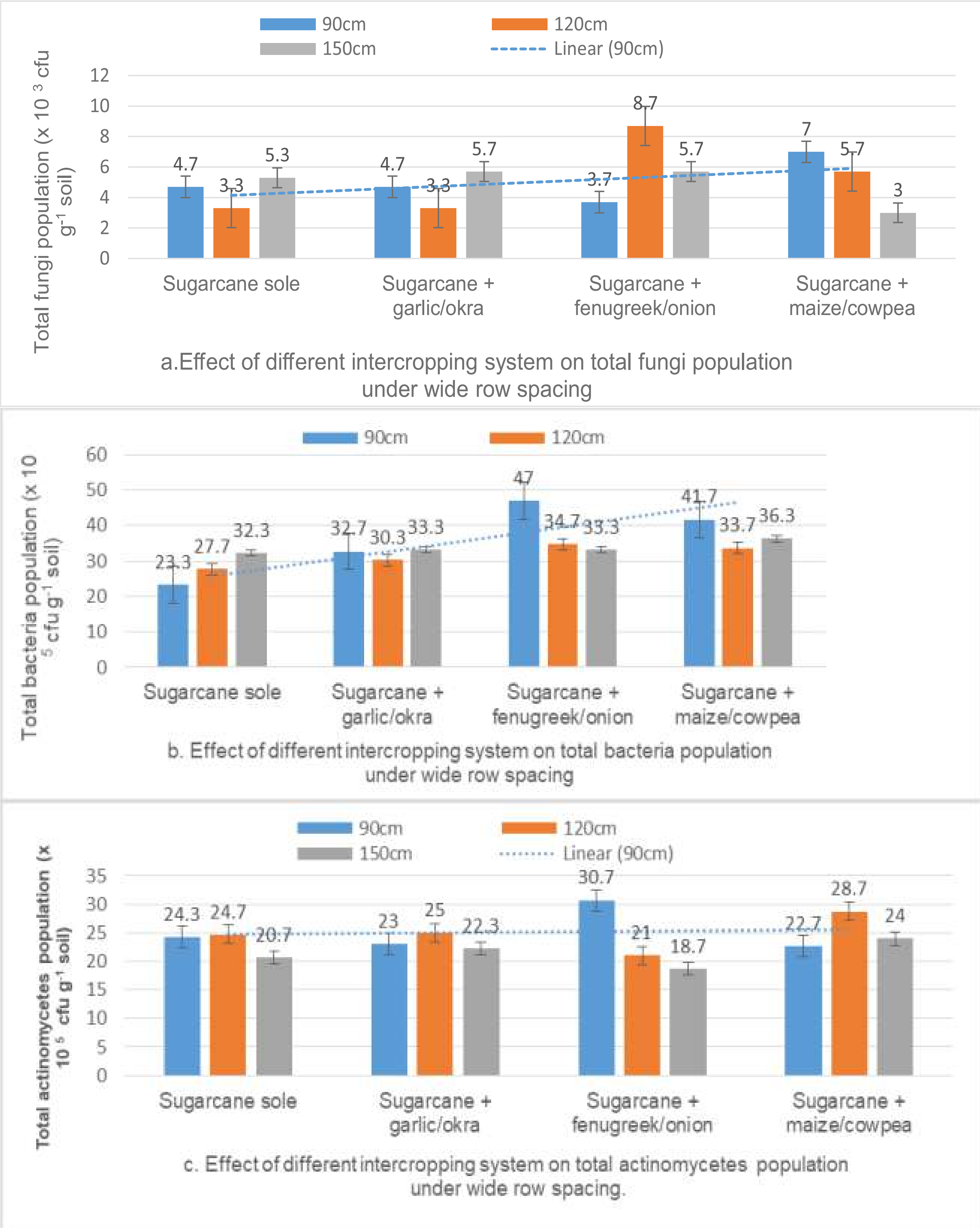


Fig.2.6 *(a) Total fungi population (x 10 3 cfu g-1 soil), (b) total bacteria population (x 10 5 cfu g-1 soil), and (c) total actinomycetes population (x 10 5 cfu g-1 soil).*

Response of Sugarcane crop to application of Croptek 9:24:24 complex fertilizer on crop growth, yield and quality in sugarcane

Salient achievements:

The field experiment on Response of sugarcane crop to application of Croptek 9:24:24 complex fertilizer on crop growth, yield and quality in sugarcane was conducted in randomized block design with three replications with the objective to validate Croptek dose and assess response to sugarcane in terms of crop growth, cane yield & quality & to assess the Croptek response through NUE of NPK and micronutrients. Treatments were allocated per the experiment's protocol.

- The trial was laid out at ICAR-Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh during spring season of 2022-23 in Kharika Farm and planted with sugarcane early variety (cv. CoLk 11203) and the ratoon crop was initiated.
- The soil of the experimental field was sandy loam (Inceptisol), pH of soil is high (pH 8.13), high in organic carbon (0.81 %), low in available N (175.62 kg/ha), and very high in available P (65.41 kg/ha) and K (685.22 kg/ ha).
- Significantly higher NMC (132.06 thousand /ha) and cane yield (101.66 t/ha) was recorded with Croptek 9:24:24 complex fertilizer applied as RDF (NPKS kg/ha-150:60:60:45) at par with Croptek 9:24:24 incorporated (NPKS kg/ha - 175:120:150:45), NMC (123.10 thousand /ha) and cane yield (93.39 t/ha) and Croptek 9:24:24 applied 20% more (NPKS kg/ha -180:72:72:45) the NMC (121.75 thousand /ha) and cane yield (91.94 t/ha) than rest of the fertilizer doses.
- It was also observed that Croptek 9:24:24 complex fertilizer application beyond NPKS kg/ha - 175:120:150:45 doses have detrimental effect on growth and cane yield.
- The juice quality parameters viz. brix value and sucrose were improved with the application of Croptek 9:24:24 (NPKS kg/ha -175:120:150:45) and Croptek 9:24:24 (NPKS kg/ha-180:65:25:9), however, non- significant. There was little improvement in NMC (111.4306 thousand /ha) and cane yield (85.06 t/ha) in farmers practice fertilizer (NPKS kg/ha-180:65:25:9) + liquid bio fertilizers consortia @ 2 l/ha than the standard farmer's practice - straight fertilizers based on survey of 15 farmers (NPKS kg/ha-180:65:25:9), NMC (106.34 thousand /ha) and cane yield (71.75 t/ha).
- The lowest sugarcane yield (69.25 t/ha) was recorded in absolute control treatment where no fertilizers were applied.

CHAPTER 3

Management of Insect Pests and Diseases

Survey and surveillance of insect-pests and diseases of sugarcane in subtropical India

The survey was conducted in the research farm of ICAR-IISR, farmers' fields as well as different sugar mills of UP and Bihar. At ICAR-IISR research farm, natural incidence of red rot was observed in the genotype LG 21183 and CoLk 09204. Other fungal diseases such wilt (Co 7717-upto 15%), smut (CoLk 11203, CoLk 11204, Co 0238-upto 20%) and pokkah boeng (CoLk 8102, Co 7717, Co 0238-upto 30%) were recorded in the farm. Minor diseases like red stripe, ring spot, eye spot and red leaf spot were observed in traces. Viral diseases like YLD, SCMV, SCBV were seen in most of the varieties planted in the farm. The incidence of red rot was 5-15% in Co 0238. The incidences of other diseases were - wilt 10-20% in Co 0238; pokkah boeng 5-20% in CoLk 14201, mosaic 30-60% in CoLk 14201 and Co 0238 in the survey villages of command areas of Biswan Sugar Mill, Biswan, Sitapur. In the command area of DSCL Sugar Mill, Hariawan, incidence of wilt (19-46 %), YLD (15-32 %) and SCMV (11-24%) was noticed, along with other minor diseases like ring spot (1-5%) and red leaf spot (1-2%). In DSCL Sugar Mill, Loni, incidence of root borer, top borer, termite and pink borer was observed to be 50%, 40%, 40% and 10%, respectively in CoLk 94184. The incidence of wilt (40%), YLD (70 %), SCMV (60%) and SCBV (90%) together resulted in severe stunting of the variety. Other minor diseases like ring spot (5-10%) and red leaf spot (2-8%) were also observed. In command areas of K.M Sugar Mills, Masaudha, Ayodhya natural incidences of red rot in some varieties, *viz.*, Co 0238 (60-70%) and CoJ 85 (20-25%) was recorded. The varieties CoLk 14201, Co 98014 and Co 11015 exhibited 15-30% incidence of wilt, 15-25% ratoon stunting disease and pokkah boeng diseases in different sugarcane varieties. Smut and leaf scald diseases were recorded (5-10% incidence) in Co 0238. Viral diseases like SCMV and SCBV were common in almost all sugarcane varieties. Foliar diseases like ring spot, brown spot, leaf scorching and black stripe were found in traces (1-10%). In Sultanpur district of UP, the incidence of red rot (40-70%), wilt (30-40 %) and viral disease (20-30%) was observed in Co 0238.

Death of young settling

Midrib infections

Severe red rot

Red rot in canes

Field view of red rot

Heaps of red rot -affected discarded cane

Fig. 3.1. Different stages of red rot symptoms in sugarcane crop.

In the command areas of sugar mills, the incidence of pink mealy bug (30-70%) was reported in plant crop of CoS 13035, Co 0238 and CoS 15023. Sporadic incidence of top borer, stalk borer and white fly was observed in Co 0238, CoLk 14201 and Co 0118. In all villages under survey, mealy bug, *Pyrilla* (egg parasitized) and its nymphal and adult parasitoid, *Epiricania melanoleuca* (cocoon) were observed. The incidence of top borer (2-5%), pink borer (6-8%) and mealy bug (5-10%) was noticed in command areas of Hasanpur Sugar Mill, Hasanpur, Samastipur, Bihar.

Fig. 3.2. *Insect pests of sugarcane in the NWZ and NCZ of subtropical India.*
a: Bunchy top due to top borer; b: Internode borer larva; c: Top borer infested cane; d: Pink mealy bug; e: Crown mealy bug; f: White fly; g:Nymph and adult of pyrilla; h: Eggs of pyrilla; i:Nymph of pyrilla parasitized by Epiricania; j: Adult Pyrilla parasitized by Epiricania;

Artificial intelligence-based detection of insects, pest and diseases

A total of 1,307 RGB images of red rot, wilt, smut, pokkah boeng, YLD, top rot, leaf scald, leaf scorching, ratoon stunting disease, scale insect, mealy bug, white fly, aphid, black bug, top borer, internode borer, termite and porcupine damage symptoms were captured manually in real-time and under controlled conditions, through different cameras (Canon EOS 77D DSLR camera, smartphone One Plus 7T Pro HD1911 (OnePlus Technology (Shenzhen) Co., Ltd.) Android Version 11 (Oxygen OS 11.0.7.1 HD01AA), Snapdragon TM 855 plus processor) camera and 16.1 MP Sony Cyber-Shot DSC-H70 with 10x Wide-Angle Optical Zoom G Lens camera). The symptoms of cane and leaves of sugarcane were captured under different levels of illumination, under varying temperature and humidity, at various growth phases of the crop, and at different locations (North Central and North West Zone). The images were collected from susceptible varieties such as Co 0238, CoJ85, CoJ64, CoSe 18452, CoLk 94184, CoLk 14201, CoS 8436, Co 1148, CoLk 11203 and CoS767. The dataset was labelled properly and annotated to a specific folder. A repository of 15, 746 RGB images of insects, healthy and injured symptoms of insects, pests, diseases, and physiological disorders is being maintained in the Division of Crop Protection, ICAR-IISR, Lucknow.

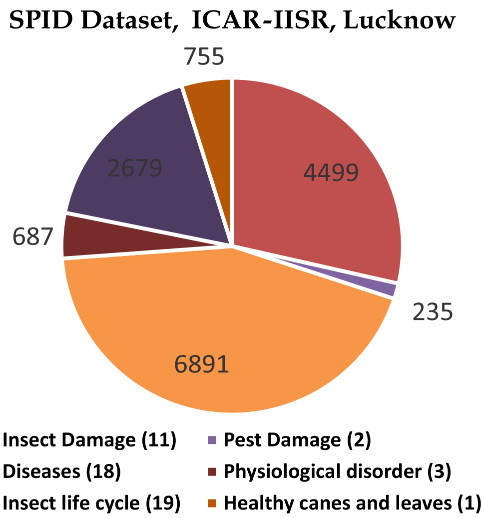


Fig. 3.3. *Artificial intelligence-based detection of insects, pest and diseases*

Mapping of ratoon stunting disease and its impact on quantitative and qualitative parameter of sugarcane

A collection of 228 sugarcane clones/varieties used for DUS testing were screened for the RSD pathogen in 2023-24. The quality parameters were also recorded. The genotypes/varieties exhibited cane node infection to varying degrees (<10%->40%) (Table 1). The susceptible varieties identified were CoS767, CoP 9206, CoP 9702, CoS 8432, CoS 8207, CoSe 03279, CoS 94270, UP 05, CoLk 94184, and CoH 94, while the resistant clones/varieties (*Ikshu* ISH 12, SC 8001-6, LG 05201, *Ikshu* ISH 22, *Ikshu* ISH 9, *Ikshu* ISH 1, CoS 88230, *Ikshu* ISH 3, SC 91-2, SC 91-7, LG 02005, ISH 135, ISH 126, and CoS 99259) were planted again to validate the disease reactions and impact on qualitative parameters. It was observed that disease intensity had an impact on all qualitative parameters. Additionally, all resistant varieties, except for *Ikshu* ISH 12, showed a slight level of susceptibility (1-2%) and the susceptible varieties, CoSe 03279, CoP 9206, UP 05, CoH 94, and CoS 767JL recorded a higher disease intensity (Fig. 4).

Fig. 3.4. *Presence of dot and streak symptoms of ratoon stunting disease in ICAR-IISR, Lucknow*

Unveiling the sugarcane virome to enhance productivity in sub-tropical India

A total of sixty- eight sugarcane mosaic symptomatic samples from sorghum and sugarcane were collected from different parts of Uttar Pradesh viz., Lucknow, Balrampur, Mankapur; Bihar and Maharashtra. The samples exhibited 50-70% mosaic incidence on the scale of 1-5 both in sugarcane and sorghum, mostly in the newly emerged leaves. The symptomatic samples were subjected to RNA isolation and RT-PCR analyses which resulted in amplicon of 600 bp for the presence of Sugarcane streak mosaic virus in twenty-five tested samples (Fig. 3.5). The samples were Sanger sequenced and the sequences revealed identity with Sugarcane streak mosaic coat protein. The sequenced samples were also subjected to phylogenetic analyses by comparing with the known sequences collected from NCBI. The phylogenetic tree was constructed using MEGA11 software for the 12 SCSMV sequences under study as well as those retrieved from the NCBI database (Fig. 6).

Fig. 5. *Amplification of sugarcane streak mosaic virus at 600 bp by using RT- PCR. Lane1- Sorghum, IISR, 2- Sorghum, IISR, 3- Sorghum, IISR, 4- Sorghum, IISR, 5- Sorghum, IISR, 6- Sorghum, IISR, 7- Sorghum, IISR, 8- Sorghum, IISR, 9- Sorghum, IISR, 10- Sorghum, IISR, 11- Sorghum, IISR, 12- Sorghum, IISR13- Sorghum, IISR, 14- Sorghum, Mankapur, 15- Co 0238, 16- Sorghum, Balrampur, 17-Sorghum, Ayodhya, 18-Sorghum, Ayodhya, 19- CoLk 16201, 20- CoLk 16203, 21- CoLk 15207, 22- CoLk 15207, 23-CoLk 010, 24- CoLk 14201, 25- 83V15.*

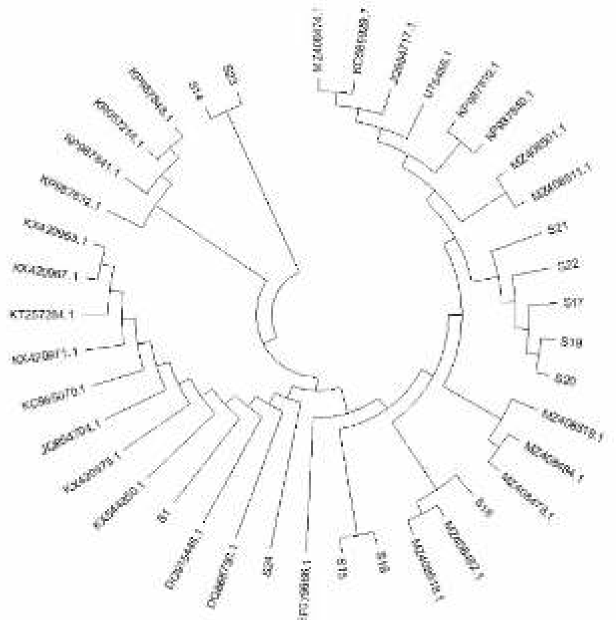


Fig. 3.6. *Phylogram of SCSMV reconstructed with the CP gene using maximum likelihood (ML) and Neighbour joining methods using MEGA 11 software*

Management of pokkah boeng disease of sugarcane

The experiment was conducted to study the bio-efficacy of *Trichoderma harzianum* strain T6 for the management of pokkah boeng disease caused by *Fusarium moniliforme* strain F2 and *Fusarium proliferatum* strain F7. *Trichoderma* culture inoculation through sett treatment, soil application, and foliar application were adopted. The foliar application of pathogenic culture, *F. proliferatum* strain F7 was done 45 days after planting. The $1x10^7$ fungal conidia per ml were maintained and applied through an automizer. Setts were sterilized at $50^{\circ}C$ for 2 hours. Two % CMC was added in fungal inoculum at the time of application. Foliar application of Carbendazim @0.1%, was the standard control, along with a negative control. Maximum disease severity (25.33) was recorded in the negative control in the month of August. The disease severity in standard control was 12.0. Less disease severity (5.33) was recorded in *Trichoderma* sett treatment of *Trichoderma* which was statistically significant. Significantly improved plant growth attributes (height, girth, length, and yield) and plant physiological parameters (photosynthetic rate, stomatal conductance of H_2O, transpiration rate, and PAR activity) were recorded in *Trichoderma* applied through sett treatment compared to the standard as well as negative control (Fig. 3.7).

Fig. 3.7. Pot experiment laid out for pokkah boeng disease management

Isolation, identification and pathogenicity of wilt pathogen in sugarcane

A total of 30 endophyte *Chaetomium globosum* isolates were characterized and evaluated for their antifungal potential against sugarcane wilt caused by *F. sacchari*. The isolates of *C. globosum* showed large variation in colony colour, growth rate, colony diameter, ascospore shape, sporulation time, conidia size and ascomata hairs. The most promising CGSR13 strain inhibited colony diameter (Fig. 3.8), spore germination, sporulation, and spore size by 66.66, 55.17, 75.00 and 3.46-8.40 (macro), 6.66-10.00 % (micro) respectively in *F. sacchari*. The CGSR13 showed 66.39, 60.09, and 46.37% inhibition in *F. sacchari* (Wilt) *in vitro*, in planta, and field conditions. Soil analysis showed that the CGSR13 treatment increases the nutrients and soil biomass than untreated control i.e., N (14.32%), P (30.06%), K (20.55%), Zn (5.95%), Cu (47.46%), Fe (14.68%), Mn (6.08%), soil organic C (44.22%), microbial biomass C (28.93%), microbial biomass N (32.48%), total actinomycetes (26.30%), total fungi (40.00%), total bacteria (24.07%), and soil respiration (25.97%) in CGSR13 treated *F. sacchari* infected plants than the untreated control (Fig. 9). There was an increase in sett germination (14.49%), fresh shoot weight (6.47%), dry shoot weight (3.09%), FSW/DSW (3.44%), cane diameter (5.77%), fresh root weight (23.62%), dry root weight (44.44%), FRW/DRW (27.09%), internodes length (20.83%), number of internodes (35.52%), cane length (48.90%) and cane weight (68.79%) in CGSR13 treated *F. sacchari* infected plants than untreated control. Biochemical and physiological characterization showed an increase in catalase (CAT) (31.83%), peroxidize (PO) (0.46%), net photosynthesis rate (Pn) (60.30%), chlorophyll a (22.14%), chlorophyll b (25.00%), total chlorophyll (14.32%), carotenoid (2.56%), transpiration rate (E) (0.88%), stomatal conductance (gs) (14.94%) and photosynthetically active radiation (PAR) (1.65%) in CGSR13 treated *F. sacchari* infected plants. Juice quality analysis showed an increase in sucrose (26.20%), purity (14.10%), and brix (11.10%) in CGSR13-treated *F. sacchari* infected plants than the untreated control. The liquid chromatography-mass spectrometry (LC-MS) results showed that the methanolic extract of *C. globosum* CGSR13 contains plant growth regulator melatonin, cysteine, formononetin and antagonist scoulerine and sarsasapogenin.

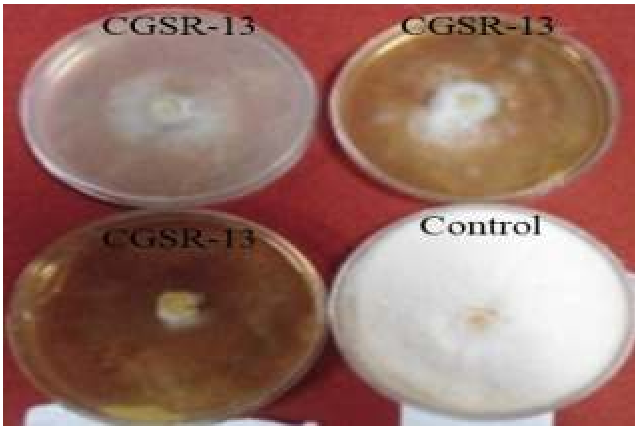


***Fig. 3.8.** In vitro inhibitory effect of the crude extracts of the endophyte Chaetomium globosum CGSR13 on Fusarium sacchari using liquid culture filtrate method.*

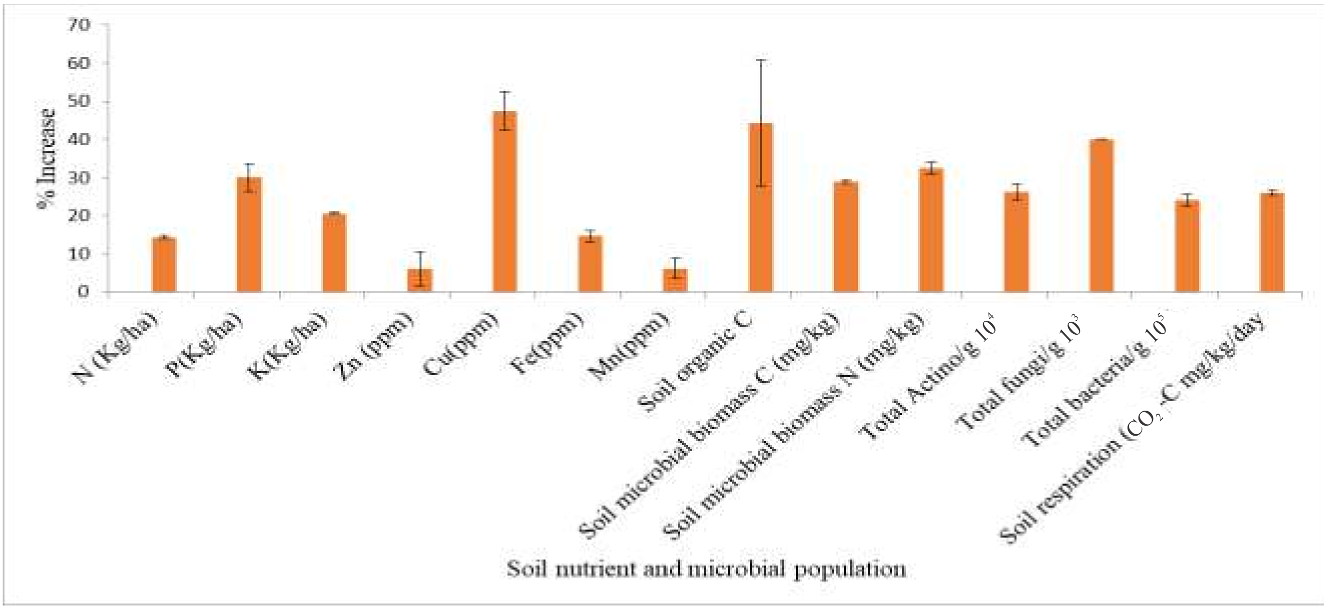


Fig. 3.9. Effect of endophyte *Chaetomium globosum* CGSR13 strain on soil nutrients in the field conditions during 2022-2023 crop season

Comparative evaluation of sett treatment device and MHAT as delivery systems for agrochemicals for management of RSD disease

A trial was conducted with the sugarcane variety CoLk 14201 to determine the effect of sett treatment device (STD) for the delivery of agrochemicals and to investigate the impact of Streptocyclin (at concentrations of 60, 18, and 6 PPM) on RSD. The combination of STD and Streptocyclin at 18 ppm resulted in reduced cane node infection and increased cane height, cane girth, and internode length (Table 3.2).

Table 3.1. Evaluation of sett treatment device and MHAT as delivery systems of agrochemicals for management of RSD.

Sr. No.	Name of Treatment	Number of Cane	Total Number of nodes	No. of infected nodes		Dot Intensity (%)	Streak Intensity (%)	Cane length (cm)	Cane Weight (kg)	Cane girth (mm)	Internode length (cm)
				Dot	Streak						
1.	MHAT treatment	10	266	24	2	9.0	0.8	149.8	9	26.8	5.7
2.	STD + Streptocyclin 60 PPM	10	260	19	1	7.3	0.4	150.6	8.5	25.7	5.8
3.	STD + Streptocyclin 18 PPM	10	248	13	4	5.2	1.6	162.1	9.1	28.6	6.7
4.	STD + Streptocyclin 6 PPM	10	264	26	4	9.8	1.5	154.6	9.65	29.1	6.0
5.	STD + Fertilizer	10	243	27	4	11.1	1.6	133.6	8.6	26.9	5.5
6.	Control	10	262	27	4	10.3	1.5	149.8	8.9	25.4	5.8

Smart delivery of agro-inputs using Sett Treatment Device for biotic and abiotic stress management in sugarcane

A trial was laid out during autumn 2022 at Balrampur Chini Mills Limited, Mankapur Unit using Sett Treatment Device (STD) for treatment of seed material for red rot management with the sugarcane variety Co 0238. The experiment comprised of three treatments T1: Mechanized sett treatment with Thiophanate methyl (Hexastop – 70%WP) – 0.1% - 1000 ppm (1.3g/L); T2 – Mechanized sett treatment with Thiophanate Methyl - 0.7g/ L + *Paenibacillus alvei* (mix) – 0.05% (0.5ml/L); T3- Control. Maximum germination and no. of shoots/ metre was recorded in the treatment of mechanized sett treatment with fungicide Thiophanate methyl alone @ 0.3g/L followed by Thiophanate methyl + *Paenibacillus alvei* (Table 3.3).

Integrated insect pests and disease management for subtropical sugarcane

To manage the major disease of sugarcane red rot and insect pest, top borer an integrated management strategy was taken up in six sugar mill command areas, *viz*., (i) Hariawan, (ii) Loni, (iii) Rouzagaon, (iv) Haidergarh in Uttar Pradesh and (v) Harinagar and (vi) Narkatiaganj in Bihar. Large plot trials were laid out in ~1.0 ha area in each of the above sugar mills endemic to red rot with the popular variety Co 0238. Observations on disease and pest occurrence were monitored at monthly intervals. The observations indicated that the treated plots were either free from red rot or has 1-10% incidences, whereas the neighbouring untreated fields had 60-70% infections (Fig. 3.11).

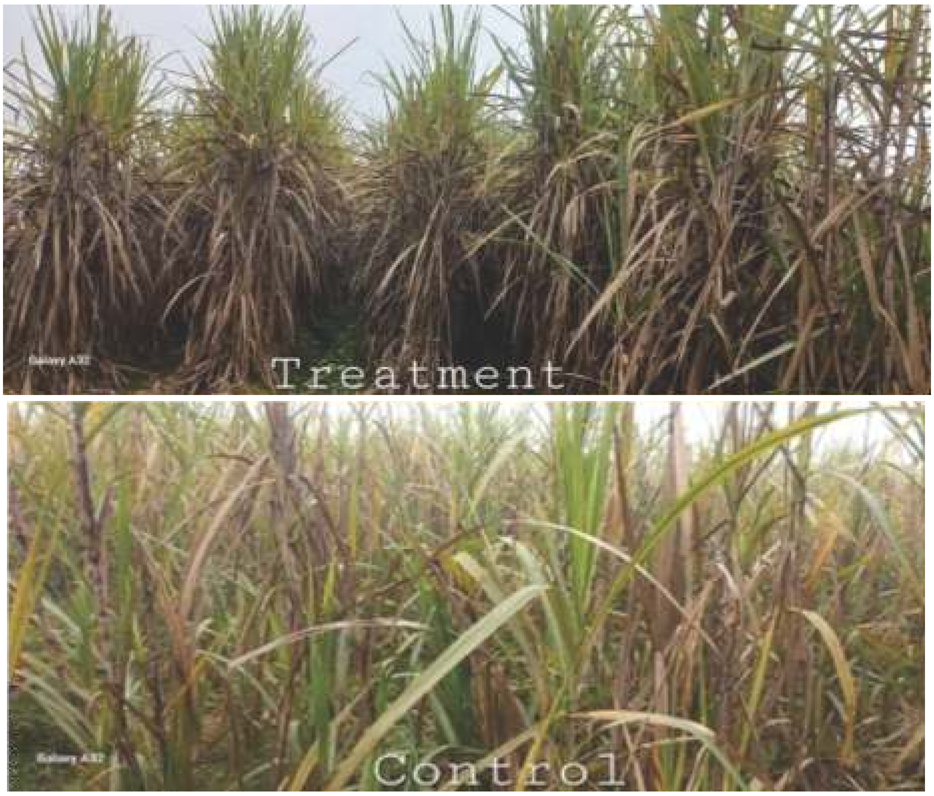


Fig. 3.11. *Management of red rot using IPM techniques.*

The integrated pest and disease management strategies include the following treatments viz. i. Selection of clean seed and mechanized sett treatment with systemic fungicide (Thiophanate methyl 70%WP@ 0.1%) in STD, ii. Soil application of effective strain(s) of *Trichoderma* with FYM @ 200kg/ha at the time of planting, iii. Furrow treatment – Bifenthrin @ 100g ai/ha at planting, iv. Cultural Practices – Roguing & removal of red rot affected shoots at 45 DAP, v. Chemical management – Chlorantraniliprole (75a.i.) 18.5% SC @ 375g in 1000 l of water/ha & Thiophanate methyl 70%WP @ 0.1% at 45 DAP, vi. Chemical management – need based pesticide application at 180 DAP, vii. Biocontrol – Release of parasitoides from July to October, viii. *Trichogramma* - eight releases at 15 days interval @ 50,000 adults/ha and ix. *Trichoderma* – soil application during July.

Developing arthropods-based soil health indicators for subtropical sugarcane ecosystem

The project aimed to study the suitability of soil arthropods in assessing sustainability of production systems and as early warning of system decline. Community structure of soil arthropods and microflora was assessed from sugarcane and from adjacent non-sugarcane land uses. The undisturbed soils under trees, grasses, and grass along with tree systems have lower abundance of microarthropod fauna as well microflora and nematodes, compared to sugarcane ecosystem. Abundance of these soil biota may be used as an indicator of soil health (first quartile as lower baseline and third quartile of as highest base line for monitoring). Shannon, Berger parker and Chao1 indices are useful in assessing sugarcane agroecosystems. The following were identified as abundant species of microbiota in the study sites (Table 3.2 & Fig. 3.12).

Table 3.2. Abundant species of microbiota under subtropical sugarcane ecosystem.

Biota	Taxonomic groups
Acari	Epilohmanniidae, Ameronothridae, Oribatellidae, Oribatulidae, Phthiracaridae, Tarsenomidae, Bdellidae, Cunaxidae, Cercomegistidae, Dermanyssidae,
Collembola	Entomobryidae, Orchesellidae, Lepidocyrtidae, Isotomidae, Onychiuridae, Proisotoma, Brachystomellidae, Sensophorura, Neelidae, Sminthuridae
Meso fauna	Japygidae, Formicoidea, Araneae, Polyxena, Symphyla, Palpigardi, Pseudoscorpiones, Pauropoda
Bacteria	Proteobacteria, Acidobacteriota, Planctomycetota, Actinobacteriota, Bacteroidota.
Fungi	Ascomycota, Basidiomycota, Mortierellomycota, Chytridiomycota, Rozellomycota, Glomeromycota
Nematodes	Dorylaimida, Tylenchida, Enoplida, Triplonchida, Araeolaimida, Monhysterida, Mononchida, Chromadorida, Rhabditida

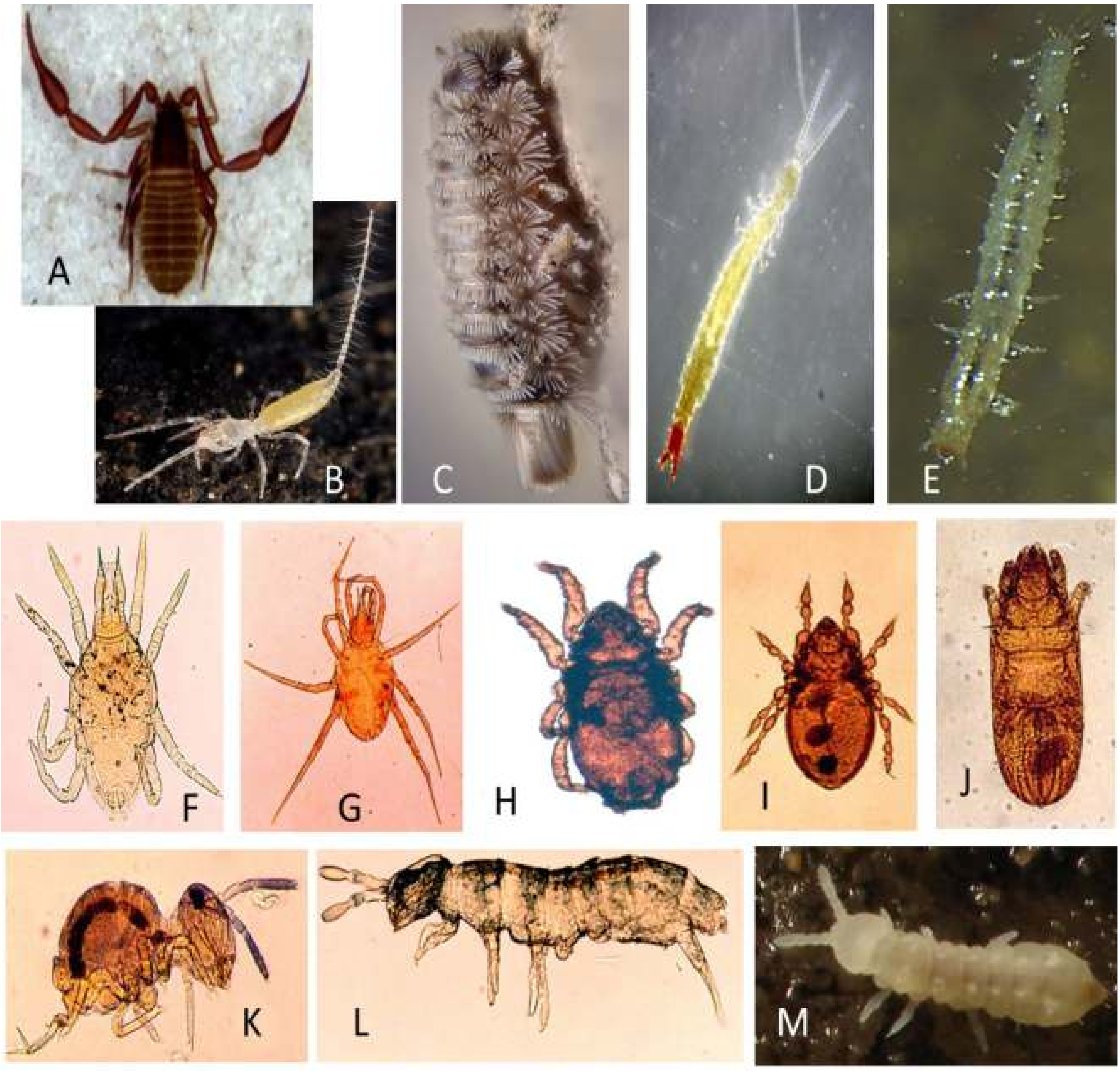


Fig.3.12. *Soil microarthropod fauna of study site (A -Pseudoscorpion; B - Palpigradi; C - Polyxena millipede; D – Zapyx; E - Pauropoda; F to J - Acari; K toM–Collembola)*

The impact of recommended doses of fertilizer for better crop production/productivity on the arthropod population, was studied. Two sites were selected at IISR Farm; one, with an initial high SOC (>0.7) and another having initial lower SOC (<0.4). Treatments were based on recommended doses of fertilizer, manure, combination of fertilizer and manure along with recommended pesticides. Rate of growth in population build up was more in low SOC sugarcane plots in comparison to high SOC plots. Abundance and diversity increased from tillering to maturity. Combination of NPK+FYM as nutrient source significantly supported faunal build up and diversity. Higher initial SOC supported higher diversity and abundance. Impact of soil application of chlorpyriphos and chlorantraniliprole at recommended doses revealed that the overall population of soil microarthropods was reduced in comparison to their respective controls.

Development of eco-friendly technologies for the management of termites in sugarcane

The project was aimed to develop effective management schedule against termites in sugarcane agro ecosystem, using the associated termite fauna, microbial entomopathogens, laboratory rearing techniques and ecofriendly management strategies like defaunation of gut protozoa.

Three species of termites *Odontotermes vaishno* Bose, *O. bellahunisensis* Holmgren and Holmgren, and *Odontotermes horni* (Wasmann) were recorded for the first time from sugarcane. *Odototermes obesus* recorded the maximum percentage of occurrence (28.57%) followed by of *Microtermes obesi, O. horni, O. vaishno, O. bellahunisensis* and *Odototermes* sp. (21.42%, 14.28%, 14.28%, 14.28% and 7.14% respectively). Bacteroidetes and Proteobacteria phylla were the two most predominant present in the gut with *Treponema* and *Pseudomonas* being the dominant bacterial genus. Two species of the spirochete bacteria *Treponema* viz. *T. azotonutricium* and *T. primitia* were identified as the most prevalent bacterial species in termite gut. The metagenomic analysis revealed the presence of four protozoan species viz. *Metadevescovina cuspidate, Pyrsonympha grandis, Spirotrichonympha leidyi* and *Trichonympha* sp. in termite gut along with several bacterial endosymbionts (*Ca. Ancillula trichonymphae, Ca. Azobacteroides pseudotrichonymphae, Ca. Desulfovibrio trichonymphae, Ca. Endomicrobium trichonympha*e) associated with termite gut protozoans.

Wood powder of Sheesham (*Dalbergia sissoo)* (15 gm) with agar powder (5 gm) in 250 ml water was found to be the best artificial diet over many others, for rearing of termites under laboratory condition. Termites (both workers and soldiers) could survive up to 45 days. Different anti-protozoan medicines viz., Metronidazole; Albendozole; Ornidazole; Tinidazole; Nitazoxanide were evaluated for their bio-efficacy against termites under laboratory conditions using artificial diet. Amongst these, 100 % mortality of termites was recorded in 10 days in the treatment of Albendozole and Tinidazole (Fig. 3.13).

***Fig.3.13.** Termites rearing in vitro (A-termites released in Petri plates with artificial diet based on sheesham wood; B- feeding galleries; C Eggs & adults in gallery.*

The study on impact of different pest management tools on non-target soil arthropods revealed that Chlorantraniliprole and Imidacloprid had least effect on diversity and abundance of studied fauna, while Chlorpyrifos was highly detrimental to faunal diversity and abundance of soil micro-arthropods. Environmental Impact Quotient (EIQ) and EIQ-Field Use Rating (EIQ-FUR) values of different chemical insecticides used against termites indicated that Chlorantraniliprole was the safest insecticide with reference to environmental impact followed by Imidacloprid, Bifenthrin and Chlorpyrifos.

Dispersal, host location, kairomonal effect and recovery of bio-agents, *Trichogramma chilonis* and *Tetrastichus howardi*

(i) Oviposition behavior of sugarcane adapted top borer strain of egg parasitoid, *Trichogramma chilonis* Ishii

Oviposition behavior of sugarcane adapted strain of *T. chilonis* (collected from egg masses of top borer in March 2023) was studied up to 8th day on the eggs of

Fig.3.14: *Parasitized eggs of Corcyra cephalonica by Trichogramma chilonis*

Corcyra cephalonica in the laboratory at 28 ± 20° C and 60° ± 5 percent relative humidity (Fig. 3.14).

The development period varied from 7.7 to 9.0 days which was at par in different days. Oviposition and fecundity was also observed up to 8th day (0.1 - 29.8). Rate of oviposition was significantly higher (96.17%) in the first three days of oviposition, which decreased thereafter. (Table 3.3). Adult emergence was also highest in the first day (102.3%) and sex ratio was maximum (3.4F:1M) in first day. Later it reduced drastically to 0.8:1 to 0.00. Maximum female emergence (76.8%) was recorded on the first day and it decreased as days of oviposition increased. *Trichogramma* usually deposits the maximum egg allocated to the host during a single insertion of ovipositor. The number of progenies allocated to a host varies with the quantity and nutritional quality of the host contents. In addition, *Trichogramma* species adjusted their progeny allocation in order to maximize their reproductive success, when exploiting aggregations of the host.

Table 3.3. Oviposition behaviour of sugarcane adapted top borer strain of *Trichogramma chilonis*

Oviposition (days)	Development Period (days)	Fecundity	Ovi-position (%)	Ovi-position in first 3 days (%)	Emergence (%)		Sex ratio (F:M)
					Adult emergence (%)	Female (%)	
1	8.2^{a}	29.8^{e}	42.26	96.17	102.3^{c}	76.8^{d}	3.4:1
2	8.5^{a}	23.6^{d}	33.48		71.9^{b}	36.3^{c}	0.8:1
3	9.0^{a}	9.4^{c}	13.33		55.3^{b}	9.6^{b}	0.1:1
4	8.5^{a}	5.0^{b}	7.02		44.9^{b}	16.0^{b}	0.3:1
5	8.5^{a}	1.1^{a}	1.56		23.8^{a}	1.9^{a}	0.0:1
6	7.7^{a}	1.0^{a}	1.35		19.4^{a}	4.1^{a}	0.1:1
7	8.2^{a}	0.5^{a}	0.71		20.0^{a}	0.0^{a}	0.0:1
8	9.0^{a}	0.1^{a}	0.41		5.0^{a}	0.0^{a}	0.0:1

Means followed by different letters in the same column are significantly different (P<0.05)

(ii) Insemination capacity of male of *T. chilonis* (internode borer strain)

The fecundity of sugarcane adapted internode borer strain of *T. chilonis* (7♀: 1♂) was maximum (69.0) followed by 4:1 (4♀: 1♂) and 5:1 ratios. The lowest adult emergence was observed in 7:1 ratio (97.0%) and maximum in 5:1 ratio (104.7) followed by 4:1 ratio (Fig. 15). As number of females mating increased, the female progeny also increased (21.1 to 73.0%). One individual male successfully mated up to 7 females and more sex ratios was found when one male mated with five females.

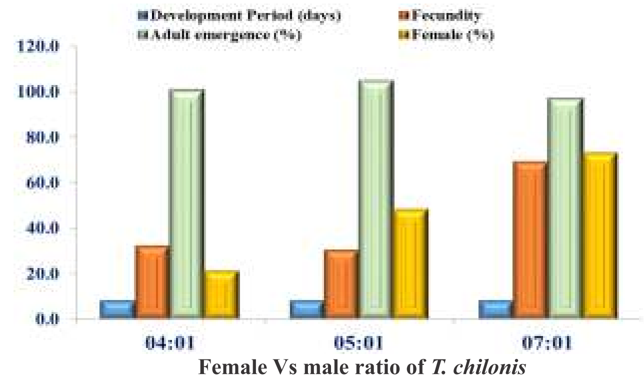


Fig. 3.15. *Insemination capacity of male of sugarcane adapted internode borer strain of T. chilonis*

(iii) Response of adult nutrition on reproductive potential of *Tetrastichus howardi* on top borer pupa

The effect of adult nutrition is of vital importance in the mass rearing of *T. howardi* on alternate hosts and in developing strategies for their subsequent release in the field. The life cycle of the parasitoid varied from 15.4 to 17.0 days in different nutrient media. Unfed supported fast development as compared to the different nutrition types tested (Fig. 3.17). Mustard aphid solution as a food source supported maximum progeny (107.8/pupa) as compared to other nutrient regimes. Female progeny (>95%) was observed in all nutrients. The sex ratio was 22.0:1 to 31.6:1 (F: M) as observed in different nutrient regimes. The parasitoid sex ratio had a major impact upon its population dynamics. Female biased ratio in fed condition is very relevant for use as biological control agents and can assist in improving mass rearing programme. In the present study, the sex-ratio of *T. howardi* was influenced by the quality of food. Female requires more nutrition for egg production and host searching activity.

Fig. 3.16. Parasitisation and emergence of T. howardi on top borer pupa.

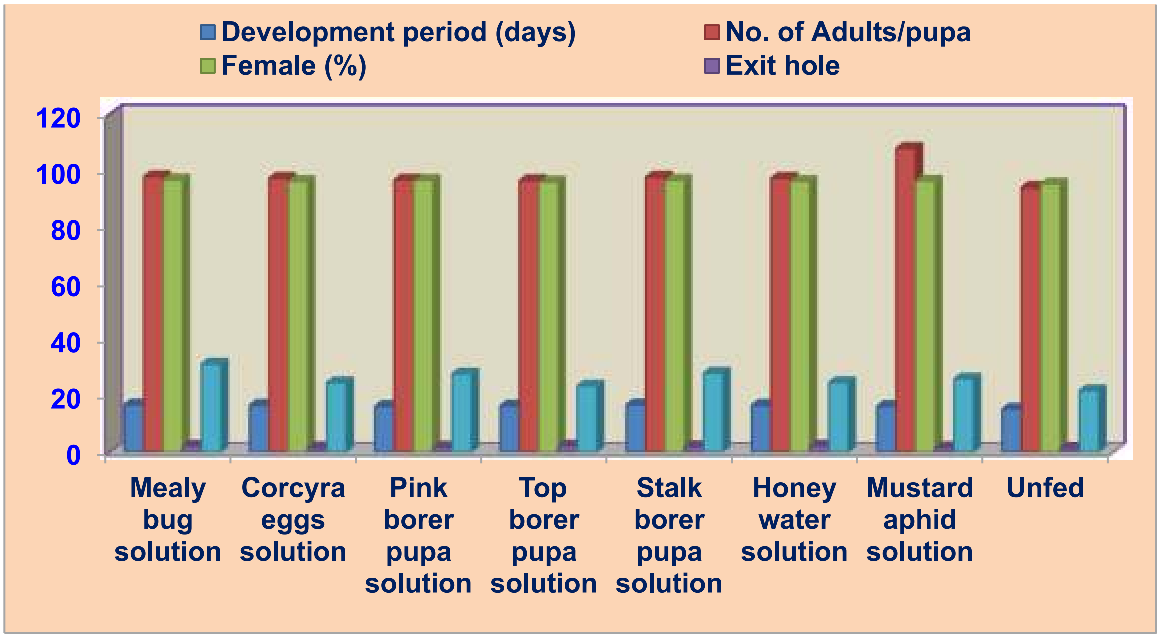


Fig. 3.17. Response of adult nutrition on reproductive potential of T. howardi on top borer pupa

(iv) Effect of storage period on parasitizing efficiency of *T. howardi* on top borer female pupa

The lower host nutritional quality due to long-term refrigeration can cause biochemical, physical, and morpho-physiological modifications compromising the nutritional quality of the host pupae for parasitoid reproduction. One of the difficulties encountered in the mass production of parasitoids is non-availability of suitable hosts in sufficient quantity, when they are needed. Therefore, conserving different host pupae to rear *T. howardi* will be useful in biological pest control programs. The development period in fresh as well as in storage (5, 10,15,20,30 days), varied from 17.60 to 18.80 days. The development of parasitoids depends on the resources available, different hours of exposure, host size and host quality. The number of adult emerged/pupa from different storage period and fresh pupa varied from 46.0 to 125.60 and was maximum in fresh pupa with 5 days of storage (Fig.3.17). The number of progenies per top borer pupa decreased drastically at 30 days of storage.

There was no significant difference in female emergence among fresh pupa and that in different days of storage (90.88 to 94.76%).The male emergence (%) increased with increase of storage period (5.24 to 9.12%) and also decreased male-female ratio (19.00 to 13.20).The parasitoids can modify and regulate the number and sex of their offspring according to size and quality of the host resource. The storage of pupa at 10°C in refrigerator was found to have an adverse effect on emergence of adult with male- female ratios.

(v) Dispersal of *T. howardi* in sugarcane field

Studies in the sugarcane variety Co 0238 showed that the flight distance required by females of *T. howardi* to locate and to parasitize top borer pupa (third brood) was 20 meters on an average, from the releasing point in the experimental field, with parasitism of 42.21%. The successful searching and parasitism of top borer pupae by *T. howardi* in the field indicate the potential of parasitoid for biological control against the key pest of sugarcane crop.

Maintenance of natural population of insect-pests of sugarcane

The incidence of first brood of top-borer was significantly high (19.2.-31.8%) in CoS 8436, CoLk 14201, CoLk 16204, CoLk 11206, CoS 767, CoJ 64, CoLk 94184, CoLk 8102 and Co 0238, while CoLk 16203 and CoLk 13204 were less susceptible. The incidence of stalk borer in standing cane (August) varied from 9.0 to 48.7% in twenty varieties. The most susceptible variety was CoLk 13204 (48.7%) followed by CoS 8436 (36.4%), CoLk 16201 (29.9%), BO 91 (24.4%) and CoLk 11203 (21.7%). Maximum of pink mealy bug infestation was observed in CoS 8436, CoLk 8102, Co 0238, CoLk 11206, CoLk 94184, CoC 671, CoJ 64, CoLk 13204, CoLk 16201, CoLk 16203 and CoLk 16204 in July (Fig.18). However, during August incidence was increased with maximum incidence in CoJ 64 (89.7%) and CoS 8436 (80%).The level of incidence varied from 39.7%-64.5% in the other varieties studied.

Incidence of top borer (*Scirpophaga excerptalis*) under natural conditions

The incidence of first brood of top-borer was found to be significantly high (19.2.-31.8%) in CoS 8436, CoLk 14201, CoLk 16204, CoLk 11206, CoS 767, CoJ 64, CoLk 94184, CoLk 8102 and Co 0238, while the varieties CoLk 16203 and CoLk 13204 were less susceptible (Fig.6).The maximum incidence (16.6%) was recorded in CoLk 8102 (Fig. 18). The surviving tillers of a clump grew normally. The loss of the mother shoot and primary tillers were easily compensated by extra tillering and growth of the sugarcane plant. The second brood infestation was lower than first brood.

The incidence of third and fourth brood, that are considered to be critical, ranged 2.9-8.8 % and 2.8-10.9%, respectively (Fig.18). The incidence was very low because of heavy rainfall coinciding with moth emergence in these broods, resulting in severe mortality of larvae/pupae. Warm weather with rainfall had variable impact on attack of third brood and fourth broods of top borer. The fifth brood, also an overlapping brood, appeared in October. At harvest, the incidence was low (2.7-8.0) in all the twenty varieties/clones.

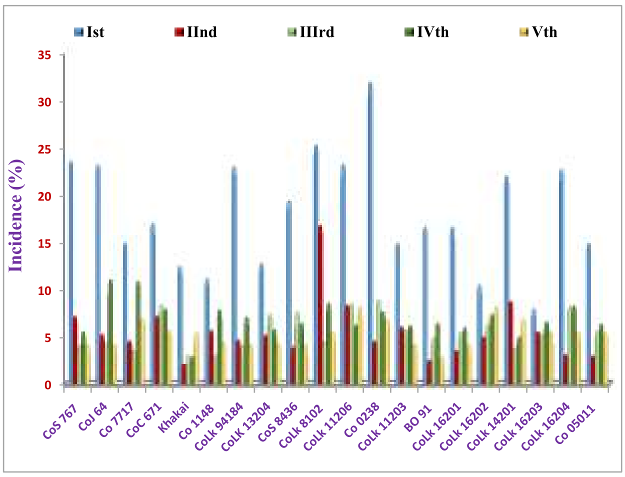


Fig. 3.18. Incidence of top borer (I to V broods) under natural conditions

(ii) Stalk borer (*Chilo auricilius* Dudgeon.)

The incidence of stalk borer in standing cane in the month of August varied from 9.0 to 48.7% in the twenty varieties studied. The most susceptible variety was CoLk 13204 (48.7%) followed by CoS 8436 (36.4%), CoLk 16201 (29.9%), BO 91 (24.4%) and CoLk 11203 (21.7%) (Fig.19). However, the incidence was up to 45% in CoLk 13204, CoS 8436, Co 0238, BO 91 and CoLk 8102 at the time of harvest. In general, the pest incidence ranged from 17.3-34.7%. Four to seven caterpillars were observed in a single cane of CoLk 13204, CoS 8436 and Co 0238.

The activity of stalk borer increases considerably during the monsoon months (August onwards) and overall crop damage is accentuated. Larval population of stalk borer was found to dwindle during summer period.

(iii) Internode borer (*Chilo sacchariphagus indicus* Kapur.)

The incidence of internode borer was 3.2 to 15.8% in different varieties in standing cane in August 2023 (Fig. 3.20). A significantly higher incidence (22.1%) was observed in CoC 671 followed by CoLk 14201 and Co 1148 and rest of the varieties were less susceptible at harvest (4.0-10.4% incidence). The borer remained active throughout the year except while hibernating in winter. This pest seldom assumed a very high population in a field, due to the collective management by the bio-agents.

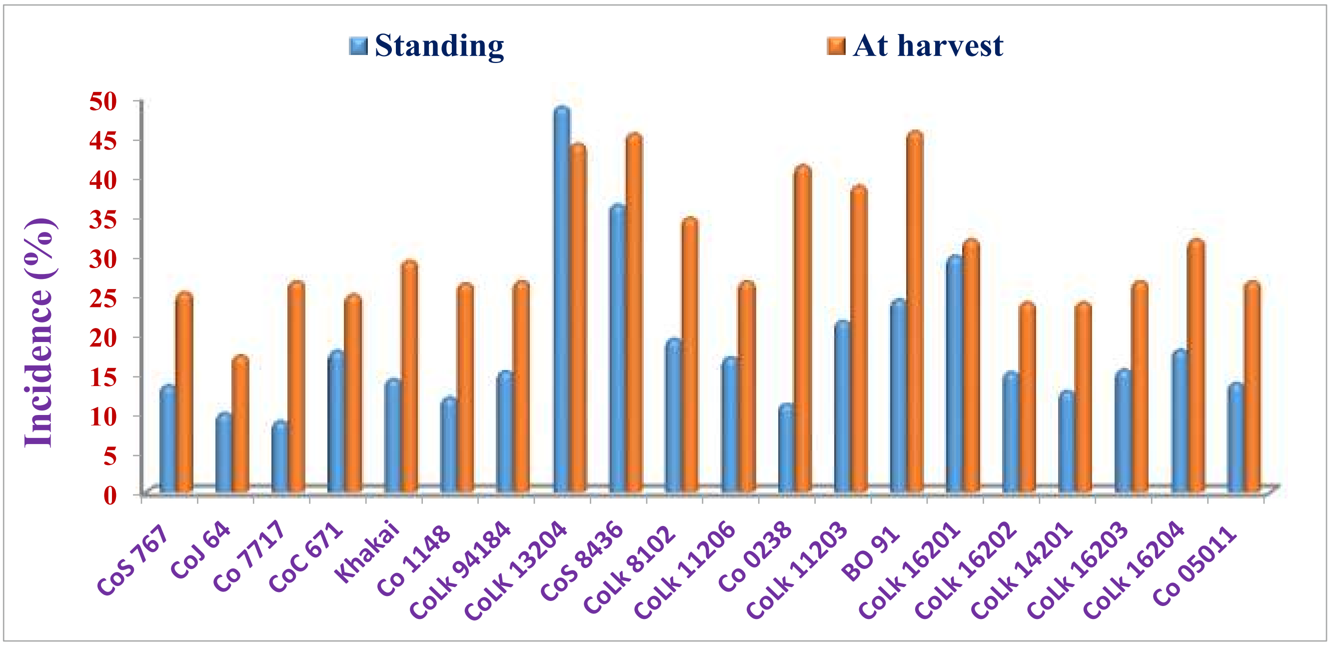


Fig. 3.19. Incidence of stalk borer, Chilo auricilius in different varieties

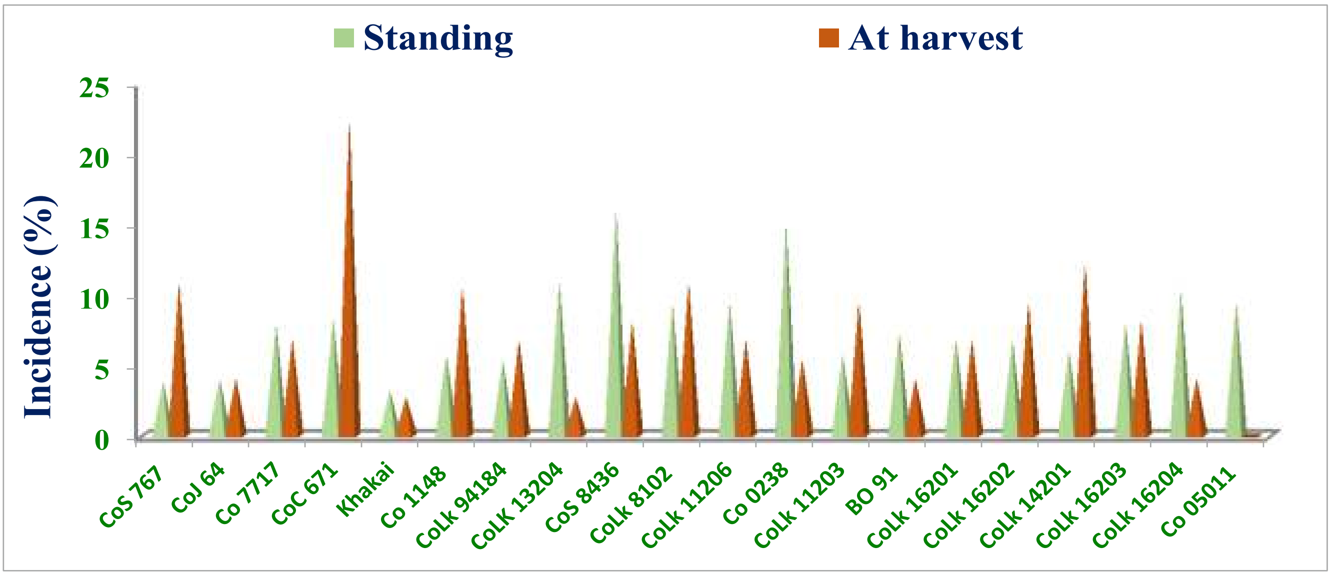


Fig. 3.20. Incidence of internode borer (Chilo sachhariphagus indicus) in different varieties of sugarcane under natural conditions

(iv) Mealy bug (*Saccharicoccus sacchari* Ckll.)

An increased incidence and rapid spread of mealy bug infestation was observed in different areas during the year. The incidence of mealy bug was observed in standing cane in July and August 2023. The maximum incidence was observed in CoS 8436, CoLk 8102, Co 0238, CoLk 11206, CoLk 94184, CoC 671, CoJ 64, CoLk 13204, CoLk 16201, CoLk 16203 and CoLk 16204 (Fig. 3.21) in July. However, during August, the incidence increased with maximum in CoJ 64 (89.7%) followed by CoS 8436 (80%) and it varied in the other varieties (39.7-64.5%).

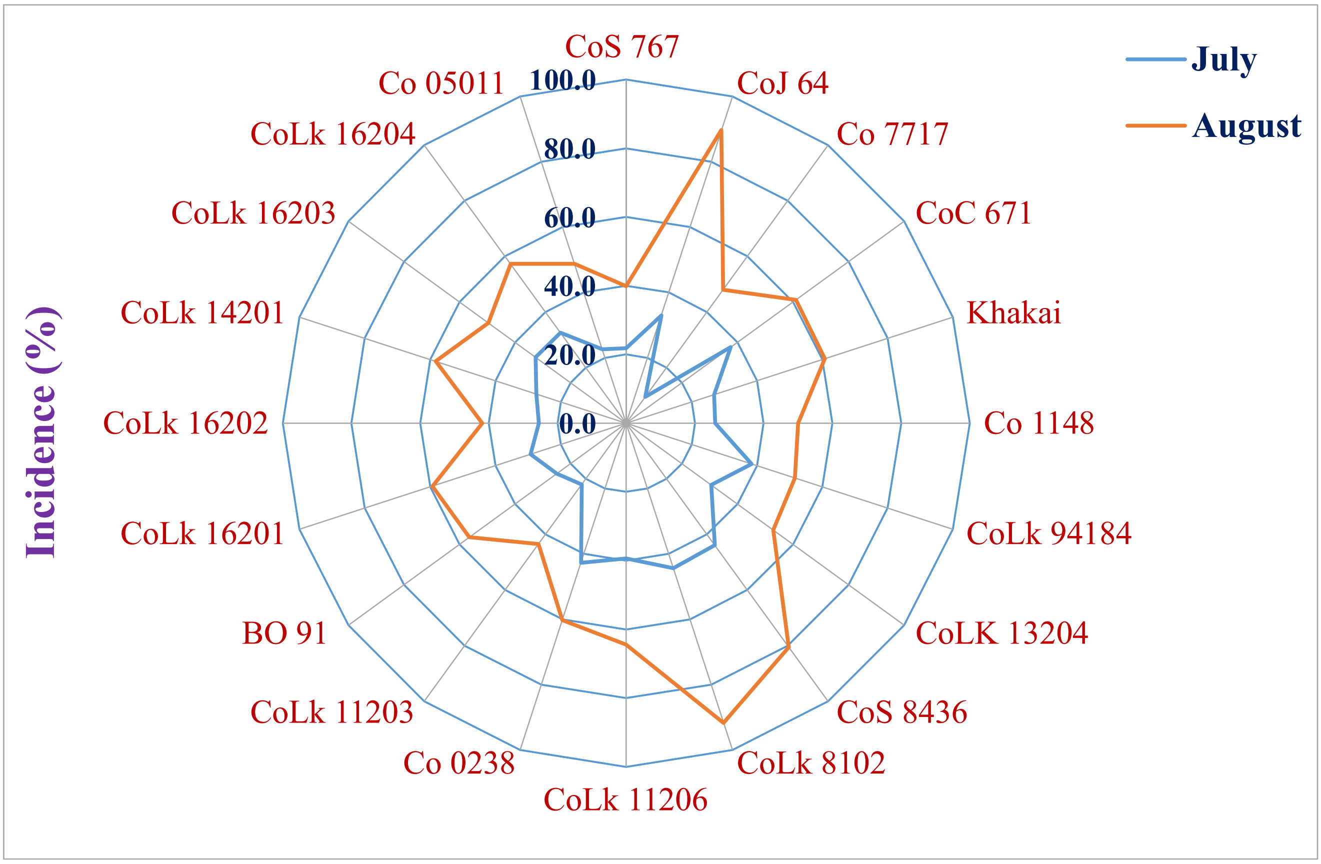


Fig. 3.21. Incidence of pink mealy bug in different varieties of sugarcane

Fig. 3.22. Pink mealy bug infested canes of sugarcane under natural conditions

(v) Incidence of whitefly and crown mealy bug in net house

The incidence of white fly (*Aleurolobus barodensis* Maskel and Crown mealy bug (*Phenacoccus saccharifolii* Green) was observed in CoLk 14201 and CoLk 13204 during August 2023 (Fig.23). The infestation of white fly ranged from 33.3 to 94.10% with a mean incidence of 62.23% in CoLk 14201 whereas in CoLk 13204, it ranged from 46.2 to 100. 0%, with a mean incidence of 81.2%.The mean population of nymph and pupae of white fly on lower, middle and upper leaves of CoLk 13204 and CoLk 14201 (per 3.5 sq. cm of leaf) was 38.8 ± 4.6, 79.2 ±5.4 and 79.3±10.4 and 42.50±10.23, 55.40±7.94, 44.30±12.78, respectively. The middle and upper portion of leaves harboured a larger population of white fly than lower leaves. In general, the incidence of white fly was more than on CoLk 13204 than CoLk 14201.

The incidence of crown mealy bug varied from 50 to 100% with mean incidence of 97.33 in CoLk 14201 whereas in CoLk 13204 it ranged from 27.3 to 100% with mean incidence of 94.16%. During severe infestation, the population was found on adaxial surface, mainly in crown and the inner top portion of leaf sheath at the leaf joint cupping the stem. The mature females were prominent on the abaxial surface of the leaves. Young crawler often reached the leaf whorl and congregated around the unopened leaf for feeding. The young nymphs developed on leaf blade under the protection of mealy mesh of matured nymphs as well as adult females.

The co-existence of white fly and crown mealy bug was observed on CoLk 14203 and CoLk 13204 under net house condition (Fig. 3.24). The infestation of crown mealy bug started in the month of June. The entire crown was affected by the month of October. White fly appeared in the month of August, with all the leaves drying up by October. The combined attack resulted in stunted growth of the plants in both the varieties.

Fig. 3.23: *Crown mealy bug infested sugarcane*

Fig. 3.24. *White fly and mealy bug infested canes*

(vi) Field parasitization of different broods of top borer larvae

The incidence and parasitization of larvae of top shoot borer (first to fourth broods) by three parasitoids i.e., *Isotima javensis*, *Rhaconotus scirpophagae* and *Stenobracon nicevillae* were observed in two early varieties (Co 0238 and CoLk 94184) and one mid late variety (CoLk 8102). The percentage incidence and parasitization was 16.3, 17.9, 13.8 and 5.7, 14.4, 13.3 in CoLk 94184, Co 0238, CoLk 8102, respectively, in first brood of top borer. *Isotima javensis* was the dominant parasitoid resulting in maximum mortality of larvae in first brood (Fig. 3.25).

Maximum parasitization was observed in Co 0238 (23.9%) followed by CoLk 94184 (14.3%) and in CoLk 8102 (11.4%) in the second brood, with the incidence varying from 9.7-21.8%.The mortality of larvae of top borer by three parasitoids was observed in third brood (8.0-11.4%) in all three varieties which was lower than that for the second brood and incidence of top borer (5.6-12.9%) also lower than second brood. In the fourth brood, the extent of parasitization was 12.9-14.0%, with the incidence ranging from 8.0-21.7% in all three varieties. The synchronization of parasitization with the availability of the borer larvae in the fields helped a good deal in keeping the pest under check.

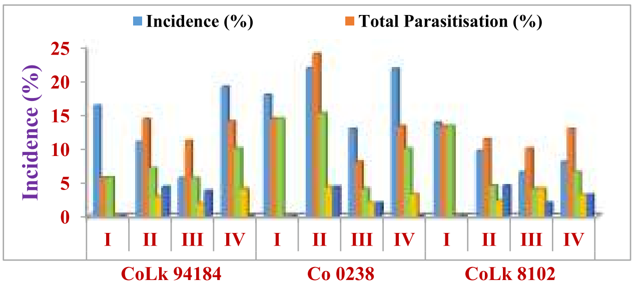


***Fig.3.25.** Field parasitization of different broods (first-fourth) in three varieties*

Evaluation of plant based extracts and essential oils against major pests of sugarcane

(i) Plant Extracts:

A field experiment was taken up with ratoon crop of commercial sugarcane variety CoLk 94184 during 2023-24 cropping season to study the effect of leaf extracts from different plant sources on pest incidence. Leaf extracts of Neem (*Azadirachta indica*), Behaya (*Ipomoea carnea*), Datura (*Datura wrightii*), Neelgiri (*Eucalyptus* sp.), *Lantana camara*, Bottle Brush (*Callistemon citrinus*), Latjeera (*Achyranthus aspera*), Aak (*Calotropis procera*) and seed kernel extract of Karanj (*Pongomea pinnata*) were prepared and concentrated in the laboratory. Both extracts and hydrates were stored at 5°C in refrigerator. Chlorantraniliprole 18.5 SC and Chlorpyriphos 20 EC were taken as standards along with one untreated control. The experiment was conducted in RBD with 21 treatments and 3 replications. Leaf extracts and leaf hydrates were applied @ 12.5 liters/ ha and recommended doses of standards were applied as foliar spray in standing crop. Plant based extracts were sprayed at monthly intervals from February to June and in September. Drenching with chlorantraniliprole was done during the last week of June. Chlorpyriphos was sprayed in the month of September. The incidence of borer pests and termites were recorded in standing crop and at harvest. Incidence of top borer (II Brood) was lowest (3.85%) in Karanja seed extract followed by chlorantraniliprole, bottle brush extract and latjeera extract. Incidence of top borer (III Brood) was lowest (1.50%) in chlorantraniliprole, followed by latjeera extract, eucalyptus, besharm neem extract. Incidence of top borer (IV Brood) was on par (4.0 %) with chlorantraniliprole, chlorpyriphos, bottle brush and neem extract. Incidence of top borer (V Brood) was lowest (2.67%) in besharm extract followed by chlorantraniliprole, lantana extract and neem extract. Incidence of stalk borer and internode borer was low in chlorantraniliprole. All the treatments with different products were superior over untreated control. Damage by termite in standing crop was low in besharm hydrate followed by latjeera (extract and hydrate), neem hydrate, karanja extract etc. Cane yield was higher in chlorantraniliprole (78.75 t/ha) followed by karanja seed extract (Table 4).

(ii) Plant Essential oils:

A field experiment was taken up with ratoon crop of commercial sugarcane variety Co 0238 during 2023-24 cropping season. Essential oils of 6 plants viz. Eucalyptus, Bottle brush, Lemon grass, Lemon peel, Tulsi and Golden Cypress were isolated from leaves and evaluated for their effect on major insect pests of sugarcane. Essential oils were sprayed @ 10µl/ 100 ml of water. Tween 80 was used as an emulsifier. Incidence of top borer (III Brood) was nil in bottle brush and higher (4.67%) in eucalyptus. Tulsi was effective against IV brood of top borer followed by bottle brush. Incidence of top borer (V Brood) was on par in all treatments but less than untreated control. The treatments with lemon peel, bottle brush and lemon grass spray were superior with respect to cane yield, while it was low in untreated control and golden cypress (Table 3.5).

Table 3.4: Effect of plant leaf extracts on incidence of major insect pests of sugarcane ratoon

S.N.	Treatment	Incidence of borer pests (%)						Term-ites	Cane Yield (t/ha)
		Top Borer				Stalk borer	Inter-node borer		
		II Brood	III Brood	IV Brood	V Brood				
1	Besharm Extract	4.77	4.39	5.33	2.67	6.67	16.00	12.50	67.67
2	Besharm Hydrate	10.71	6.69	8.00	12.00	17.33	25.33	6.25	65.75
3	Neem Extract	4.28	4.86	4.00	4.00	8.00	13.33	10.42	68.75
4	Neem Hydrate	10.21	9.50	10.67	14.67	17.33	25.33	8.33	67.50
5	Eucalyptus Extract	6.07	3.02	5.33	6.67	8.00	12.00	10.42	58.75
6	Eucalyptus Hydrate	8.82	5.24	9.33	13.33	18.67	26.67	14.58	57.25
7	Latjeera Extract	4.14	2.95	6.67	6.67	8.00	12.00	8.33	59.75
8	Latjeera Hydrate	18.09	7.22	10.67	12.00	17.33	26.67	8.33	60.25
9	Dhatura Extract	4.22	6.17	5.33	6.67	8.00	12.00	10.42	63.50
10	Dhatura Hydrate	10.42	14.29	10.67	12.00	18.67	29.33	10.42	61.75
11	Karanja seed extract	3.85	6.05	5.33	5.33	9.33	17.33	8.33	71.25
12	Karanja seed hydrate	11.69	9.48	14.67	9.33	20.00	24.00	8.33	70.00
13	Bottle Brush Extract	4.79	8.06	4.00	5.33	6.67	10.67	10.42	67.75
14	Bottle Brush Hydrate	13.84	11.50	14.67	9.33	16.00	28.00	12.50	65.50
15	Madaar Extract	10.06	6.31	6.67	5.33	8.00	17.33	8.33	66.67
15	Madaar Hydrate	13.06	11.47	12.00	9.33	17.33	16.00	10.42	59.00
17	Lantana extract	5.22	4.95	6.67	4.00	8.00	18.67	12.50	64.50
18	Lantana Hydrate	12.83	8.89	14.67	12.00	14.67	26.67	10.42	65.55
19	Chlorantraniliprole @ 375 ml/ha	4.10	1.50	4.00	4.00	4.00	8.00	10.42	78.75
20	Chlorpyriphos	7.44	5.25	4.00	17.33	12.00	28.00	10.42	64.50
21	Control	28.02	30.49	21.33	20.00	26.67	37.33	16.67	54.44

Table 3.5. Effect of plant essential oils on incidence of major borers of sugarcane in ratoon crop

S.N.	Treatment	Incidence (%)					Cane yield (t/ha)
		Top Borer			INB	SB	
		III Brood	IV Brood	V Brood			
1	Eucalypts	4.67	9.33	5.33	16.00	19.33	50.78
2	Bottle Brush	0.00	3.33	5.33	16.67	12.67	64.78
3	Lemon Grass	2.0	4.40	4.13	11.67	13.20	59.63
4	Lemon Peel	2.7	3.4	5.67	15.67	10.27	66.29
5	Tulsi	2.23	1.73	5.33	15.33	14.67	43.70
6	Golden Cypress	3.33	4.0	4.67	6.78	7.44	38.84
7	Control	9.89	18.22	17.28	33.7	20.28	33.33

CHAPTER 4

Division of Plant Physiology & Biochemistry

Physiological and molecular bases of multiple abiotic stress tolerance in sugarcane

Growth, physiological, nutritional, and molecular analyses were performed at the end of stress treatment. Among different stresses, drought caused maximum reduction in different growth parameters like, plant height, single cane weight, internode length, internode number, cane girth, fresh leaf weight, root weight and root volume.

Identification of physiological and molecular traits conferring tolerance to single/multiple abiotic stresses is being done. Tolerant (CoS 767) and susceptible (CoJ 64) varieties of sugarcane were exposed to single stresses; drought, salinity and waterlogging and to combination of these stresses. Results revealed that the tolerance index of CoS 767 was higher than CoJ 64 under all single/ combined stresses, except for salinity where CoJ 64 showed higher tolerance index than CoS 767. A significant positive correlation was found between chlorophyll stability index (CSI) and stress tolerance index suggesting that stay green character may be one of the visual screening criteria for single/ multiple stress tolerance. The leaf tissue K concentration dropped below the critical deficiency level under different stresses. The leaf K had a significant correlation with stress tolerance index which suggest that maintenance of high leaf K concentration may be one of important trait for multiple abiotic stress tolerance. Transcriptomic study revealed that five K transporter genes were significantly downregulated under drought, salinity and waterlogging which indicate that upregulation of K transporter genes may play a significant role in maintenance of high leaf tissue K concentration and hence better stress tolerance. There was a breakdown in root membrane integrity under different stresses and a significant correlation existed between leaf K concentration and root membrane integrity. The root tissue density for the both varieties was highest under drought and lowest in waterlogging. Under combined stress of drought+ waterlogging+ salinity, CoS 767 had highest root tissue density than CoJ 64. Low canopy temperature depression was visualized as an important tolerance trait for drought. High stalk/aerial root ratio, higher internodal elongation rate was recognized as important tolerance trait for waterlogging. Low Na/K ratio in LTM leaves was found as important selection criteria for salinity tolerance.

Response of CoS767 and CoJ 64 to different stresses

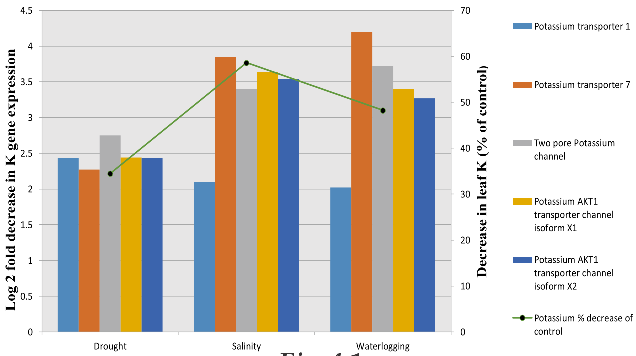


Fig. 4.1

Evaluation of silica in relation to moisture stress and productivity of sugarcane

Effect of two silica compounds viz., silicon dioxide and silicic acid @ 100 and 200 kg Si ha^{-1} as a basal dose and their foliar application at 90 and 120 DAP @ 14 g L^{-1} were assessed for the germination and substrate mobilization. Significant changes in the germination (%), reducing sugar content and acid invertase activity were observed with silica as compared to control. Maximum sprouting % was found with silicic acid at the rate of 200 kg ha^{-1} at both 20 and 45 DAP (30.15 and 42.44 %). Acid invertase activity (mmol min^{-1}mg^{-1} protein) was highly modulated with silicic acid (0.51 and 0.65 mmol min^{-1}mg^{-1} protein) as compared to control (0.14 and 0.17 mmol min^{-1}mg^{-1} protein) at both 20 and 45 DAP respectively. Maximum reducing sugar content (mg/g fw) was found with silicic acid at both 20 and 45 DAP (8.7 and 13.85 mg/g fw), while it was 7.3 and 7.5 in control.

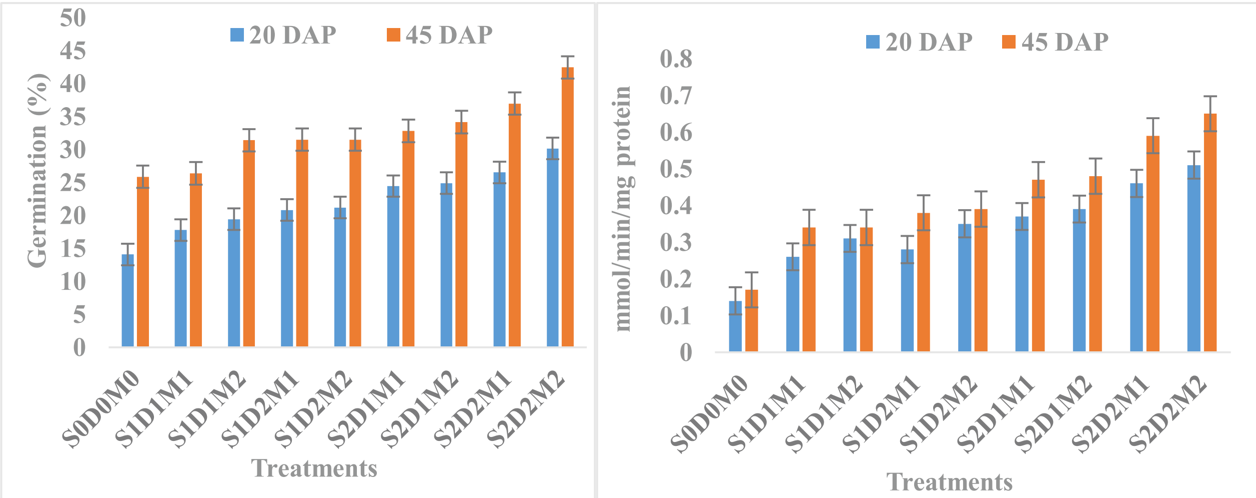


Figure 4.2 *Effect of silica on germination (%) and acid invertase activity*

Furthermore, physiological and biochemical studies were carried out to understand the role of silica against moisture stress. Leaf relative water content at 100 DAP or 10 days after stress imposition was maximum with silicic acid in both non-stressed (85.35 %) and stressed condition (75.58%). However, leaf relative water content in control was 54.48% and 45.28 % respectively. Silicic acid at its maximum dose significantly increased the proline content in leaf of stressed plant (1.36 µmol/g fw) as compared to non-stressed plant (0.34 µmol/g fw). Moreover, in non-stressed plant proline content was maximum with control (0.68 µmol g^{-1} fw) while it was minimum with silicic acid (0.34 µmol/g fw). Antioxidant enzyme such as superoxide dismutase (SOD), catalase and peroxidase specific activity were assayed. Silicic acid @ 200 kg ha^{-1} exhibited highest SOD activity (16.23 Units/mg protein) during stressed condition whereas, it was 15.06 (Units/mg protein) in non-stressed plants. Maximum catalase activity during non-stressed condition was observed in control (18.03 µmol min^{-1} mg^{-1} protein). However, during stress silicic acid exhibited maximum catalase activity (36.65 µmol min^{-1} mg^{-1} protein) which is more over their non-stress counterpart (13.33 µmol min^{-1}mg^{-1} protein). Peroxidase activity in the control (55.03 µmol min^{-1} mg^{-1} protein) was maximum during non-stressed condition while it was least in stressed plant (60.09 µmol min^{-1} mg^{-1} protein). Moreover, pronounced increase in peroxidase activity was observed with silicic acid (86.45 µmol min^{-1} mg^{-1} protein) in stressed plant over non-stressed (40.43 µmol min^{-1}mg^{-1} protein)

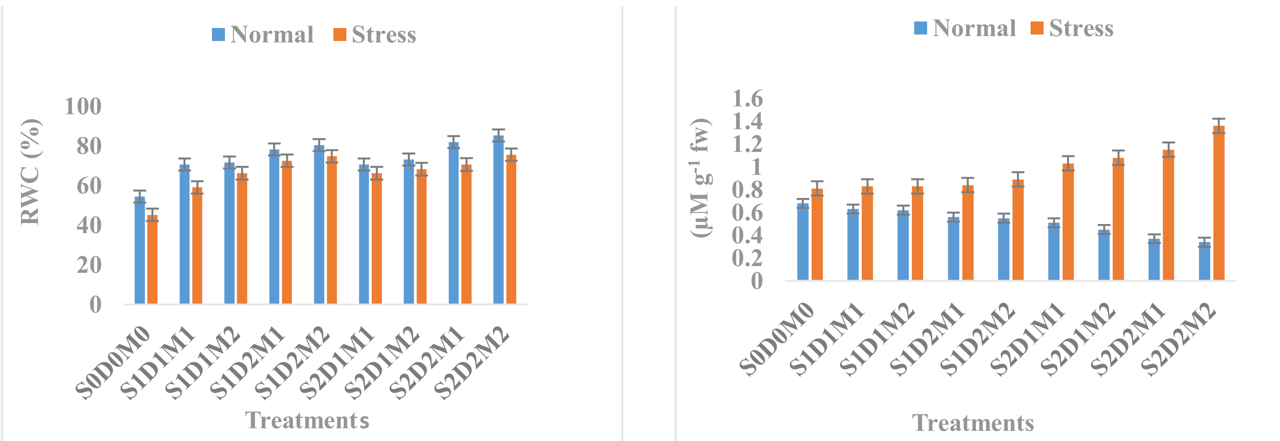


Figure 4.3 *Effect of silica on relative water content (%) and proline content (µM g-1 FW)*

Impact of Jeevamrutha on sugarcane growth yield and juice quality attributes

An experiment was conducted in autumn with CoLk 94184 with *Ethrel, Jeevamrutha*, and water for the setts priming and control. Prior to planting, setts were soaked overnight. Results obtained indicated 83% and 69 % increase in germination with Ethrel, while it was 40.86% and 68 % in *Jeevamrutha* treated setts as compared to untreated setts at both 20 and 45 DAP. Invertase activity (mmol min^{-1}mg^{-1} protein) and reducing sugar content (mg/g fw) was highly increased in Ethrel treated setts at both 20 and 45 DAP.

Maximum Invertase activity was recorded in Ethrel 94184 (0.65 and 0.72) followed by *Jeevamrutha* (0.46 and 0.72). Maximum reducing sugar content (mg/g fw) was found in Ethrel treated setts at both 20 and 45 DAP (13.86 and 15.08 mg/g fw) followed by *Jeevamrutha* (8.61 and 15.02). Growth attributes such as number of leaf/stalk and leaf area/stalk at 180 DAP indicates the both Ethrel and *Jeevamrutha* augmented these growth characters. However, it was prominent in Ethrel (8 and 2406.82 cm^2/ stalk) while in Jeevamrutha (7 and 2111.83 cm^2/ stalk).

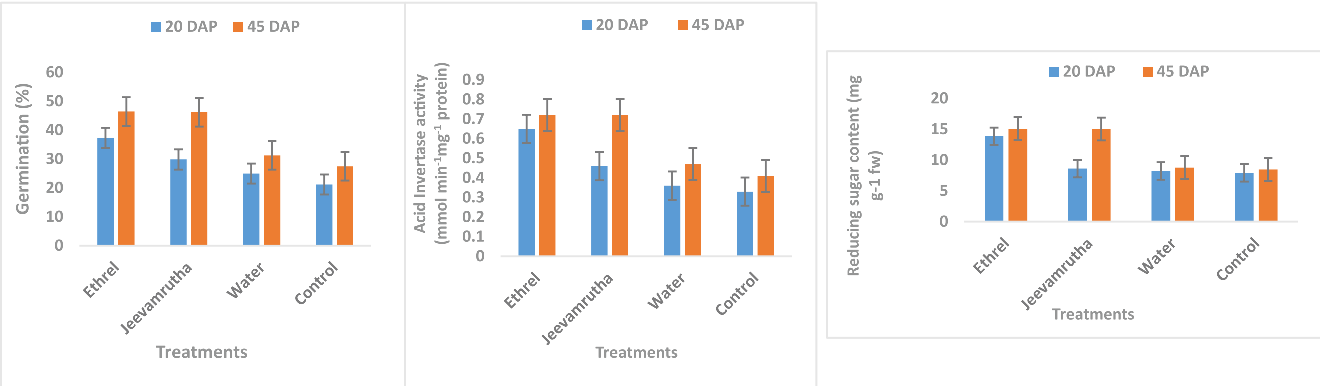


Figure 4.4. *Effect of different sett treatment on germination (%), acid Invertase activity and reducing sugar content.*

Data on gaseous exchange parameters such as photosynthesis rate (µmol m^{-2} s^{-1}), stomatal conductance (mol m^{-2} s^{-1}) and transpiration rate (mmol m^{-2} s^{-1}) were carried out at 180 DAP. It was observed that photosynthesis rate recorded in Ethrel was maximum (26.15 µmol $m^{-2}s^{-1}$) followed by *Jeevamrutha* (22.57 µmol m^{-2} s^{-1}). However, it was minimum in control (12.83µmol m^{-2} s^{-1}). Stomatal conductance maximally recorded in ethrel (0.22 mol m^{-2} s^{-1}) treated setts followed by Jeevamrutha (0.18 mol m^{-2} s^{-1}) while in control it was (0.107 mol m^{-2} s^{-1}). Moreover, maximum transpiration rate was recorded in control (9.11 mmol $m^{-2}s^{-1}$), while both Ethrel (4.19 mmol $m^{-2}s^{-1}$) and Jeevamrutha (6.22 mmol $m^{-2}s^{-1}$) exhibited least transpiration rate. Biomass accumulation in different plant parts *viz*., shoot, leaf sheath, leaf and root at 180 DAP indicated the Ethrel recorded maximum (39.82, 33.20, 22.50 and 14.30 g/100g) followed by Jeevamrutha (38.24, 31.17, 20.73 and 13.28) however, in control it was (32.19, 20.45, 15.36 and 10.06).

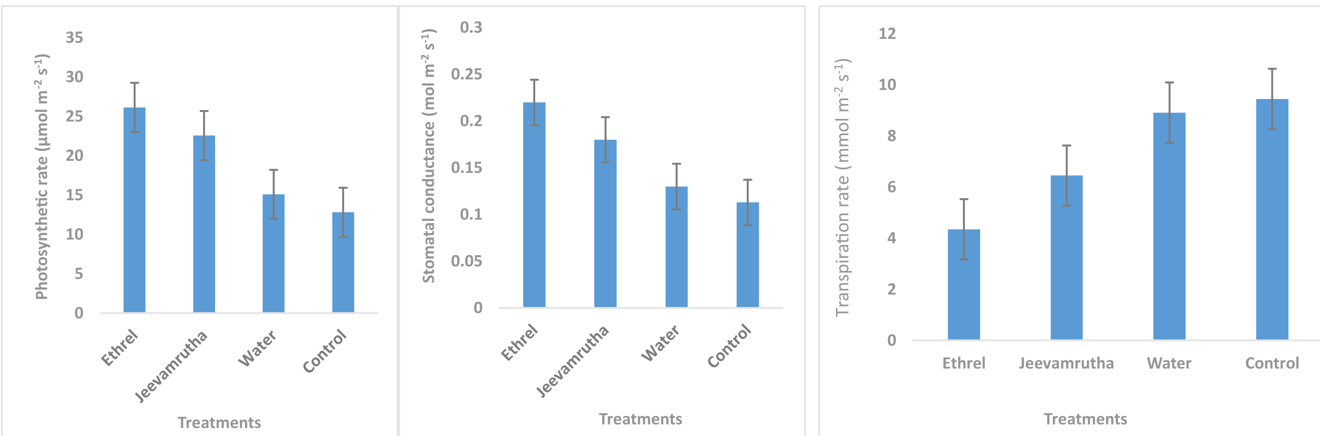


Figure 4.5 *Effect of different sett treatments on photosynthetic rate, stomatal conductance and transpiration rate.*

Juice quality attributes such as sucrose (%), purity coefficient and °Brix were recorded and found to be maximum with Ethrel (18.49, 92.01 and 19.92) followed by *Jeevamrutha* (18.01, 91.22 and 19.35) while in control it was (17.02, 86.02 and 18.01) respectively. Yield (308000 and 294000 NMC ha^{-1}) and their attributes such as cane length (322.25 and 275 cm), girth (2.90 and 2.90), number of internode (25 and 25), internodal length (12.89 and 11.00 cm) and single cane weight (1.03 and 0.97 kg) highly influenced in Ethrel treated setts followed by *Jeevamrutha* respectively. However, in untreated control both yield (227000 NMC ha^{-1}) and their attributes (232.32 cm, 2.80 cm, 22, 10. 56 cm, 0.90 kg) was significantly lower as compared to Ethrel and *Jeevamrutha*.

Augmentation in germination of bud, enhanced invertase activity and reducing sugar content at 45 DAP with *Jeevamrutha* indicates the importance of *Jeevamrutha* as a germination promoter. Furthermore, stimulation of growth attributes, gas exchange behaviour, biomass accumulation and juice quality attributes in *Jeevamrutha* applied cane suggests it can be utilised as indigenous plant growth promoter that can be cheap and eco-friendly technology to the cane grower.

Process development for enhancing ethanol recovery from sugarcane trash and "β-heavy" molasses.

Sugarcane lignocellulosic biomass is an attractive renewable feedstock for future EBP programmes. Efficient and cost-effective production of bioethanol from lignocellulosic biomass depends on the development of a suitable pre-treatment system. A new pre-treatment method was attempted and found to be highly efficient and effective for downstream bio catalytic hydrolysis of various sugarcane lignocellulosic biomass materials, which can accelerate bioethanol commercialization. The optimal conditions for the hydrogen peroxide–acetic acid pre-treatment was 75°C, 2.5 h, and an equal volume mixture of hydrogen peroxide and acetic acid. Compared to previous pre-treatment processes under the same conditions, the pre-treatment was more effective at increasing enzymatic digestibility. After HPAC treatment, the composition of the recovered solid was 71.0 % cellulose, 18.0 % hemicelluloses, and 1.69 % lignin. Notably, 93.5 % of the lignin was removed with the pre-treatment and no inhibitory compounds were developed during the pre-treatment procedure. The assessed pre-treatment was highly effective for removing lignin from lignocellulosic cell walls, resulting in enhanced enzymatic accessibility of the substrate and more efficient cellulose hydrolysis. This pre-treatment produced less amounts of fermentative inhibitory compounds. In addition, it shall enable year-round operations, maximizing utilization of sugarcane lignocellulosic biomass from various crop stages.

Assessment of scope for invigoration of biomass dynamics during sugarcane growth cycle through plant growth regulators

i) Biomass dynamics during sugarcane ratoon crop growth cycle through usage of PGRs -

Ratoon crop was initiated with spray of two doses of NAA (@50 and @100 ppm) on ratoon stubbles along with water, *Ethrel* and absolute control using CoLk 94184 (Plate 1). Tiller numbers and biomass accumulation till 210 DAP indicated that maximum improvement in sett sprouting and biomass dynamics occurred with *Ethrel* spray as compared to water spray and control. Maximum sprouting % was recorded with Ethrel spray @*100* ppm > NAA spray @ 50 ppm spray > NAA spray @ 100 ppm against water spray and control at 20, 30 and 45 DAP. At 120 DAP, average initial shoot numbers were highest with Ethrel spray (1,22,735 shoots ha^{-1}) followed by NAA spray @ 50 and 100 ppm against 1,15,966 and 91,078 shoots ha^{-1} and 72,286 and 50,207 shoots ha^{-1} with water spray and negative control respectively. Biomass partitioning into leaves decreased from about 75% at sprouting emergence to 20-25% at the end of the tillering phase. Cane stalk was about 9-12 % of the total biomass at 75 DAP and peaked to about 60-80% at GGP of the crop cycle. Ethrel spray @100 ppm partitioned more biomass into the stalks than NAA spray at both the concentrations assessed. The trend was especially clear after partitioning to stem had peaked during the grand growth stage at 210 DAP while stalk to total biomass ratios were close for Ethrel spray and NAA spray @ 50 ppm, ranging from 56.0 to 52.1%. Stalk to total biomass ratios were 43.0-44.9% for *Ethrel* spray *a*nd NAA spray @ 50 ppm at 280 DAP. While biomass partitioning to leaves with all PGRs assessed were close across the crop growth season, remarkably lower partitioning to leaves with PGRs after GGP was associated with more rapid sucrose accumulation pattern. The biomass accumulation pattern remained same till 180 DAP. Thus, biomass accumulation was highest in Ethrel spray against all compounds at all concentrations. Tiller numbers ha^{-1} were 1,50,218, 1,25,716, 1,11,282 shoots ha^{-1} with Ethrel spray @ 100 ppm, NAA spray @ 50 & 100 ppm against 1,02,371 shoots ha^{-1} with water spray at 180 DAP . Other biometric traits showed similar trends with maximum impact with sett soaking with Ethrel spray followed by NAA spray @ 50 and 100 ppm till 240 DAP. Number of plants ha^{-1}, per cane weight and cane weight (t ha^{-1}) indicated maximum effect of *Ethrel* spray, followed by NAA spray @ 50 & 100 ppm with 1,19,282, 1,11,672, 1,14,531 plant numbers ha^{-1} against 97,191 plant numbers ha^{-1} in water and 65,743 plant numbers ha^{-1} in control.

ii) Demonstrations sugarcane ratoon crops -

PGR Technology works on the principle of manipulative phasic physio-chemical processes that optimizes plant population through improved physiological efficiency created by reduced lag in emergence, improvement in germination %, improved growth in early phase, synchronized tillering, improved tiller numbers, diversion of photosynthates towards enhancing cane weight and sucrose content, thus increasing cane and sugar harvest index. Exogenous application of Ethrel & gibberellic acid stimulated physiological growth, increased initial plant population and caused internodal elongation. Significant improvements were recorded in biometric traits responsible for yield attributes. PGR technology led to enhanced NMC ha^{-1} and cane yield ($t\ ha^{-1}$).

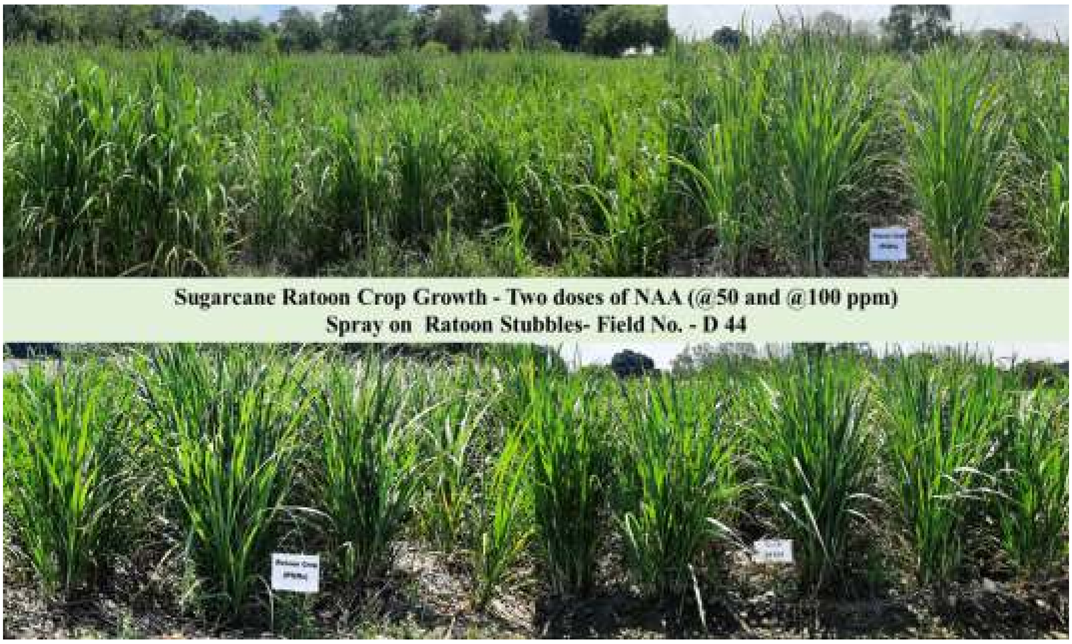


Figure 4.6. CoLk 94184 Ratoon crop initiated with spray of two doses of NAA (@50 and @100 ppm) along with water, Ethrel and absolute control

Figure 4.7. CoLk 94184 Ratoon crop initiated with PGR Technology

Modified atmosphere packaging of sugarcane juice in closed system

This study evaluated the chemical kinetics and thermodynamics for the thermal inactivation of polyphenol oxidase, total plate count, L^*, a^* and b^* -values of sugarcane juice. Sugarcane billets were blanched at different time-temperature combinations in the range of 0-20 min and 70-90°C. Blanching led to significant alterations in PPO activity, total plate count and color of sugarcane juice. PPO activity, total plate count, and color (L^*, a^*, and b^*-values) alterations followed the first-order reactions between 70 to 90°C. The variations in PPO activity, total plate count and color (L^*, a^* and b^*) followed the first order kinetics and

Figure 4.8 *CoLk 94184 ratoon crop initiated with PGR Technology at Technology Park ICAR-IISR, Lucknow.*

reaction rate increased with the increase in temperature. The half time (t ½) values dropped from 16.5 min -3.47 min, decimal reduction time (*D-values*) dropped from 54.83 min to 11.52 min for thermal inactivation sugarcane PPO. The activation energy (*Ea*) for the thermal inactivation of the sugarcane PPO was calculated to be 81 kJ mol-1 from 70°C to 90°C. As $t^{1/2}$, *D-values and Ea* values decreased with increase in temperature, the reactions were temperature-sensitive. Thermodynamic studies indicated an endothermic (positive enthalpy values, $\Delta H > 0$; 78.10 kJmole-1) and reversible process (negative entropy values $\Delta S<0$; -0.044 $kJmole^{-1} K^{-1}$). The Line weaver Burk Plot indicated that the affinity of juice decreases with the increase in the lemon juice concentration as *Km* values increased from 5.53 mM to 15.81 mM and *Vmax* decreased from 666.67 to 384.61 Uml^{-1}, when the lemon juice concentration was increased from 0 to 10% v/v in fresh sugarcane juice.

Screening and identification of sugarcane clones tolerant to water-logging and their physio-biochemical investigation

Transcriptome analysis using four samples (S1, S2, S3, S4) having leaf tissue of control and waterlogging induced plant, CoLk 94184 and CoJ 64 varieties revealed a total of 2,95,618 unigenes. These were further processed using seven databases (Nr, Uniprot, GO, KOG, PFAM, KEGG and Transcription factor) (Table 1). Unigenes showed 49.2% similarity with *Sorghum bicolor*, 14.9%% with *Zea mays*, 2.1% with *Oryza sativa*, 4.1% with *Setaria italics*, 1.87% with *Saccharum* hybrids and 19.48% with others (Nr annotation) (Fig.1). Based on GO annotation, genes are grouped under three different components, biological process (BP), cellular component (CC) and molecular function (MF). The most enriched KOG category was "Signal transduction mechanisms (T)" followed by "General function prediction only (R)" and "Posttranslational modification, protein turnover, chaperones (O). In Pfam analysis, most abundant domains identified were representing "Protein kinase domain" followed by "Protein tyrosine kinase", "Cytochrome P450" and RNA recognition motif. The most abundant transcription factor families enriched were bHLH followed by WRKY, NAC and MYB related.

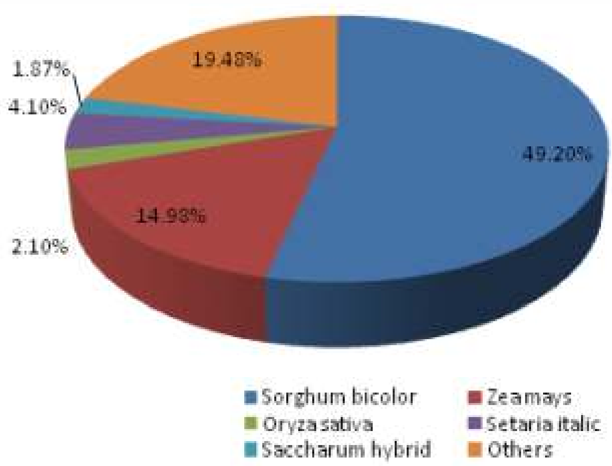


Fig.4.9 *Species classification of Nr distribution*

Table 4.1 Number of Unigenes annotated with different sets of databases

	No of Unigenes	Percentage (%)
Annotated in NR	66731	22.6
Annotated in Uniprot	47817	16.2
Annotated in GO	31893	10.8
Annotated in KOG	29933	10.1
Annotated in Pfam	29243	9.89
Annotated in Transcription factor database	33082	11.19
Annotated in KEGG	10380	3.51
Annotated with all 4 databases	20261	6.85
Annotated with at least 1 database	66785	22.59
Total no of unigenes	295618	

Differentially expressed genes (DEGs) were identified in four sets of samples (S1 vs S2, S1 vs S3, S2 vs S4 and S3 vs S4) using total RNA of both the varieties planted under control and waterlogged conditions, as per the DESeq R/Bioc package (Fig 4.2).

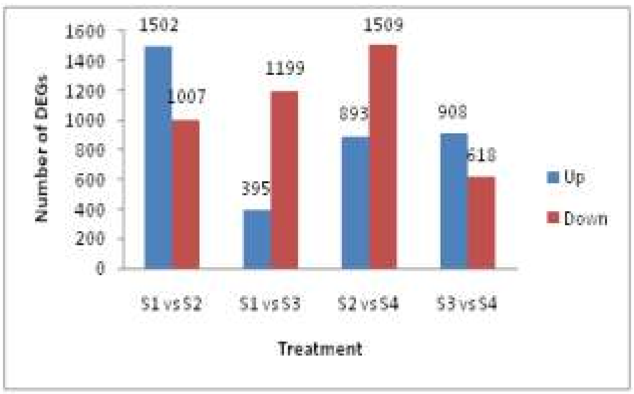


Figure 4.10 *Differentially expressed genes (DEGs) of four sets of sample*
S1 = CoLk94184 Control leaf tissues;
S2 = CoLk94184 waterlogging exposed leaf tissues
S3 = CoJ 64 control leaf tissues;
S4 = CoJ 64 waterlogging exposed leaf tissues

Among significantly expressed genes, a total of 30 transcripts associated with carbohydrate metabolism, environmental adaptation and transcription factor genes were used and primer pairs were designed to validate those using different sets of RNA samples isolated from both the varieties (Fig.4.11).

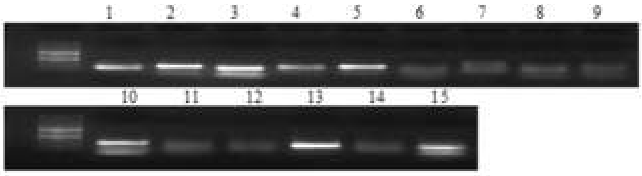


Figure 4.11 *Validation of 15 designed primers based on novel transcripts sequence using total RNA isolated from sugarcane leaf. Eight primers showed reactions.*

Fifteen designed primers based on novel transcripts sequence were validated using total RNA isolated from sugarcane leaf. Eight primers showed reactions (Fig.4.11). qRT-PCR performed using total RNA of leaf tissue of both the varieties indicated higher expression of uncharacterized protein (Unigene 5311), ADH gene, lower expression of metal-nicotianamine transporter YSL16 (Unigene 192156) in both the varieties and higher expression of transcription factor bHLH30 (Unigene 223205) in variety CoJ 64 under waterlogged condition.

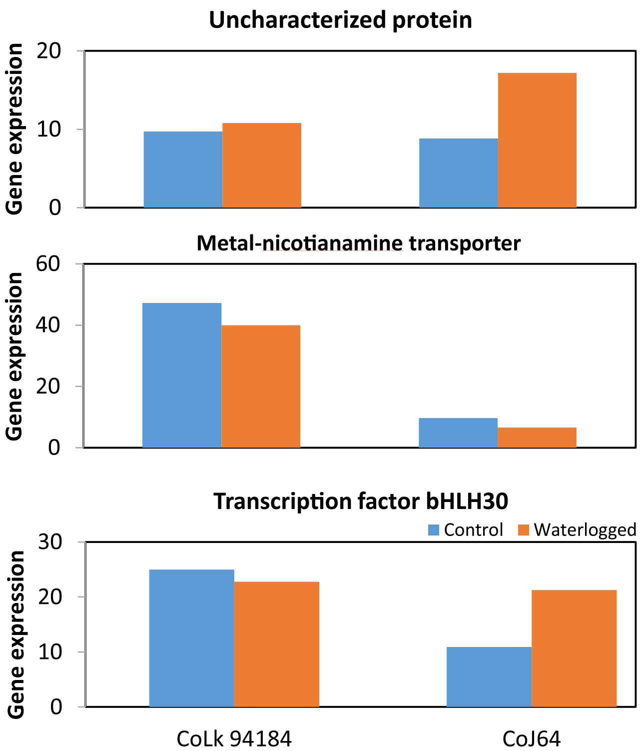


Figure 4.12 *Expression behaviour of some selective transcripts performed through qRT-PCR using total RNA of leaf tissues of both the genotypes (CoLk 94184 and CoJ 64) subjected to waterlogging along with untreated control.*

CHAPTER 5

Mechanization of Sugarcane Farming

Development of cane node planter

A prototype of tractor operated cane node planter was developed. The developed planter was tested in the field. Based on the field test results, design modifications were done in the cane node metering mechanism. Modifications during the period under report modified cane metering mechanism was fabricated and integrated with the planter mainframe (Fig. 5.1). Preliminary laboratory and field testing were conducted. The performance of the cane node planter was satisfactory with the modified metering mechanism. Detailed field testing will be conducted during this year.

***Fig. 5.1** Tractor operated cane node planter with modified cane metering mechanism*

Development of sugarcane trash management machinery

The new prototype machine for trash management in sugarcane ratoon crop, which could perform ratoon initiation operations as well as trash management in sugarcane has been field tested, demonstrated and very satisfactory performance was found (Fig. 5.2). The prototype machine covers two rows of sugarcane and trash in between the rows. The stubble shaving unit operates after the trash shredding operation. The stubble shaving unit will be required if ratoon crop is to be grown. The stubble shavers are surrounded by three sides with rubber flaps to provide safety from pebbles and chopped cane pieces cut by stubble shavers. The prototype equipped with chemical spraying unit as well for applying trash decomposer for its faster decomposition will be evaluated in the spring season next year. A patent was applied to the Patent Office, New Delhi, India (Application No. 202211007706 dated 14.02.2022). As per the First Examination Report of Patent Application, the revised claims and complete specifications with other modifications were submitted in March 2023.

***Fig. 5.2** Testing of tractor-operated trash mulcher-cum-stubble shaver device*

Development of e-powered multipurpose equipment adapted to Controlled Traffic Farming for Sugarcane

Design and development of the matching implements for various farm operations in the field for controlled traffic farming(CTF) was carried out. A field experiment was laid in the IISR farm for one hectare to study the CTF and conventional sugarcane cultivation. The sugarcane planting was done at different row spacing in November 2022. The weeding and interculturing were done with modified machines while maintaining the same wheel lane. The performance of the modified weeder and interculturing machine was satisfactory in accomplishing the unit operations involved. A new two cane rows machine, furrower-cum-packer which will make ridges and firm them to avoid lodging.

Ergonomic evaluation of tools and equipment for drudgery reduction in sugarcane cultivation

i) Ergonomic evaluation of newly developed manual sugarcane *stripper-cum-detopper*:

Ergonomic evaluation of newly developed manual stripper-cum-detopper (Fig. 5.3) was carried out at IISR farm for stripping of dry and green leaves from the harvested cane and cutting of green top. Technical specifications of manual stripper-cum-detopper are

Fig. 5.3 Newly developed manual sugarcane *stripper-cum-detopper*

given in Table 5.1 This tool was made up of MS pipe of 40 mm diameter. Two equal parts were made by cutting this pipe vertically and then joined with a hinge from the outside. The opening at the ends of this pipe is of different diameters. There is a protection cover at the end points on both sides of pipe. With the help of thumb and fingers, operator can wear this in hand with given handles. By holding in hand, the operator can open it to put cane inside the pipe from the top side and then close its openings to strip the cane. After doing hand up and down one or two times, the dry leaves get separated from the cane. After stripping, detopping of cane can be done with the help of blade provided on upper side of the stripper.

Table 5.1 Technical specifications of manual stripper-cum-detopper

Parameters	Value
Overall dimensions (L×B×H), mm	320×130×135
Weight, g	460
Diameter of main MS pipe, mm	40
Thickness of MS pipe, mm	1.6
Diameter at front of pipe, mm	30
Diameter at bottom of pipe, mm	35
Length of blade, mm	170
Thickness of high carbon steel blade, mm	2

Testing of this tool was conducted at Institute farm for more than 30 hours by male and female farm workers (Fig 5.4, Table 5.2). It was observed that 85-110 kg of cane can be cleaned in one hour by male and female farm workers for harvesting CoLk 14201 cultivar.

The average heart rate of male and female farm workers was within the acceptable limit. The energy expenditure rate was 7.41 and 7.91 kJ/min with male and female farm workers, respectively. Physiological workload was in the light category with male workers but it was moderately heavy with female workers (Table 5.3). It was also observed during testing that the weight of manual stripper-cum-detopper should be slightly less for better comfort of the operator and enhanced efficiency. So, it is proposed to make it with suitable PVC material.

***Fig. 5.4** Testing of newly developed manual sugarcane stripper-cum-detopper*

Table 5.2 Test results of sugarcane newly developed stripper-cum-detopper

Parameters	Values	
	Male	Female
No. of cane stripped and de-topped/h	210	146
Weight of the clean cane, kg/h	110	85
Green top weight, kg/h	37	28
Dry trash, kg/h	20.1	12.4

Table 5.3 Average physiological response of selected subjects for the stripping and de-topping operation

Parameters	Manual sugarcane stripper-cum-detopper	
	Male	Female
Working Heart rate, beats/min	99.8	104.6
Δ Working Heart rate, beats/min	25.6	29.5
Oxygen consumption rate, l/min	0.46	0.51
Δ Oxygen consumption rate, l/min	0.29	0.33
Energy expenditure rate (EER), kJ/min	7.14	7.91
Δ Energy expenditure rate(Δ EER), kJ/min	4.07	4.69
Overall discomfort rating, ODR	3.6	4.6

Manual sugarcane seed sett cutting machine

The machine developed for doing three operations separately *viz.* cutting cane node, bud chip scooping and seed sett cutting of sugarcane as seed material required for sugarcane planting by various methods. The machine has a handle, high-carbon steel blade, a scoop and platform to fix the machine. One person can easily operate by holding cane in one hand and pressing handle with other hand for the required operation. The preliminary testing of the machine has been done. Machine performed satisfactorily but it needs some modifications for operators' comfort and performance point of view (Fig. 5.5).

Fig. 5.5 Manual sugarcane seed sett cutting machine

The modification was done in the already developed manual sett cutting machine. In the initial prototype, the operator has to insert force by putting his/her foot on the machine platform for its stability. Now, the stool was fixed with the machine platform. The operator while working sits on the stool and due to operator's weight this platform is not required to be pressed with the foot. The working capacity and efficiency of the operator with this new machine have improved. It was observed that heart rate and energy consumption rate were moderately high after 30 minutes of continuous work and operator needed some rest for further work. There is increase in operator's efficiency in terms of No. of sett cut/h after modification (attaching the seat with the platform) by more than 20% as compared to initial prototype (Table 5.4).

Table 5.4 Performance results of the machine for cutting various cane sizes

Parameters	Cane node	Bud chip	2 or 3 bud setts
No. of cane node/bud chip/sett cut per hour	850-880	860-900	1350-1400
Damage, %	6-8	1-2	Nil
Cost of operation, Rs/1000 cut	57	56	36

Development of inter-intra row weeding system for transplanted sugarcane

Development of the new prototype has been conceptualised for inter- intra row weeding system for transplanted sugarcane. The fabrication of the main framework and inter-row weeding unit has been completed. The sensor-based weed identification system has been finalized. Further, fabrication work for intra-row weeding system and its components is in progress.

Testing, evaluation and demonstration of different applications of spraying drone in sugarcane

Preliminary testing of drone for spray rate and nozzle volume was done at laboratory (Fig. 5.6). Parameters optimization for spraying of agrochemicals (Fig. 5.7) using an agricultural drone was initiated in sugarcane with all precautionary measures. The recommended dose of selective agrochemicals (Metribuzin 1.2 kg/ha and Sempra 0.09kg/ha) were sprayed at the stage of two to three weed leaves in the planted sugarcane 30-40 days after planting for control of weeds during the first fortnight of December 2023. In the initial trials, a total of 30 l/ha water was used for the spray at a height of 1.0 m from the crop, 5.0 m/s speed with a swath width of 3.0 m. Similarly, agrochemicals were sprayed at various heights from the crop to check the spray efficacy using systemic fungicides. Spray distribution parameters have been recorded using water-sensitive papers of size 74×26 mm.

Inter Institutional collaborative research project on evaluation of multiple auger planting technique for fruit crops in partially reclaimed sodic soil

Tractor operated PTO driven multiple (three) auger system was developed for digging multiple three circular pits simultaneously. It was mounted type equipment rigidly attached to three-point linkage. Multiple auger system (MAS) was designed to make deep (1.0 m) with large diameter auger (300 mm) in the centre whereas adjacent auger on both sides would make small diameter (150 mm) shallower holes (0.90 m). The developed MAS consisted of main frame, pit digging blades and power transmission units. During pit digging operation auger blades cut the soil and flutes carry the cut soil out off pit for getting clean pit.

Vertical and horizontal angles of the blade and speed of auger flutes are critical parameters for achieving the desired results. These parameters were optimized and pit digger was designed and developed (Fig. 5.8).

A rigid framework was provided to support pit digging blades and power transmission units. The framework was made of MS square pipe and was properly strengthened by cross supports. The framework was mounted through 3-point linkage with the tractor. The equipment was provided with three blades for digging three pits at a time. Each blade was like two augers having replaceable blades at the tip. Augers rotate in clockwise direction. Flutes of the auger blades were designed in such a way that caused least chocking. Performance of blades at three levels of vertical angle i.e. 0°, 5° and 10°, three levels of horizontal angle i.e. 0°, 15°, 30° and 45° for two types of shapes i.e. straight and curved edges was observed. Blades having 5° vertical angle, 30° horizontal angle and with curved edge performed the best. Designed

Fig. 5.6 Preliminary testing of drone for spray rate and nozzle volume at laboratory.

Fig. 5.7 Parameters optimization for spraying of agrochemicals using drones.

Fig. 5.8 First prototype of Multiple Auger System (MAS)

blades had 5° vertical angle, 30° horizontal angle, curved sharpened edges and 370 mm flute pitch. Rotary power from tractor PTO was transmitted to main gear box through UJ cross and flexible propeller shaft and from main gear box output shaft to pit digging blades. Main gear box consisted of a pair of heavy-duty bevel gears. Main gear box was a bevel gear box with speed ratio of 1.8:1. The power from main gear box output shaft was transmitted to central pit digging blades directly and through V-belt pulleys to adjacent pit digging blades. The first prototype of MAS was fabricated in the workshop of Agricultural Engineering Division of IISR. All the moving parts were guarded to avoid any accident. After digging three holes in direction of the machine, it was transversely rotated for making five holes. Several improvements in the parts were done after running the prototype in real field conditions in normal soil of ICAR-IISR fields (Fig. 5.9).

Fig. 5.9 Process of making auger hole in sodic soil.

Field layout and preparation: It was found that the auger holes made in a line should be at higher elevation in order to avoid entry of water in the holes to avoid waterlogging situations. To achieve it, a ditch line was created and outward slope was given for quick removal of rainfall induced rainfall (Fig. 5.10).

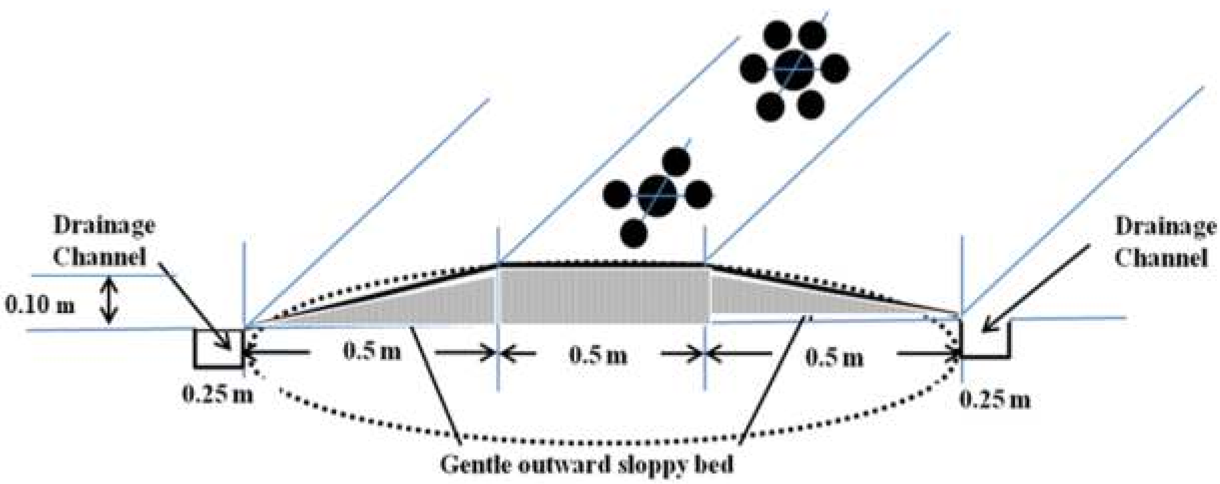


Fig. 5.10 Outward sloping field for quick removal of the runoff.

A schematic diagram of auger holes is shown in the Fig. 5.11. For collecting leachate from the hole bottom a transparent plastic tube should be inserted in the holes. Leachate can be collected through the plastic tube. For taming roots of plants away from the main hole small diameter hole filled with treated soils and nutrients could be made in a desired pattern in future.

Input mixtures of 33.3% volume of dugout soil + 33.3% sand + 33.3% FYM + 2 kg gypsum with and without microbial formulations were filled in the auger holes after thorough mixing of all inputs manually. Nursery of apple ber (cloned plants) were procured from Malihabad nursery and planted during February (Fig. 5.12).

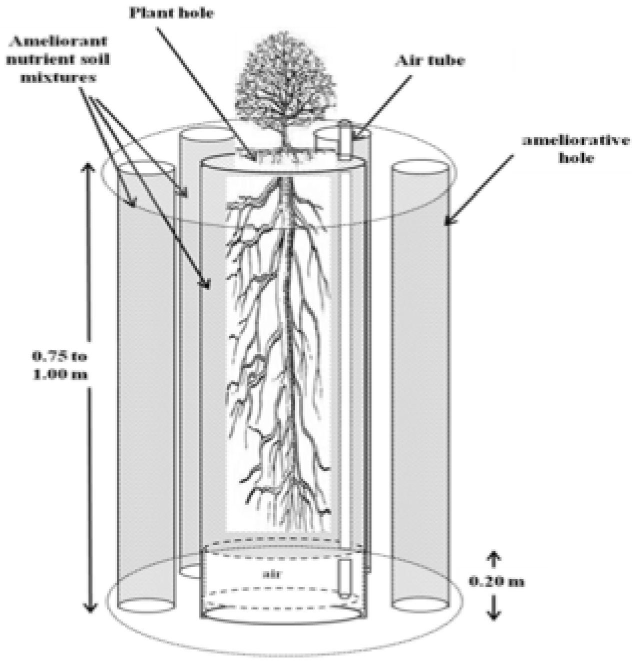


Fig. 5.11 *Schematic diagram of 5 auger hole system for plantation.*

Fig. 5.12 *Process of input mixture preparation, filling and field preparation.*

AICRP on Farm Implements and Machinery (FIM)

Manufacturing of prototypes for conducting field adaptability trials under varying agro-climatic and soil conditions

Table 5.5 Prototypes fabricated

Machine/Implement	Source of power	Achievement
IISR T.O. Deep furrow sugarcane cutter planter	Tractor	1
IISR T.O. deep furrow sugarcane cutter planter-cum-multicrop raised bed seeder	Tractor	-
Trench opener	Tractor	-
Deep furrower	Tractor	2
Disc type sugarcane management device	Tractor	2
Manual cane detrasher	Manual	-
Manual cane stripper-cum-detopper	Manual	40
Manual cane node cutter-cum-bud scooper	Manual	-
IISR gurmoulding frame	Manual	2
Total		**47**

Table 5.6 Prototypes supplied

Name of prototype	Supplied to	Number
IISR TO deep furrow sugarcane cutter planter	PAU Ludhiana	1
IISR TO deep furrow sugarcane cutter planter	JAU Junagadh	1
IISR TO disc type sugarcane ratoon management device (Disc RMD)	UAS Mandya	1
IISR TO deep furrow sugarcane cutter planter-cum-multicrop raised bed seeder	HAU Hisar	1
IISR manual cane node cutter-cum-bud scooper	Mr. B K Pandey, Nedula, Basti, U.P.	1
IISR manual cane node cutter-cum-bud scooper	Mr Ram Sewak Yadav, Cane Supervisor, Sugar Mill Mahmoodabad, U.P.	1
IISR manual cane node cutter-cum-bud scooper	Mr. Satya Prakash Mishra, Mehamoodabad, Sitapur, U.P.	1
IISR manual cane node cutter-cum-bud scooper	Mr Yogesh Singh, Jaitpur, Bulandshahar, U.P.	1
IISR Manual cane stripper-cum-detopper	KVK Moradabad	15
IISR Manual cane stripper-cum-detopper	KVK Amroha	20
IISR Manual cane stripper-cum-detopper	KVK Hapur	15
IISR Manual cane stripper-cum-detopper	Mr. Sanjay Kumar Verma, Shivrajpur, Bahraich, U.P.	1
IISR Manual cane stripper-cum-detopper	Mr. Muzaffar Hussain, Vill. Biswa, Sitaour, U.P.	1
IISR Manual cane stripper-cum-detopper	KVK, Gopalganj, Bihar	7
Total		**67**

Prototype feasibility testing

i) Prototype Feasibility Testing of Automatic potato-cum-sugarcane trench planter

Prototype feasibility testing of tractor operated automatic potato-cum-sugarcane trench planter was conducted at IISR farm (Fig. 5.13). Planter performance parameters like sett length, number of setts cut and dropped per unit length of furrow, depth of furrow, depth of soil cover, height of ridge, number of seed potatoes dropped per unit length of ridge, wheel slippage of tractor etc. were recorded. Performance of the planter was compared with manual planting as intercrop and manual planting as relay crop. Planter was operated by a 30-kW tractor.

The effective field capacity of the planter was 0.127 ha/h, thus to plant one hectare area it would take approximately 8 hours. The cost of planting operation with the planter was Rs 3500 per ha whereas Rs. 13600 per ha when planting was done manually. Thus, there was 74.20 % cost saving in planting with this machine. Saving in labour by planting with developed machine was 90.1 %.

Fig. 5.13 Automatic potato-cum-sugarcane trench planter under field operation

ii) Prototype Feasibility Testing of Pedal operated paddy thresher

Prototype Feasibility Testing of Pedal operated paddy thresher was conducted at at farmers field of Sitapur district (Fig. 5.14). It was operated for 50 hours at farmer's field. It's performance was compared with the conventional practice of beating the paddy bundle on stones or wooden platform in bending posture. Thresher was operated by both male and female worker. The total man-h requirement was recorded for threshing under different moisture contents and stalk lengths of the bundles for further conversion into energy equivalents.Threshing capacity of pedal operated paddy thresher was 60-85 kg/h and efficiency 92-97%. It is suitable for small and marginal farmers.

Fig.5.14 Pedal operated paddy thresher in operation

Centre of Excellence in Farm Machinery

i) Development of solar powered manual paddy thresher

A solar powered manual paddy thresher suited to small and marginal farmers was developed for threshing of paddy crop (Fig. 5.15). The thresher was having main frame, drum, DC motor, battery, solar paneland switch. One person can operate the machine easily. The height of the drum is 850 mm. The power transmission was through V-belt pulley. The specifications of the thresher is given in the Table 5.7.

Fig. 5.15 Solar powered manual paddy thresher

Table 5.7 Specifications of Solar powdered manual paddy thresher

Parameters	Values
Length × Breadth × Height, mm	1530 × 680 × 2000
Diameter of the threshing drum with and without pegs, mm	260 & 380
No. of strip on the drum & pegs/strip	6 & 13-14
Length of drum, mm	480
Height of drum, mm	850
Average speed of the threshing drum, rpm	400
Power transmission to threshing drum	V-belt pulley
Diameter of pulleys, mm	200, 50
Battery	12V, 32Ah
Solar Panel	330 W
DC Motor	24 V, 300 W

The preliminary testing of the thresher was conducted at IISR farm for threshing paddy variety Pusa Basmati 1. The machine operated well and the capacity of the machine was 1.5 q/h. The tentative cost of machine was Rs. 25,000/- including solar panel, battery and motor.

ii) Development and testing of manual nursery transplanting device

A hand-held manual nursery transplanter was developed for transplanting of vegetable nursery (Fig. 5.16). This device works very well in the vegetable nursery transplanting. The main components of this device are handle, clutch lever with wire, seedling delivery tube/pipe and jaw in the lower side. Seedlings has to put one by one from upper opening of the pipe and after pressing the lever, nursery can be put in the well-prepared soil. The preliminary testing of its feasibility for transplanting of sugarcane seedlings raised in portrays was also examined. The device works well for transplanting sugarcane seedlings but in this case the diameter of the pipe should be slightly more.

iii) Development of small harvesting system for sugarcane

A small harvesting system for sugarcane is being developed (Fig. 5.17). A brush cutter was purchased and the necessary modificationsi.e. fabrication of guider, selection of blade etc. arebeing done and will be tested for further modifications, if any.

Fig. 5.16 Manual nursery transplanting device

Fig. 5.17 Development of small harvesting system for sugarcane

Frontline Demonstrations

i)Frontline Demonstrations of IISR Tractor operated modified sugarcane cutter planter

IISR tractor-operated modified sugarcane planter was demonstrated at farmers field of Lakhimpur and Biswa Sugar Mill area of Sitapur in 7.5 ha area (Fig. 10.1). It performs all the unit operations involved in sugarcane planting simultaneously in a single pass of the equipment. It covers two rows at variable row spacing of 75 or 90 cm. The performance of the planter was satisfactory for planting of sugarcane. There was a saving of 65% in cost of operation and 90% in labour requirement while using this planter as compared to conventional method.

Frontline Demonstrations of IISR Tractor operated two row Disc Type ratoon management device

IISR two row disc type ratoon management device (Disc RMD) demonstrated at DSCL Hariyawan and at

Fig. 10.1 IISR tractor operated modified deep furrow sugarcane planter in field operation

IISR Lucknow (Fig 10.2). A total of approximately 5.5 ha area was covered. The machine performs the cultural operations of stubble shaving, off barring, interculturing, fertilizer and insecticide application after the harvest of sugarcane for improved initiation of the ratoon crop. The effective field capacity of the machine was 0.30 ha/h.

Fig. 10.2 IISR tractor operated two row disc type ratoon management device in field operation

Frontline Demonstrations of IISR Tractor operated deep furrow sugarcane cutter planter-cum- raised bed multi-crop seeder

Demonstration of IISR tractor operated raised bed seeder-cum-sugarcane planter was conducted at farmers field of Biswa sugar mill area Manpur of Sitapur district (Fig 10.3) in 5 ha area. It covers two rows of cane planting in deep furrows and two rows (one full raised bed and two half raised beds on either side of furrows) of sowing of intercrop simultaneously in single pass of the machine. Performance of the planter was satisfactory with effective field capacity of 0.20 ha/h. Saving in cost of operation was up to 70%.

Frontline Demonstrations of IISR Tractor operated multipurpose interculturing equipment

Demonstration of IISR tractor operated multipurpose interculturing equipment was conducted at farmers field of Biswa Sugar mill area of Sitapur district (Fig

Fig. 10.3 IISR Tractor Operated Deep Furrow Sugarcane Cutter Planter –Cum- Multicrop Raised Bed Seeder in field operation

10.4) in 7.5 ha area. Equipment covered two inter rows for interculturing and intra-row weeds were killed by spraying herbicide. Thus it facilitated inter-row interculturing as well as intra row weeding and also fertilizer application near to root zone simultaneously in single pass of the equipment. The effective field capacity of the equipment was 0.30 ha/h. Cost of operation in performing combination of operations during weeding/interculturing and fertilizer application in the conventional system was Rs 4500 per ha whereas with the developed equipment it was Rs 1800/ha. The saving in cost of operation was 60%.

Fig. 10.4 IISR Tractor operated multipurpose interculturing equipment in field operation

Frontline Demonstrations of Manual multicrop planter for sowing intercrop in sugarcane

Field demonstrations of IISR manual multicrop planter for sowing of intercrops in sugarcane were conducted at Biswa sugar mill area in different villages. Sugar mill purchased and distributed IISR manual multicrop planters to the farmers for sowing of intercrop in sugarcane. A total of 32.64 ha area was covered at 95 farmers'field for sowing of intercrop in sugarcane in different blocks of Biswa sugar mill area of Sitapur distrct. (Fig 10.5)

Fig. 10.5 IISR manual multicrop planter

Frontline Demonstrations of manual sugarcane stripper-cum-detopper

Total of 57 number of manual sugarcane *stripper-cum-detopper*(Fig. 10.6, Table 10.1) sold to KVK, Amroha (U.P.), KVK Hapur, KVK Muradabad and KVK Gopalganj (Bihar) for multi-location testing.

The test results of this tool showed that the highest number of cane were stripped and de-topped in a given time by both male and female farm workers. One person can clean nearly 140 to 150 kg of the cane in one hour with this new tool whereas it was 15-20% less with conventional tool. However, the physiological workload with this tool and conventional tool was observed in "Very Light" category by both male and female worker.

Fig. 10.6 IISR manual sugarcane stripper-cum- detopper

Table10.1 Technical specifications of the IISR manual sugarcane stripper-cum-detopper

Parameters	Model III
Weight, g	225
Material of blade	High carbon steel
Thickness of blade, mm	2.0
Thickness of cutting edge, mm	0.5
Dia. of hand grip, mm	30
Cutting length of the blade, mm	85
Material of handle	PVC
Overall dimensions (L×B), mm	310x55

RKVY funded 'Agri Drone Project'

Agricultural Spray Drone was demonstrated at Vill. Dashrathmau, Block Rudauli, District Ayodhya on Oct 04, 2023 to 150 farmers (Fig. 10.7) for agrochemical spraying in sugarcane crop. Also, drone demonstration was conducted in the sugarcane crop for 15 trainee farmers at ICAR-IISR Lucknow on Oct 11, 2023.

Fig.10.7Agricultural Spray Drone demonstration to the farmers

Technology demonstration

Details	Date	Number of participants			
		Male	Female	Student	Total
Production, Storage and Handling of Jaggery Technical Session of B.Sc.(Ag) Students of Sri Mahesh Prasad Degree College, Mohanlalganj, Lucknow at IISR, Lucknow	08.08.2023	30	22	-	52
Value added jaggery Training programme of State Agricultural Management Institute Rehmankhera at IISR, Lucknow	14.09.2023	25	10	-	35
छोटी जोत हेतु गन्ना आधारित फसल प्रणाली का मशीनीकरण, भारतीय गन्ना अनुसंधान संस्थान, लखनऊ	09.10.2023 - 13.10.2023	75	20	15	110
Sugarcane Technology and management-Training Programme of B.Sc. (Hons) Agriculture II[nd] year students at IISR, Lucknow	16.10.2023 - 20.10.2023	06	03	-	09
RAWE for B.Sc. (Ag) students of Narayan Institute of Agriculture Science,Sasaram, Bihar at IISR, Lucknow	01.12.2023 - 31.12.2023	30	15	-	45
गन्ने के रस से गुड़ व अन्य मूल्यवर्धक उत्पाद बनाने की उन्नत तकनीक, भारतीय गन्ना अनुसंधान संस्थान, लखनऊ	09.08.2023	55	15	5	75
Industry Interface Fair on Agro-Processing (IIFA-2023) & KISAN MELA,	03.10.2023 - 05.10.2023	2500	1500	1200	5200

Details of Machine/Technology Transferred

Name of the machine/technology transferred	No of units	Address of farmers/ entrepreneurs/ manufacturers	Date
Moulding Frame (Steel Frame:03 Silicon Frame:07)	10	Prabhas Shukla, Village Mahawa, BikapurAayodhya 224206	17.01.2023
Moulding Frame (Steel Frame:05 Silicon Frame:10)	15	Avinash Chand Dubey, Ayodhya	09.03.2023
Moulding Frame (Steel Frame:02 Silicon Frame:10)	12	Akhilesh Yadav, Dariyabad Road, Lucknow – Faizabad Highway Barabanki	22.09.2023
Moulding Frame (Steel Frame:05 Silicon Frame:60)	65	KuiyandheerPrakartik Krishi Farmers Producer Company Limited, Farrukhabad	20.11.2023

Field day

One Field Day on "Improved technologies for sugarcane Mechanisation" was organised at village Dashrathmau, Block - Rudauli, District Ayodhya in collaboration with Balrampur Chini mill, Rauzagaon on 04 October 2023 in which more than 150 farmers participated.

Field Day organized in Ayodhya district

Distinguished visitors in Jaggery Unit

- Nearly 1500 farmers, students and other visitors visited the jaggery unit in year 2023.

Training and Field Days Organized

Training organized on Mechanization of Sugarcane based cropping system

One 5-days Farmer's training program on, "Mechanisation of sugarcane based cropping system for small holdings" was organized from October 09-13, 2023 at ICAR-IISR Lucknow in which 19 farmers from five districts (Hardoi, Lakhimpur kheri, Sitapur, Behraich, Ayodhya and Barabanki) of Uttar Pradesh participated.

CHAPTER 6

Diversification and Value-addition in Sugarcane

Development of integrated drying system for jaggery drying

An air heater for the integrated drying system has been fabricated. It is 182 cm long and 76 cm wide. It is put into a frame (made of 35×35×5 mm angle iron). The heater is inclined 41° to south and kept on a stand, made of 50×50×5 mm angle iron with higher side height as 214 cm and smaller side as 115 cm. Input air entering through opening of 2.5 cm and exit through a 2.5 cm diameter pipe with a valve arrangement. This air reaches to a mixing chamber. Size of chamber is 21×21cm. It is kept on a stand (height: 62 cm), A blower (200W power rating and 0.018m^3/sec flow rate) is fitted with mixing chamber. Two other inputs are reaching to mixing chamber, through 5 cm diameter pipe and gate valve arrangement, each one for electrical and waste heat recovery system respectively. Exit air from mixing chamber is sent to drying chamber through a pipe of length 76 cm and diameter 5 cm.

Refinement of sugarcane cleaner cum washer for jaggery

A sugarcane cleaner-cum-washer was developed for cleaning of canes prior to crushing. It worked well when tested with sugarcane in single, double and triple pass. Cleaning increased with number of passes. Four to five canes at a time can be fed to the machine with a capacity of 1000-1100 kg canes per hour matching with available sugarcane crusher in Jaggery Unit. A wire mesh filter has been provided below the rollers for filtration and re-usage of wash water.Since the machine has several moving parts, a safety cover has also been designed, manufactured and installed on the machine (Fig. 6.1).

***Fig. 6.1** Safety/protective cover provided on sugarcane cleaner-cum-washer*

Development of IISR model jaggery unit for enhanced capacity

The unit was modified for making provision for more air availability for combustion; two self-rotating ventilating fans were fitted on the top of the boiling pan and scum removal pan. Two high volume exhaust fans were also installed. Three phase electrical points were provided to operate bagasse dryer, automatic moulding machine and other equipment's.

Development of small powder jaggery cubes

The pressure application which was manual was made hydraulic so that plunger will come down for fix height and will move upwards mechanically.

Development of solar powered water recovery system for open pan jaggery making process

About 4.5 to 5.0 litre of water is evaporated per kilogram of jaggery made from sugarcane. Therefore, even a small unit producing 1.0 quintal jaggery per day evaporates 450 to 500 litres of water. This evaporated water goes aswaste in the atmosphere. Secondly, fog generated in and around jaggery units results in poor visibility and there are chances of short-circuiting of electrical gadgets. Water is becoming precious nowadays and people have started advocating conservation of water at all levels. Due to these reasons, a solar powered water recovery system for open pan jaggery making process has been conceptualized. This will consist of a water vapour collection hood, a solar PV operated fan for sucking in vapours and a vapour condensing and collection unit. The conceptual schematic diagram is shown in Fig. 6.2.

Development of jaggery coating machine for value added products (AICRP)

Design of the small capacity jaggery coating machine has been finalized. It consists of coating vessel (SS), power driving mechanism, blower, gas burner and solid jaggery melted.

Development of home scale portable jaggery manufacturing unit (AICRP)

The machine consisted of stainless-steel top, crusher, induction plate, moulding frame and storage area was fabricated.

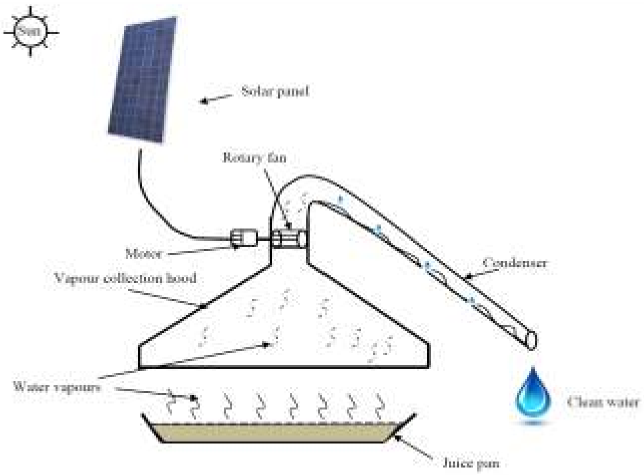


***Fig. 6.2** Conceptual design of water recovery unit*

Modified Atmosphere Packaging of Sugarcane Juice in Closed System (DST Funded)

Shelf life of the prepared juice was done. Final report of the project was submitted. Progress was presented in DST which was accepted and praised.

Establishment of ABI unit at ICAR-IISR Lucknow (NAIF-II funded)

One incubatee graduated and two new incubatees were admitted. Upgradation of ABI unit was done. A proposal for ABI office was given to office. The ABI unit for jaggery was made operational. Expression of interest was uploaded on IISR website.

Technology/process development

Millet *Panjiri*

Millet *Panjiri* (Fig. 6.3) is a supplementary food for improvement of nutritional status. All the ingredients i.e. wheat flour, jowar flour, bengal gram (roasted), hemp seed powder, gond, almond, green cardamoms, ginger, makhana, coconut dry, flax seed, ghee, etc. were procured from the local market. The prepared wheat flour, bajra flour were roasted before storage in airtight container. Roasting was done at 70-80°C on a low flame to avoid burning of flour. Roasting gave a pleasant flavour to flour.To prepare flax seed, Hemp seed, Bengal gram and dry fruits are roast 5 minutes then electric grinder to make fine flour. All the ingredients were mixed with jaggery and ghee to form a homogeneous mixture.The mixture thus obtained was packed in the air-tight pouches.

***Fig. 6.3** Millet Panjiri*

Jaggery & Millets based *rabri*

The ingredients required for the making of millets based *rabri* (Fig. 6.4) are given in the Table 6.1 and process as follows

- Soak little millet for 4-5 hours, then drain the water.
- Take a pan and add 200 ml water.
- Now add the soaked little millets and cook for 5 to 10 minutes.
- Then add 350 ml of milk, stir and cook properly until thick.
- Add 60 grams of jaggery powder and 1.0 gram of green cardamom.
- Get rid of the heat transfer to a serving plate once cool.
- For garnishing chop cashew nuts and almonds and sprinkle our.

Table 6.1 Ingredients required for rabri

Ingredient	Quantity
Little Millet	100 gm
Milk	350 ml
Water	200 ml
Jaggery	60 gm
Almond	5-6 Piece
Green Cardamom	2-3 Piece
Little Millet	100 gm

***Fig. 6.4** Jaggery & Millets Based Rabri*

Jaggery Making Using Nylon Moulds for Automatic Moulding Machine

Food grade nylon moulding frames were developed (Fig. 6.5) with the help of a private manufacturer for making tablet shapes of 5 g value aided jaggery candy. The cost of one mould was Rs.10,000 per mould.

***Fig. 6.5** Nylon Moulds for automatic moulding machine*

CHAPTER 7

Economics, Statistics and ICT

Development of District-level database on sugarcane growth and sustainability in India

The district-level data for the period of (2007-08 to 2018-19) w.r.t. area, production and productivity of sugarcane was analyzed, and growth (compound annual growth rates, CAGRs) for the period was worked out for the districts in all major sugarcane growing states. Based on the criteria of intensiveness and the growth rates in sugarcane area and productivity, these districts were grouped in different categories of growth in area and productivity. The distribution of all sugarcane growing districts as well as the most intensive cane districts as per observed growth in area and productivity for four major cane growing states Uttar Pradesh, Maharashtra, Karnataka and Tamil Nadu is presented in (Table 7.1). In UP, out of 75 districts, 48 grow sugarcane up to a significant level. Out of these 48 districts, 29 were sugarcane intensive districts having more than 10,000 ha area in each. The 29 main sugarcane intensive districts accounts for 93.82 % of area in UP. There were some districts having sugarcane area more than 1 lakh ha that account for 47% of the cane area in the state, while six districts, each having sugarcane area from 0.50 to 1.0 lakh ha account for 24.2% of total area. The three districts, viz., Pilibhit, Bareilly and Gonda has achieved positive and high (CAGR) growth rates in both acreage and productivity. The nine districts of U.P. have sugarcane area 0. 25 to 0.50 lakh ha in each and the districts account for 16.1% of the area. The groups of districts having sugarcane intensiveness from 10,000-25,000 ha, 5,000 to 10,000 ha and from 2000 to 5000 ha area were 7, 12 and 10, districts accounts for 6.3%, 4.2% and 1.3% of the total area respectively.

The districts were grouped according to the variable levels of growth in sugarcane area and productivity. The sixteen districts were grouped as positive growth both in area and productivity. These 16 districts accounts for 34.86% sugarcane acreage, 8 districts were the main sugarcane intensive districts (33.67% area). These districts were Shahjahanpur, Kheri, Hardoi, Gonda, Bahraich, Bareilly, Sitapur and Pilibhit (Table. 7.1 & 7.2). The average productivity in these districts was 74.56 t/ha. In seventeen sugarcane growing districts, though CAGR was positive both in area and productivity levels, but the growth in cane area was marginal (< 1%). It highlights that sugarcane area in these districts remains almost constant. Out of these districts, 12 districts accounts for 25.88% of state cane area and have productivity of 74.58 t/ha. Thirty-four districts may be considered in the third group, where area under sugarcane decrease over the years but there was positive growth in productivity. These districts account for 37.53% of area in U.P. with productivity 67.98 t/ha (Table 7.3). Out of these 34 districts, nine districts (Ghaziabad, Moradabad, Muzaffarnagar, Balrampur, Bulandshahr, Azamgarh, Bijnore, Shamli and Meerut) are the main sugarcane growing districts, accounts for 34.26% of area with productivity 79.52 t/ha. The districts have productivity decline are those districts which do not supply sugarcane to sugar mills.

In Maharashtra, out of 35 districts, 25 districts are sugarcane growing districts. Out of these, 16 districts have sugarcane crop at significant level. These 16 districts accounts for 96.15% of cane area. The districts like Sangli, Jalna, Parbhani and Yavatmal have positive growth in area and productivity while Aurangabad has shown positive productivity growth but area growth, though it was positive but <1.0%. The Beed, Latur, Sholapur and Ahmednagar district had a negative growth in sugarcane area and productivity. The Pune, Kolhapur, Satara, Nanddurbar and Nanded districts have recorded increase in area but productivity had declined. Nasik and Osmanabad experienced increase in productivity but area has decreased during the study period.

In Karnataka, 20 districts grow sugarcane as a commercial crop. Out of these, 6 districts have sugarcane crop cultivation up to significant level and collectively account for 87.32% of state sugarcane area. The Bijapur district has positive growth in sugarcane area and productivity. Three districts, Mandya, Bidar and Gulbarga have decline in area and productivity growth levels while two districts, namely Belgaum (Belagavi) and Bagalkot has increase in sugarcane area but decrease in productivity levels. It highlights that five sugarcane growing districts have productivity decline.

In Tamil Nadu, out of 31 districts, sugarcane was grown in 29 districts. Out of these districts, 24 districts accounts for 66.98% of state cane area) and average productivity of 92.83 t/ha have exhibited negative growth in area and productivity. However, in five districts sugarcane cultivated up to significant level which account for 63.40% of cane area in TN with crop productivity 104.12 t/ha. These major sugarcane growing districts have shown decline in productivity while Villupuram district recorded increase in cane area. All the districts namely Erode, Namakkal, Cuddalore and Thiruvannamalai had negative growth in sugarcane productivity. The sugarcane productivity also declined in these districts in Tamil Nadu. The analysis highlights that while highly intensive sugarcane growing districts in UP are experiencing positive growth both in area and productivity levels; the main sugarcane growing districts in tropical states of Maharashtra, Karnataka and Tamil Nadu had experienced decline in area and productivity levels in the past decade.

Table 7.1 Distribution of sugarcane districts on the basis of area and productivity growth in India

Major sugarcane growing states	Total districts (No.)	Sugarcane area (000 ha)	Growth Rate (CAGRs) Area (%)	PY (%)	Classification of sugarcane districts on the basis of CAGR in area (A) and productivity (Py): Districts	Total	Number of districts: A>1 & PY>1	A(<1& +) & Py >1	A(-) & Py (+)	A(-) & Py (-)	A(+) & Py(-)
Uttar Pradesh	75	2188	0.79	4.05	Total	48	11	13	21	0	3
					Major	29	8	12	9	0	0
Maharashtra	35	901	2.03	-7.22	Total	25	9	1	2	7	6
					Major	16	4	1	2	4	5
Karnataka	29	429	2.94	-1.45	Total	20	4	0	2	8	6
					Major	6	1	0	0	3	2
Tamil Nadu	31	244	-5.54	-1.25	Total	29	0	0	2	24	3
					Major	5	0	0	0	4	1

Note: A and Py is the CAGRs in percent during (2008-09 to 2018-19) in area and sugarcane productivity

Table 7.2 Sugarcane area and productivity growth scenario in intensive districts in major states

State	Area (A) and productivity (Py) growth scenario in intensively sugarcane growing districts: Intensive districts	A>1 &Py>1	A(< 1 & +) &Py>1	A(-) & Py(+)	A(-) & Py(-)	A(+) & Py(-)
Uttar Pradesh	29	Sitapur, Kheri, Pilibhit, Gonda, Bareilly, Hardoi, Shahjahanpur, Behraich	Saharanpur, Kushinagar, Bagpat, Amroha, Badaun, Basti, Ambedkarnagar, Maharajganj, Ayodhya, Rampur, Hapur and Sambhal	Ghaziabad, Moradabad, Muzaffarnagar, Balrampur, Bulandshahr, Azamgarh, Bijnore, Shamli, Meerut	-	-
Maharashtra	16	Sangli, Jalna, Parbhani, Yavatmal	Aurangabad	Nasik, Osmanabad	Beed, Latur, Sholapur, Ahmednagar	Pune, Kolhapur, Satara, Nanddurbar, Nanded
Karnataka	6	Bijapur	-	-	Mandya, Bidar, Gulbarga	Belgaon, Bagalkot
Tamil Nadu	5	-	-	-	Erode, Namakkal, Cuddalore, Thiruvannamalai	Villupuram

Table 7.3 Extent of sugarcane cultivation in different growth categories of sugarcane districts in UP.

Growth Criteria	District (category)	Total	Area (000 ha)	Share in area (%)	Productivity (t/ha)	Sugarcane intensive districts
A>1 and PY>1	Total	16	768.98	34.86	70.37	-
	Main	8	742.82	33.67	74.56	Shahjahanpur, Kheri, Hardoi, Gonda, Bahraich, Bareilly, Sitapur, Pilibhit
A (<1 & +) & Py >1	Total	17	591.55	26.82	72.15	-
	Main	12	570.95	25.88	74.58	Hapur, Kushi Nagar Ambedkar Nagar, Saharanpur, Faizabad, Basti, Budaun, Sambhal, Baghpat, Maharajganj, Amroha and Rampur
A (-) & Py (+)	Total	34	827.96	37.53	67.98	-
	Main	9	755.76	34.26	79.52	Ghaziabad, Moradabad, Muzaffarnagar, Balrampur, Bulandshahr, Azamgarh, Bijnor, Shamli, Meerut
A (-)& Py (-)	Total	2	1.407	0.064	44.68	-
A (+) & Py (-)	Total	6	16.08	0.73	44.68	-

International sugar trade and export opportunities for Indian sweeteners

Indian sugar exports growth, instability as well as the trade environment for sugar exports in the neighborhood, particularly to South Asian Region (SAR) was analyzed. The sugar importers countries were more diversified. Indonesia was the largest sugar importer, accounts for 9.5 % of world sugar imports followed by China (8.5%), USA (5.8%), Algeria (4.4%) and Bangladesh (4.4%). India had exported all-time highest sugar quantity 11.75 million tons during year 2022-23 and earned revenue INR 46,309 crores. The prospects of Indian sugar and other sweetener exports during year 2023-24 could be better on account of international prices prevailing higher than domestic sugar prices. The growth in sugar exports also depend on demands from the domestic biofuel sector.

Trade profiles of SAR Countries

Globally, India is the 5th largest economy in terms of Gross Domestic Product (GDP) and 3rd largest in terms of Purchasing Power Parity (PPP) after USA and China. India's GDP may surpass 4.0 trillion USD during 2024-25 with per capita annual income 2612 USD and 6.3-7.2 per cent growth during year 2023-24. India's aggregate export showed marginal growth of 0.4% with Volume 499.6 billion USD and import was 560.9 billion USD, services imports 116 billion USD during year 2023-24. In order to provide a glimpse of overall and sugar trade pattern and export opportunities in Indian neighborhood, the competitiveness of Indian total and sugar exports in the SAR countries was analyzed by framing suitable indicators for all the countries in the region. The trade environment in SAR was analyzed through indices and ranks such as Ease of Doing Business rank, trading across borders rank, CPIA trade rank, LPI rank and LPI score. In addition, IEMP and HHMC indices were analyzed for different SARCs. The export-import trade indicators were high as compared to other seven South East Asian countries (SEAC) collectively. The analysis of world trade indicators related to trade and logistic friendly environment reveal that India was in comfortable condition. India's position with respect to ease of doing business, trading across borders, LPI score, LPI rank and CPIA rating was high as compared to other Asian countries. India's LPI rank was 44 with LPI score 3.18, while other SEAC have LPI rank beyond 80. India and Maldives have CPIA rating of 4 while other SEACs are having 3.5 CPIA score. The value of HHMC at 0.06 indicates India has diversified trade products profile. The Index of Export Market Penetration (IEMP) indicator measures the extent to which a country's exports reach already proven markets. The IEMP score for India was 31.14, which was high as compared to major sugar and jaggery exporting nations.

India is a large country by geography and demographically in SAR. It is also in terms of economy and trade volume. All the trade indicators (country's GDP, total exports, total import, service exports and services imports) for India are quite high as compared to other 7 SARCs collectively (Table 6.4). Indian exports and imports as per cent of GDP were 18.43% and 20.96%, respectively. Maldives and Bhutan have higher exports as per cent of GDP compared to India. In terms of imports, all other SARCs have higher imports as per cent of GDP in comparison to India. Trade balance per cent of GDP is negative for all SARCs but not for India. It was 2 to 5% while varies 6 to 50% in other SARCs. Trade balance (deficit) was high for Afghanistan, Maldives, Nepal and Bhutan. It means all countries have higher imports as compared to the exports. Trade growth during study period has shown mixed trend, positive in some countries and negative in others. In Afghanistan and Bangladesh, trade growth was higher than the world trade growth while it was comparatively lower in other SARCs. The total exports of SARC in value terms varies from 0.74 billion USD in Nepal to 323.25 billion USD in India. The major export group commodities from India, Pakistan and Nepal are SITC section 6 commodities (goods classified by material) while Bangladesh and Sri Lanka have section 8 commodities (misc. manufactured articles) as major export commodities (Table 6.5). Afghanistan has agriculture (Section 0+1) Commodities (agriculture commodities like food, animals, beverages) as major SITC export group. The major export groups constitute 24.2% to 87.5% share of total exports as in SARCs. The major agricultural export items of different countries in the region are different. In Sri Lanka and Afghanistan tea and grapes are main agricultural export commodity groups, respectively. The major import group items are group 3 (mineral fuels, lubricants), group 6 (goods classified mainly by material) or group 7 (machinery and transport equipment) whose share varies from 22.7 to 28.7% of total imports of respective category. Amongst major agri-export, rice from India & Pakistan, jute yarn from Bangladesh, grapes from Afghanistan, Tea from Sri Lanka and fruit juice from Nepal are main commodities of export. Amongst major agri-import, palm oil in India and Pakistan, wheat in Afghanistan and Sri Lanka, rice in Nepal and cotton in Bangladesh are major commodities. The shares of agri-export commodity as a percent of group total varies from 1.56% for jute yarn from Bangladesh to 14.97% for grapes in Afghanistan. The main agri-import commodity share varies from 1.4% to 6.6% in individual countries.

The analysis highlights that sugar is not a major import or an export commodity in total trade and in agricultural trade in SARCs. The analysis of sugar trade competitiveness reveals that India has comparative advantage in supply-side for sugar

Table 7.4 Trade indicators of South Asian Countries

Indicators	Units	AFGN	IND	MALD	NEPL	PAK	SLNK	BHUT	BNGL
Population 2019	million	37.17	1352.6	0.52	28.09	212.2	21.7	0.75	161.4
Total Exports	bln USD	0.87	323.25	0.18	0.74	23.75	11.74	0.53	31.73
Total Imports	bln USD	8.57	478.88	2.96	10.04	50.06	21.32	0.99	48.06
Trade balance	bln USD	-7.70	-155.63	-2.78	-9.30	-26.31	-9.58	-0.46	-16.32
Trade growth*	%	32.69	0.71	-15.24	3.66	-3.2	3.72	-9.02	2.68
W T growth*	%	-1.13	-1.13	3.5	5.68	-1.13	5.68	-0.01	-6.61
GDP	bln USD	19.29	2870.5	5.64	34.19	278.22	83.98	2.53	302.56
Ser. export	bln USD	0.65	214.76	3.36	1.62	5.87	7.47	0.17	6.21
Ser. import	bln USD	1.21	130.54	1.34	1.71	10.30	4.62	0.22	9.56
Export of GDP	%		18.43	69.02	7.78	10.12	23.13	34.01	15.32
Import of GDP	%		20.96	77.97	41.47	20.32	29.25	50.35	21.44
Applied tariff	%		6.59	11.39	0	8.69	8.72	0	11.82
MFN Tariff	%		8.77	12.03	0	9.82	9.16	0	12.32
T bal. % GDP	2019	-39.92	-5.42	-49.29	-27.20	-9.46	-11.41	-18.18	-5.39
	2018	-	-2.53	-8.94	-33.69	-10.20	-6.12	-16.34	-6.11

Abbreviations used: Applied tariff: Effectively applied Tariff weighted Av tariff or custom duty; MFN Tariff: MFN weighted average tariff; Exports % GDP: Exports of goods and services as percentage of GDP; Import % GDP: Imports of goods and services as percentage of GDP.AFGN, IND, MALD, NEPL, PAK, SLNK, BHUT AND BNGL stands for Afghanistan, India, Maldives, Nepal, Pakistan, Sri Lanka, Bhutan and Bangladesh, respectively.
The (*) asterisk mark shows growth for respective years.

exports to the SA countries (RCA>1) while other SARCs do not have comparative advantage in sugar export. It was observed that India has gain in comparative advantage in sugar export. Hence, there is scope for Indian sugar export in the SA region. India exported sugar and confectionery to 170 to 182 countries in the world. Indian sugar and confectionary exports were worth INR 3015.8 million USD in TE 2021, which grew @ 41.42% per year during past 5 year. The top 5 destination for sugar exports were Sudan, Indonesia, Somalia, Iran and Sri Lanka, which account for 45.29% of sugar exports. It highlights that Indian sugar export was highly concentrated towards a few countries.

Table 7.5 Merchandise Trade profiles of South Asia countries, value in million US $

Trade Parameters	Afghanistan	India	Nepal	Pakistan	Sri lanka	Bangladesh
Total merchandise trade						
Maj. export SITC group	0+1	6	6	6	8	8
Maj. export SITC export val. share	62	24.2	46.5	37.9	46.3	87.5
Major export commodity HS code	0806	2710	5701	6302	09.2	6109
	Grapes	Petro.	carpets	bed linen	Tea	T-shirts
Maj. Export comm. share in T Exp.	14.97	9.5	9.07	14.65	12.42	19.22
Maj. import SITC group	3	3	7	7	6	6
Maj. import SITC import value	22.7	28.4	24.7	22.7	28.7	28.1
Maj. import commodity HS code	2703	2709	2710,	2710,	2710	2710
	Wheat flour	Petro.	Petr. oil	Petroleum	Petroleum	Petroleum
Maj. imp. com. share in total Imp.	9.33	17.55	10.95	9.16	7.47	9.07
Total agricultural trade						
Maj agri. export comm. HS code	806	1006	2009	1006	902	5307
	Grapes	Rice	Fruit Juice	Rice	Tea	Jute Yarn
Maj agri. exp com share in T Exp.	14.97	2.89	6.13	9.45	12.42	1.56
Agri. SITC G imp share in T Imp	20.8	2.3	13.6	7.42	14.2	9.6
Maj. agri. import com. HS code	1101	1511	1006	1511	1001	5201
Maj. agri. import commodity name	wheat	Palm oil	rice	Palm oil	wheat	cotton
Maj. agri. imp. com. share in T Imp	6.59	1.39	2.45	4.61	2.34	4.64

Notes: a) SITC code description is: 0+1 for Food, animals, beverages and tobacco (Agriculture), 2+4 for crude materials + animal & veg oils, 3 for mineral fuels, lubricants, 5 for chemicals, 6 for goods classified chiefly by material, 7 for machinery and transport equipment, 8 for misc. manufactured articles and 9 for not classified elsewhere in the SITC.

b) Major commodity refers to if the commodity is in the top 10 exporting or importing commodities.

c) The figures for Nepal are of 2017, for Afghanistan 2019 year, for Bangladesh of 2015 year and for other countries these pertain to year 2020.

Mark @ shows petroleum oils other than crude; and # shows petroleum oils and oils obtained from bituminous minerals, crude.

Indian sugar export was 11.75 million tons during 2022-23 season and permitted 6.1 million tons sugar export during year 2023-24 due to an expected drop in sugar production to 34.2 million tons in 2023-24, as compare to 35.8 million tons during previous season. The sugar price was on higher side INR 49-50,000 ($604.6) per ton from overseas sale against domestic price INR36-38,000 per ton. Top 3 product categories for Indian sugar exports to Sudan are HSN code 17019990, HSN 17011390 and HSN code 17011490.

Indonesia has also emerged as a major buyer of Indian sugar due to many specific factors such as old factories, reduce sugarcane yield, processing inefficiency and low productivity, poor market imports regulation, low consumer's preferences for sugar from domestic producers as industrial sugar demands met from imports, and local sugar lobbies (food and beverage sector) keen to protect their market segment from imports despite government self-sufficiency approach, and demand from biofuel producers due to regulations regarding mandatory biofuel requirements to reduce its reliance on fossil fuels. Three South Asia countries viz., Sri Lanka, Bangladesh and Afghanistan are amongst top 10 countries demanding Indian sugar exports (Table 7.6). A country specific sugar demand preferences need to be analyzed and appropriate strategies should be adopted to enhance sugar export to the SAR countries. The Trade Intensity Index (TII) of more than one for Indian sugar imports in SACs indicates bilateral trade flow is larger than expected, given the partner country's importance in world trade.

Estimation of cost of cultivation of sugarcane in Uttar Pradesh during 2023-24

The cost of sugarcane cultivation in Uttar Pradesh for the sugarcane production year 2023-24 was estimated on the basis of primary data collected from 80 farmers from 6 districts (Three districts each from Western, and Central Region) on the basis of PRA techniques during June-Sept. 2023. The cost of cultivation worked out for plant and ratoon crop was INR 3180 and INR 3100 per ton, respectively. The average cost of sugarcane cultivation was INR 3140 per ton. During the year, the average sugarcane productivity was found to have declined due to wide spread red rot disease in the leading cane variety Co 0238 in U.P. The area under this variety has declined from 72.87 to 59.9 % as compared to past year. The estimates of per ton cost of sugarcane were also communicated to the Cane Commissioner, Sugar Industry and Sugarcane Department, Government of Uttar Pradesh as an advisory note also for its consideration during meeting for the fixation of sugarcane advice price (SAP) in UP.

Development and evaluation of sugarcane crop image dataset for varietal identification

Sugarcane variety recognition and its authentication is essential for seed quality assessment especially for seed testing and certification. PPV&FRA of India has developed guidelines for Distinctiveness, Uniformity and Stability (DUS) of sugarcane varieties with 27 visual and measurable morphological characters. These guidelines are used for distinctive, uniformity and stability testing of sugarcane varieties developed in India. However, correct identification requires detailed knowledge of morphological descriptors of cane varieties and lot of experience in traditional system. The computer vision based techniques such as detection, segmentation, are useful to handle these descriptors for varietal identification. It is a field of artificial intelligence that enables computers to derive meaningful information from digital images, videos and other visual inputs and take actions or recommendations based on data information.

Table 7.6 Direction of Indian sugar exports during 2017-18-2021-22

	Countries	Million US$	GR %	Share (%)
1	Sudan	384.7	26.17	12.76
2	Indonesia	341.6	275.79	11.33
3	Somalia	239.4	71.65	7.94
4	Iran	207.7	92.09	6.89
5	Sri Lanka	192.4	68.66	6.38
6	Bangladesh	180.4	91.93	5.98
7	Djibouti	153.3	69.66	5.08
8	United Arab Emirates	137.6	24.33	4.56
9	Afghanistan	131.0	385.53	4.34
10	Saudi Arabia	102.7	45.64	3.41
	World	3015.8	41.42	100.0
	Top 5 countries	1365.8	-	45.29
	Top 10 countries	2070.8	-	68.67

Note: Growth rate % has been calculated for the year 2017-2021

A field trial with 24 early and mid-late sugarcane varieties recommended for commercial cultivation in subtropical has conducted in two replications. The cane varieties in early group were CoLk 14201, CoLk 15466, CoLk 11203, CoS 17231, CoLk 09709, CoLk 16202, CoLk 15201, CoS 13235, Co 0118, CoLk 94184, CoLk 12207, Co 0238, while in mid-late group were CoS 767, CoS 08279, CoLk 09204, CoLk 11206, CoLk 15207, Co 05011, CoPant 97222, CoLk 12209, CoLk 14204, CoLk 15206, Co16030, CoPb 14185. Image data set and machine learning algorithms are essential part of computer vision. A large and diverse set of images are used to develop image dataset that can be used to develop algorithms for computer vision tasks of classification, detection, segmentation, etc. Approximately, 30,000 images of sugarcane crop have been collected at 15 days interval for descriptor classes of plant, leaf, leaf sheath, internode and cane node. The measurable characters viz. internode diameter, bud size, root band size and cane height were also recorded. Images were recorded in raster form with file name convention suitable for images classification with respect to objects covered and image properties. Image annotation process has started using rectangle bounding box and polygon techniques. Online free annotation tools have been used to annotate images and record coordinates in JSON, XML and CSV formats for feature engineering and annotation (for visual descriptors as per DUS guidelines) to develop object based varietal identification models.

A study of Internet of Things and Artificial Intelligence enablers in sugarcane farming system

A review of 351 research articles and keywords search about Internet of Things (IoT) in field crops reveals technologies used in such solutions under seven classes of field crop applications. The architecture of IoT implementation is important for reliability and accuracy results. The results of IoT technologies have been shown under perception, network, and processing layers of IoT architecture.

Perception Layer: Perception layer is the first physical layer of IoT architecture responsible for sensing and managing objects in real world. Physical devices in this layer in the form of sensors, actuators and embedded systems enables communication with objects at physical level and are responsible for collecting data. Literature review of IoT in field crops shows usage of sensors, wireless sensor network, microcontrollers, and carriers at perception layer.

a. Sensors: About 63% articles showed usage of sensors in field crop activities to monitor objects in this system. Major sensors found usage in field crops are soil moisture sensor, temperature sensor, humidity sensor, rain sensor, water level sensor, light sensor, pH sensor, camera, etc. Humidity, temperature and moisture sensors are in highest usage to monitor substrate and environment of field crop. Subsequent important sensors shown by literature are to monitor rain, light, water level, soil pH, geo-location, motion, fire, etc. Wireless Sensor Network (WSN) has been used for field crop activities viz. environment monitoring, growth stage monitoring & harvesting, irrigation management, crop protection, supply chain management, and soil monitoring.

b. Platform: Carrier /centralized hub is used to integrate devices and to facilitate data storage, data processing and communication at perception layer. Study found that 10% articles covered information about carriers / platform in case of field crop activities. Robots (50%) and Unmanned Aerial Vehicle (UAV) (34%) found to be in maximum usage among carriers. Obvious reasons for Robot use in field crops activities is their possible entry in hazardous conditions, remote control, versatile applications, etc. Robots has been found useful in agriculture activities viz planting & related operations, soil monitoring, growth stage monitoring & harvesting, irrigation management, and crop protection. UAV has been used for crop protection, soil monitoring, and environment monitoring activities. Use of UAV for crop monitoring is due to the potential to accelerate monitoring, optimize pesticides & fertilizers and reduce cost. Other important platforms found in this study for field crop applications are cablebot, stick, trap and smart transport. Sticks has been used for environment monitoring, while traps seen for crop protection activities.

c. Microcontrollers: 29% field crop articles mentioned microcontroller usage for monitoring and controlling various components of an IoT solution. These Single Board Computers (SBCs) has been used as sensor nodes and gateways. Among the papers that mentioned microcontrollers, 77% mentioned the use of Arduino, Raspberry Pi and ESP boards (such as ESP8266, ESP12 and ESP32). Arduino is the most commonly used embedded system platform followed by Raspberry Pi and Node / ESP. Usage of microcontrollers has been seen in all field crop activities.

Network Layer: About 29% articles revealed use of network / communication technologies for data transfer among objects in IoT implementation. Based on characteristics viz. data exchange rate, range and power consumption, communication technologies can be classified in short-range, mid-range and long-range. Wi-Fi is the most common short and mid-range wireless network technology with over 33% usage. Use of Wi-Fi technology for communication has been seen in agricultural activities namely, growth stage monitoring & harvesting, irrigation management, planting related operations, soil monitoring, crop protection, and environment monitoring. Extensive use of Wi-Fi can be justified by the fact that Wi-Fi is a ubiquitous technology and, therefore, easy to implement. ZigBee and Bluetooth are the most used short and mid-range wireless networks after Wi-Fi with usage percentage of 11% and 6% respectively. There usage characterizes with low-energy consumption give them better chance for usage in rural and remote areas. Use of ZigBee technology seen in agricultural activities namely, environment monitoring, irrigation management, growth stage monitoring, and soil monitoring, while use of Bluetooth technology seen in crop protection, and soil monitoring. BLE based communication was shown in growth stage monitoring & harvesting, environment monitoring, irrigation management, and crop protection activities. LoRaWAN and cellular network (e.g., GPRS, 3G, 4G, etc.) has been used mostly for long-range wireless networks with 11% and 14% usage respectively. 3G / 4G based communication has been utilized for agriculture activities of irrigation management, crop protection, and environment monitoring, while LoRa technology used in environment monitoring, growth stage monitoring & harvesting, and soil monitoring activities. Use of other communication technologies such as Cognitive Radio, NFC and RFID also found in literature for irrigation management and supply chain management activities.

Processing Layer: Processing layer comprises of data storage, visualization and processing resources. An increasing usage trend of AI / Advance technologies such as machine learning / deep learning, cloud computing and big data has been found in IoT implementation. Literature review reveals 25% articles cited use of AI and Advance computing technologies at processing layers. The most cited technologies within above reviewed articles are cloud computing, machine learning / deep learning, big data, block chain and augmented reality. Computer vision technologies and machine learning / deep learning technologies has been utilized for agriculture activities viz. growth stage monitoring & harvesting, soil monitoring, crop protection, irrigation management, planting & related operations, while cloud technology usage found in agriculture activities of environment monitoring, growth stage monitoring & harvesting, irrigation management, crop protection, soil monitoring activities. Literature shows utilization of big data technology for environment monitoring, growth stage monitoring & harvesting, irrigation management, supply chain management. Similarly, usage of block chain technology and augmented reality application has been seen in crop protection and growth stage monitoring & harvesting activities.

Technologies/ products/ apps developed

Fertilizer Calculator Mobile App

Converted Mobile App in bi-lingual mode to estimate fertilizer requirements in Sugarcane cultivation for targeted yield. App ask for current soil test values of N, P, K, FYM rate and target yield required for plant or ratoon crop. Based on loaded STV and target yield, it calculates desired N, P, K. Further, it estimates quantity of urea, DAP and MoP to be applied. App is available for sugarcane cultivation in North Indian conditions. Total download reached 0.5K+.

CHAPTER 8

Biological Control Centre, Pravaranagar, Maharashtra

Utilization of entomopathogenic nematodes (EPNs) against white grubs infesting sugarcane

A. Bio efficacy of *Heterorhabditis indica* against 3rd instar grubs of *Holotrichia serrata*: The third-instar grubs of *Holotrichia serrata* were challenged with two different native strains of *Heterorhabditis indica* (strains KOP HT and HT) at different infective juveniles (IJs) dosages. The grub mortality of each instar was monitored (DAI: days after EPN inoculation). The lowest grub mortality was observed at a dose of 2000 IJs per grub (66.5% and 70.4%) for both native strains after 7 and 8 DAI, respectively. The higher grub mortality was seen at a dose of 10000 IJs per grub (93.7% and 94.5%) for both strains after 5 to 6 DAI, respectively. A positive correlation was observed between the different levels of IJs dosage with increasing grub mortality (Fig. 8.1)

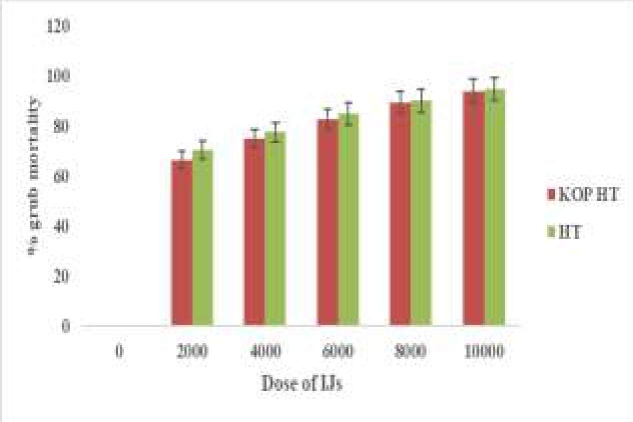


Fig. 8.1 Percent grub mortality in the 3rd stage of Holotrichia serrata due *to* Heterorhabditis indica *infection*

B. Bio efficacy of EPN against white grub under field conditions: The white grub-infested sugarcane (cv. CoM 0265) plot (25 m^2) was inoculated with a liquid suspension of *H. indica* in water (2-litre suspension containing 10000 IJs per clump). The drenching of Fipronil 40% + Imidacloprid 40% WG was kept in as control. The clump mortality % of *H. indica* treated plot was 16.58% compared to 35.89% in the untreated control 20 days after application. Very few EPN-killed grubs were observed in the plot (1 to 2 grubs per clump) (Fig. 8.2).

Fig. 8.2 Heterorhabditis indica killed white grubs observed in sugarcane field

c. Feasibility of white grub for IJs production: Field-collected EPN-killed grubs were brought into the laboratory, washed thoroughly, and put in a White trap for the emergence of IJs. The infective juveniles were collected daily from the White trap and counted for the next 5 to 6 days (144 hr). On an average, the EPN-killed grubs produced (91313 IJs per grub) when compared to *G. mellonella* (139029 IJs per grub). Also, the increasing trend of IJs production was observed up to 96 hr however the grub cadavers began to decay after 144 hr (Fig. 8.3). The study shows that the IJs were produced in maximum numbers on white grub when assayed under field conditions.

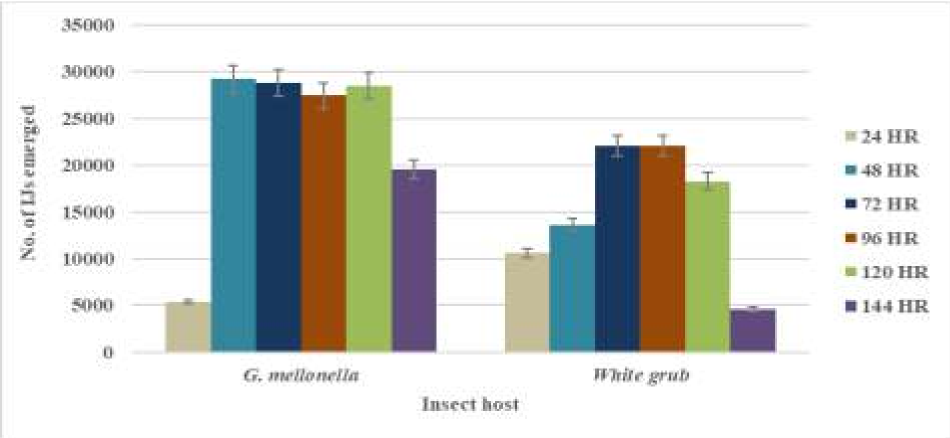


Fig. 8.3 Infective juveniles (IJs) production per larvae on insect host

C. Pathogenicity of EPN against adult beetles and pupae of *H. serrata*: The adult beetles and pupa stage of *H. serrata* were vulnerable to EPN infection. Our laboratory assay suggested that exposing freshly emerged *H. indica* (@ 10000 IJs per beetle and 500 IJs per pupa) kills both stages at various intervals. The beetles were found dead within 48 to 96 hours of post-EPN infection (24% to 69% beetle mortality) while pupae were found to be dead after 4 to 7 DAI.

D. Survey and soil sampling for isolation of native strains of EPNs: A random stratified soil sampling was conducted in white grub-infested sugarcane fields at different locations in Ahmednagar (Dadh Kh, Ashwi Kh. cv. Co 86032 & CoM 0265) and Satara (Rajale, Sathe cv. MS10001) districts of Maharashtra. On an average, 80 soil samples were composed in earthen pots and baited with 5 to 6 last larval instars of *G. mellonella*. Brick red-colored dead Galleria larvae were spotted after 10 days in only 11 soil samples (13.75% frequency of EPN occurrence). Three EPN strains were retrieved and stored separately for mass production.

E. Morphological characterization of EPN strains: The retrieved EPN strains were inoculated to the Galleria larvae and was the mortality. The larval cadavers were dissected in Ringer's solution at different intervals to examine the mature adult stages inside. Occurrence of first-generation hermaphrodite females (after 2 to 4 days upon EPN infection), second-generation females and males (after 5 to 8 days upon EPN infection) with their distinct morphological features *viz.*, presence of mural tooth, rosette formation in juveniles, pointed mucro, median and protruding vulva in females, bursal rays at tail tip, testes reflection in males suggested that these EPN strains belong to *Heterorhabditis* sp. (Fig. 8.4).

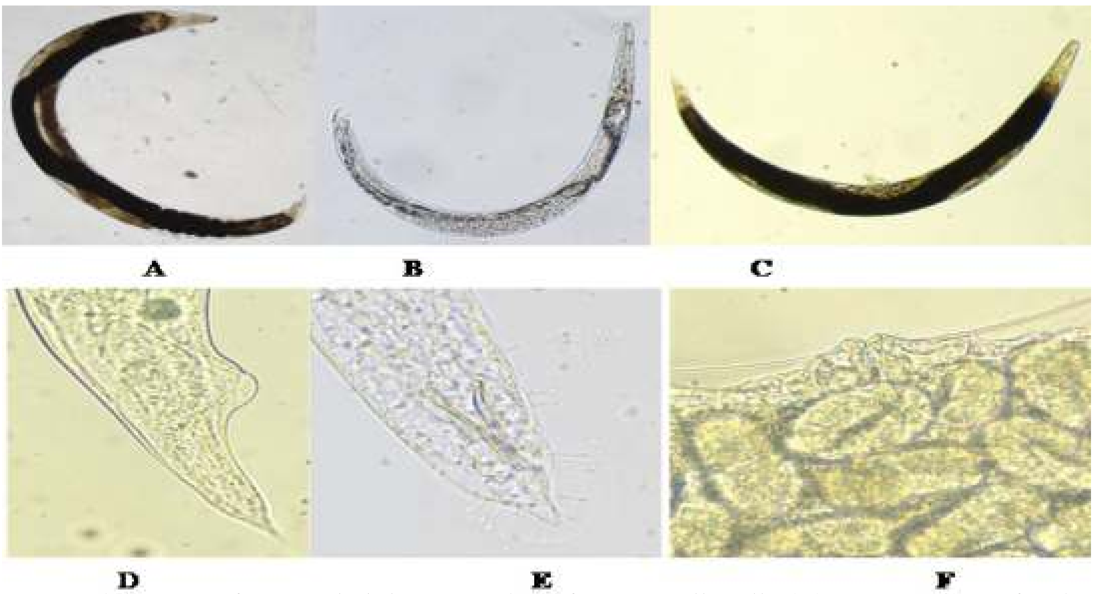


Fig. 8.4 *Mature adult stages of* Heterorhabditis *sp. isolated from* G. mellonella *(A) First generation female (B) Second generation male (C) Second generation female (D) Female tail with pointed mucro and preanal swelling (E) Bursal rays at mail tail tip (F) Protruding vulva*

Bio-prospecting of entomopathogenic bacteria for management of white grubs infesting sugarcane

The initial screening of entomopathogenic bacteria *Paenibacillus* sp. isolates (LL1) and *Bacillus* sp. isolates (Btg1 and Btg2) was conducted for insecticidal activity against the F1 population of lab-reared *H. serrata* 2nd instar grubs. In Bt1 treated grubs 40% mortality was observed on the seventh week after inoculation. However, 20 % and 40% mortality were reported in Bt2-treated grubs on the sixth and seventh weeks after inoculation respectively (Table 8.1). The treated grubs showed no significant after fifth week of inoculation indicating that protein from spores inhibited ingestion (Fig. 8.5). Both isolates were identified as *Bacillus thuringiensis* by 16S rRNA partial sequencing (Bt1 designated as IISRBCCEB01, Acc. No. OQ504327 and Bt2 designated as IISRBCCEB02, Acc. No. OQ504330).

Table 8.1 Insecticidal activity of *Bacillus* sp. against the second instar grubs of *H. serrata*

Treatment	Mortality (%)									
	Weeks after inoculation									
	1	2	3	4	5	6	7	8	9	10
Bt1	0	0	0	0	0	0	40	40	40	40
Bt2	0	0	0	0	0	20	20	20	40	40
Treated control	0	0	0	0	0	0	0	0	0	0
Control	0	0	0	0	0	0	0	0	0	0

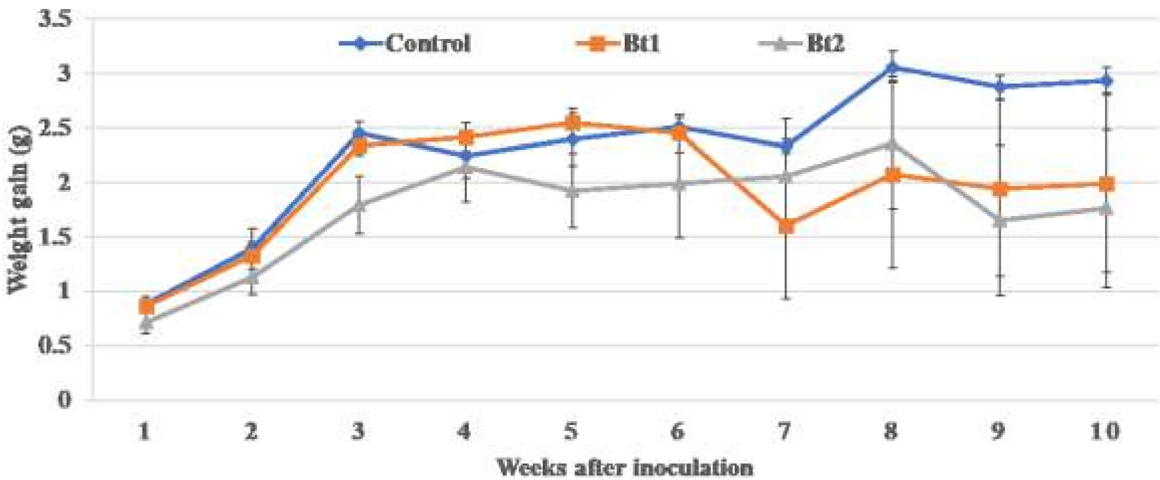


Fig. 8.5 Weight gain in third instar grub of H. serrata treated with Bacillus thuringiensis isolated Bt1 and Bt2 spore formulation

In grubs treated with LL1 isolates with spore loads of 2x10^{6} and 2x10^{8}, about 20%, 40%, and 60% mortality was seen on the fourth, fifth, and sixth weeks after inoculation; in contrast, with a spore load of 2x10^{10}, 20% and 40% mortality were observed on the fourth- and sixth-weeks following inoculation. However, the grub treated with LL1 isolates with 2x10^{12} spore load showed 60% mortality after the third week of inoculation (Table 8.2). The weight gain in treated grubs was not significant after the second and third week after inoculation of formulation with spore load 2x10^{12} and 2x10^{6}, 2x10^{8}, and 2x10^{10} respectively, which indicated that protein from spore inhibited ingestion (Fig. 8.6).

Table 8.2 Insecticidal activity of *Paenibacillus* sp. against the second instar grubs of *H. serrata*

Treatment	Mortality (%)					
	Weeks after inoculation					
	1	2	3	4	5	6
2X10^6	0	0	0	20	40	60
2x10^8	0	0	0	20	40	60
2x10^10	0	0	0	20	20	40
2x10^12	0	0	60	60	60	60
Treated control	0	0	0	0	0	0
Control	0	0	0	0	0	0

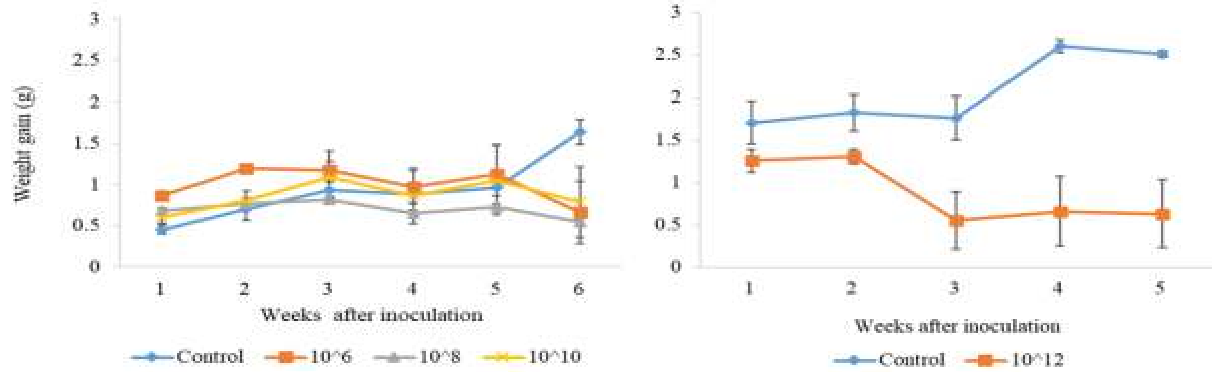


Fig. 8.6 *Weight gain in third instar grub of H. serrata treated with Paenibacillus sp. LL1 spore formulation*

Diversity profiling and management strategies of bacteria associated with post-harvest sucrose bio-deterioration in sugarcane

The dominant microflora associated with post-harvest sucrose degradation in sugarcane was estimated by a total viable count at 0, 2, 4, 6, 8 and 10 days after the harvest under two scenarios of harvesting methods i.e., manual (whole cane) and mechanical (billets) during late milling season. There was a dominance of bacterial count followed by mold and yeast irrespective of harvesting methods, cultivars, and storage, however, their proportion varied with days of storage (Fig. 8.7) In CoM 0265 gum-producing bacterial (GPB) populations were 50, 60, 51, 40, 34 and 34% in whole cane whereas in billets were 61, 54, 36, 30, 27 and 23%. The population of sucrose - degrading (SDB) bacteria were 15, 18, 23, 37, 43 and 38% while 16, 9, 35, 29, 32, and 37% in whole cane and billets of CoM 0265. Mold population was 13, 18, 15, 13, 13 and 15% in whole cane whereas 16, 26, 21, 23 and 20% in billets of CoM 0265. The yeast population ranged from 11-14% and 7-26% in whole cane and billets of CoM 0265, respectively.

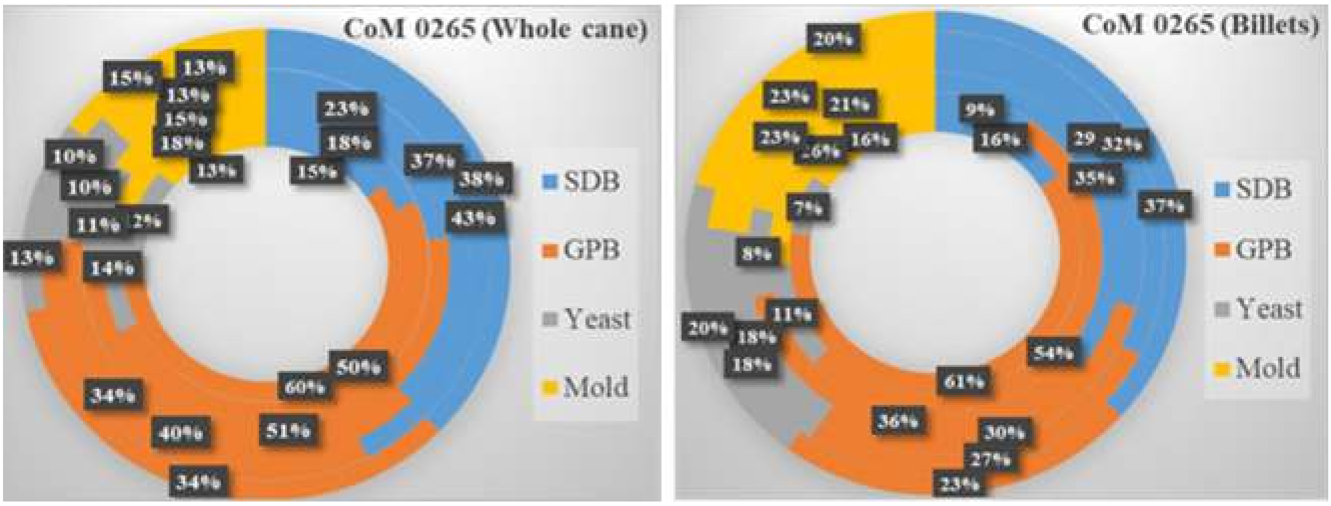


Fig. 8.7 *Distribution of microbial count in whole cane and billets in CoM 0265 over the storage period*

The order of increase of microbial population in whole cane was sucrose utilizing bacteria>gum-producing bacteria>mold>yeast whereas in billets it was gum-producing bacteria>sucrose utilizing bacteria> mold>yeast in Co86032 (Fig. 8.8). The population of gum-producing bacteria ranged from 39%-21% and 74%-32% while the sucrose-utilizing bacterial population ranged from 33% - 45% and 15%-36% in whole cane and billets of Co 86032. The yeast and mold population were in the range of 11%-14% and 14%-19% in whole cane and 5%-14% and 6%-25% in billets of Co 86032. Sucrose-utilizing bacteria were isolated from sugarcane juice using an enrichment culture technique (McCleskey et al 1947). A total of twelve distinct bacterial strains were isolated based on colony characters. There was an increase in total CFU/ml with storage time, however, bacterial isolate counts varied over a period and harvesting methods. The highest counts of isolates number 4, 8, 10 and 1, 5, 6, 8, 10 were found in CoM 0265 entire cane and billets, respectively. In whole cane, the order of greatest count was 9>8>10>4>3>1, but in billets, the sequence of increase was 7>10>8>3 as recorded in Co 86032 (Fig. 8.9).

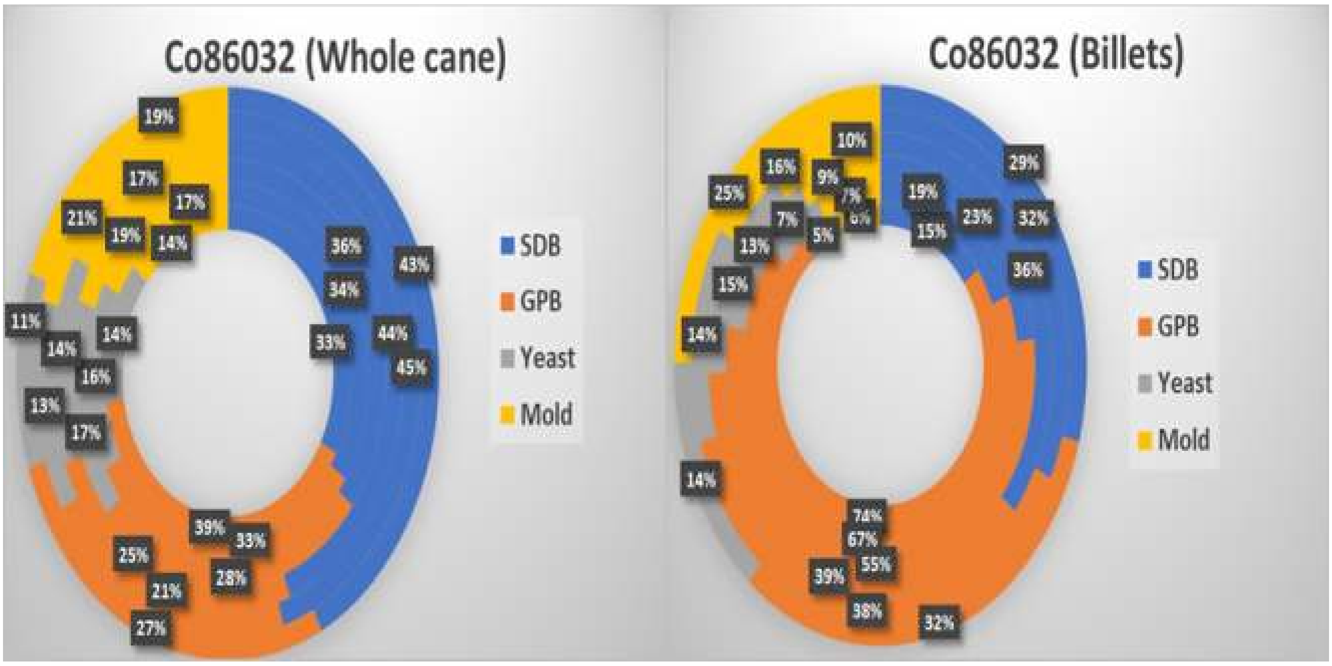


Fig. 8.8 Distribution of microbial count in whole cane and billets in Co 86032 over the storage period

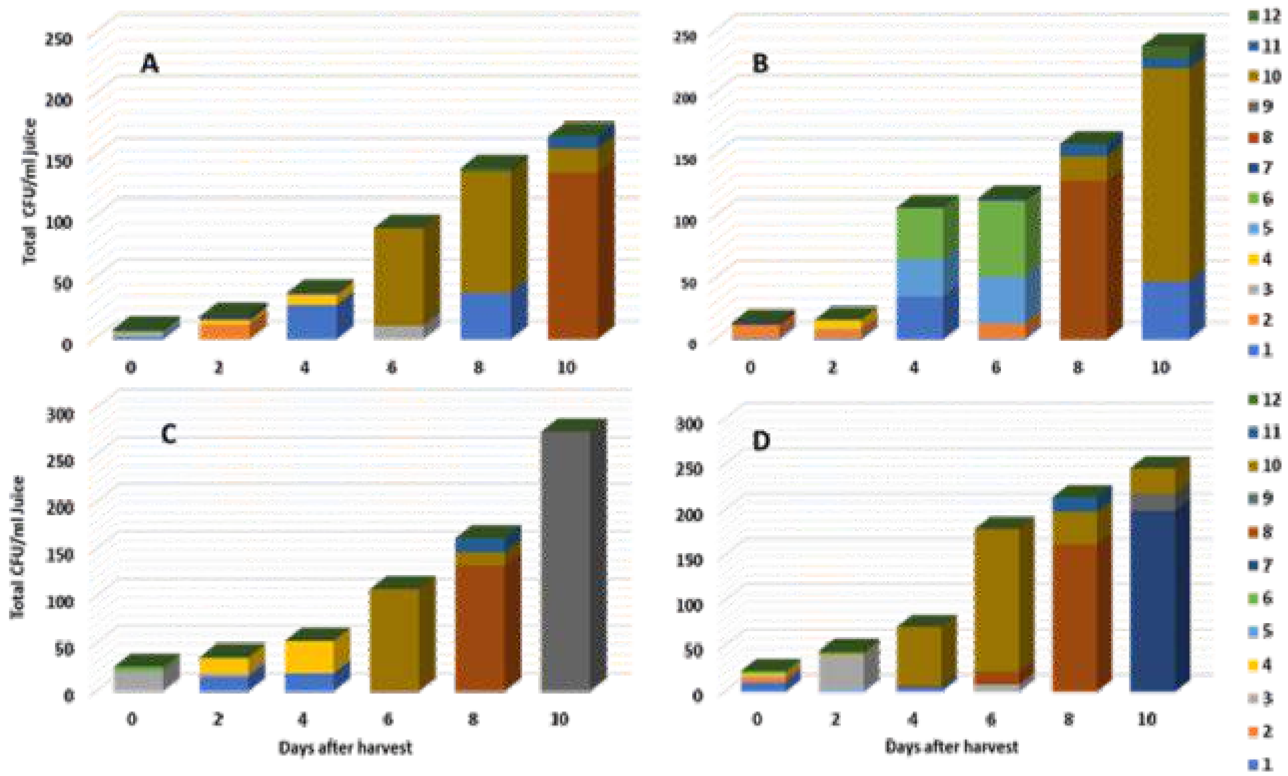


Fig. 8.9 *Abundance of sucrose utilizing bacterial population over the storage period; CoM 0265- manual(A), mechanical (B); Co86032- manual (C), mechanical (D)*

Gum-producing bacteria were isolated from sugarcane juice using a modified dextransucrase-inducing agar medium. Based on colony features, thirteen different morphotypes were identified from sugarcane juice collected from whole cane and billets kept for 0-10 days. The highest count of isolates 6, 2, 9, and 7 were observed in whole cane, while higher counts of isolates 6, 9, 1, and 5 were reported in billets of CoM 0265. In contrast, the highest count of isolates 6, 5,2,1,10 and isolates 9, 6, 13, 5 and 2 were observed in whole cane and billets respectively in Co 86032 over the storage period (Fig. 8.10)

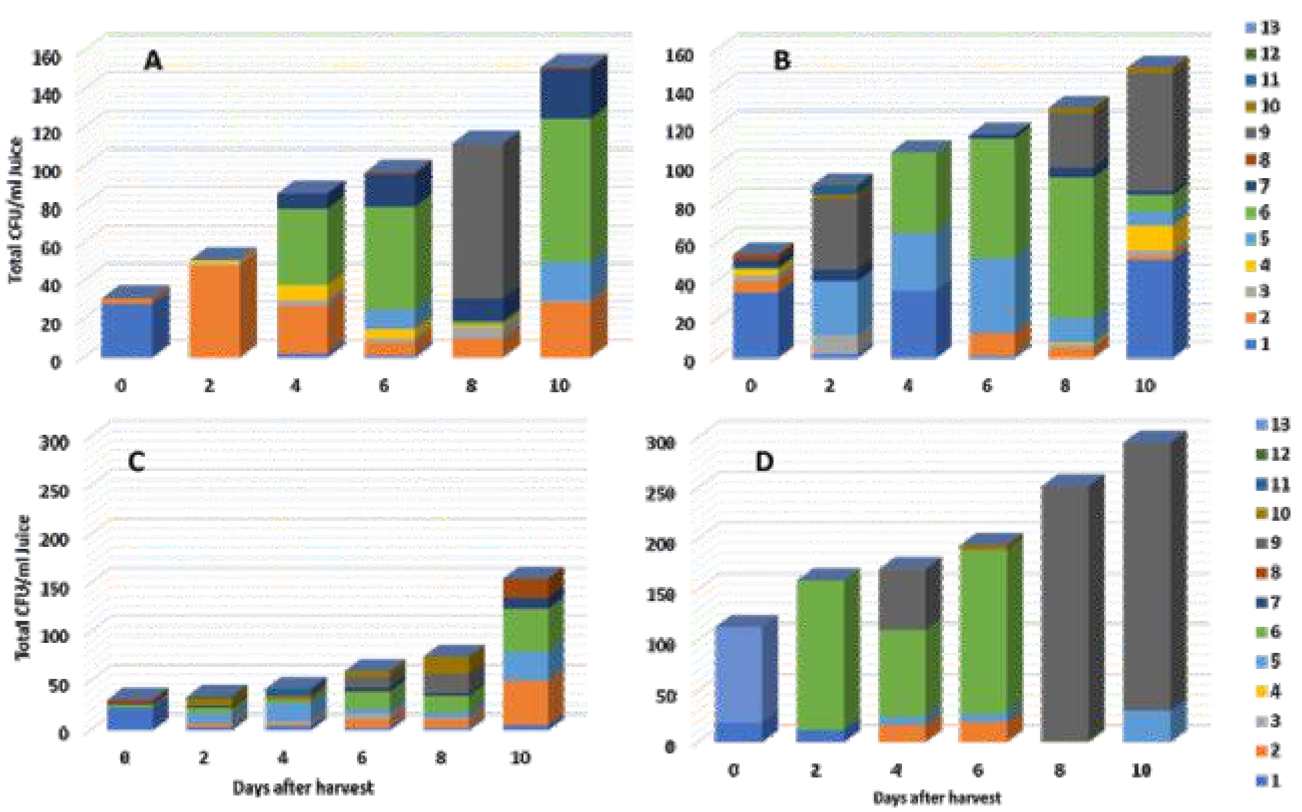


Fig. 8.10 Abundance of gum-producing bacterial population over the storage period CoM 0265- manual (A), mechanical (B); Co 86032- manual (C), mechanical (D).

The fermentation test of sucrose utilizing bacteria showed that all the isolates except isolates 1, 2, 3, 5, 6 were able to utilize sucrose, however, there was variation in their ability to use pentoses and mannitol. Isolates 1, 3, 5, 7, 9, 11, and 12 are homofermentors, while isolates 2, 4, 6, 8, and 10 are heterofermentors.

The fermentation test for gum-producing bacteria showed that except for isolates 1 and 12, all isolates were able to use sucrose. However, all isolates except no.1 could use pentoses and mannitol. The isolates nos. 1, 2, 3, 4, 5, 6, 8, 9, 10, and 12 are homofermentors, while 7 and 11 are hetero-fermentors (Table 8.3)

Table 8.3 Sugar utilization pattern in sucrose degrading (SDB) and gum-producing bacteria (GPB)

Isolates	Fermentation reaction													
	Sucrose		Xylose		Arabinose		Glucose		Mannitol		Lactose		Sorbitol	
	SDB	GPB	SDB	GPB	SDB	GPB	SDB	GPB	SDB	GPB	SDB	GPB	SDB	GPB
1	+/-	-/-	-/-	-/-	-/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-
2	+/+	-/-	+/+	+/+	+/+	+/+	+/-	+/+	+/+	+/+	+/+	+/-	+/+	+/+
3	+/+	-/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/+	-/-	-/-	-/-	+/-
4	+/+	+/+	+/+	+/+	+/+	+/+	+/-	+/+	+/+	+/+	+/-	+/-	+/+	+/+
5	+/+	+/+	+/-	+/-	+/+	+/+	+/-	+/-	+/-	+/+	+/+	-/-	+/+	-/-
6	+/+	-/-	+/+	+/+	+/+	+/+	+/-	+/+	+/-	+/+	+/-	+/-	+/+	+/+
7	+/+	-/-	+/+	-/-	+/+	-/-	+/+	+/-	+/+	+/-	-/-	-/-	+/+	-/-
8	+/+	+/+	+/-	+/+	+/-	+/+	+/-	+/+	+/-	+/+	-/-	-/-	+/-	-/-
9	+/+	+/+	+/-	+/-	+/-	+/-	+/-	+/-	+/-	+/-	-/-	-/-	+/+	-/-
10	+/+	+/+	+/-	+/+	+/-	+/-	+/-	+/+	+/-	+/+	-/-	+/-	-/-	+/+
11	+/+	+/+	+/+	-/-	+/+	+/-	+/+	+/-	+/+	-/-	+/-	-/-	+/+	-/-
12	+/-	+/-	+/-	-/-	+/-	-/-	+/-	+/-	+/-	-/-	-/-	-/-	-/-	-/-

The sucrose biodeterioration potential of bacteria was determined by measuring sucrose % (Pol% juice) in filtered sterilized (0.22µ membrane) 100mL juice inoculated with bacterial isolates after 6hrs and 12hrs after incubation. After six hours of inoculation, gum-producing bacterial isolate no. 10 was found to be the highest sucrose degrader followed by isolates no. 4, 2, and 8, whereas after 12hrs after inoculation, isolate no. 3, 4, and 8 showed the highest sucrose deterioration followed by isolates no. 6, 7, and 8 (Fig. 8.11A). Sucrose utilizing bacterial isolates nos. 11 and 12 showed the highest sucrose degradation ability after 6 hours of inoculation, followed by nos. 9, and 10. Furthermore, isolates nos. 11 and 12 also had the highest potential for sucrose degradation after 12 hours of inoculation (Fig. 8.11). The sucrose utilizing bacterial isolate no. 2, 3, 4, 7, 10, and 11 were identified as *Klebsiella* sp., *Pantoea dispersa*, *Enterobacter* sp. (IISRBCCSB02, Acc. No. OQ504353) *Lysinibacillus* sp., *Klebsiella* sp. (IISRBCCSB01, Acc. No. OQ504350) and *Pantoea agglomerans*, based on 16S rRNA partial sequences respectively.

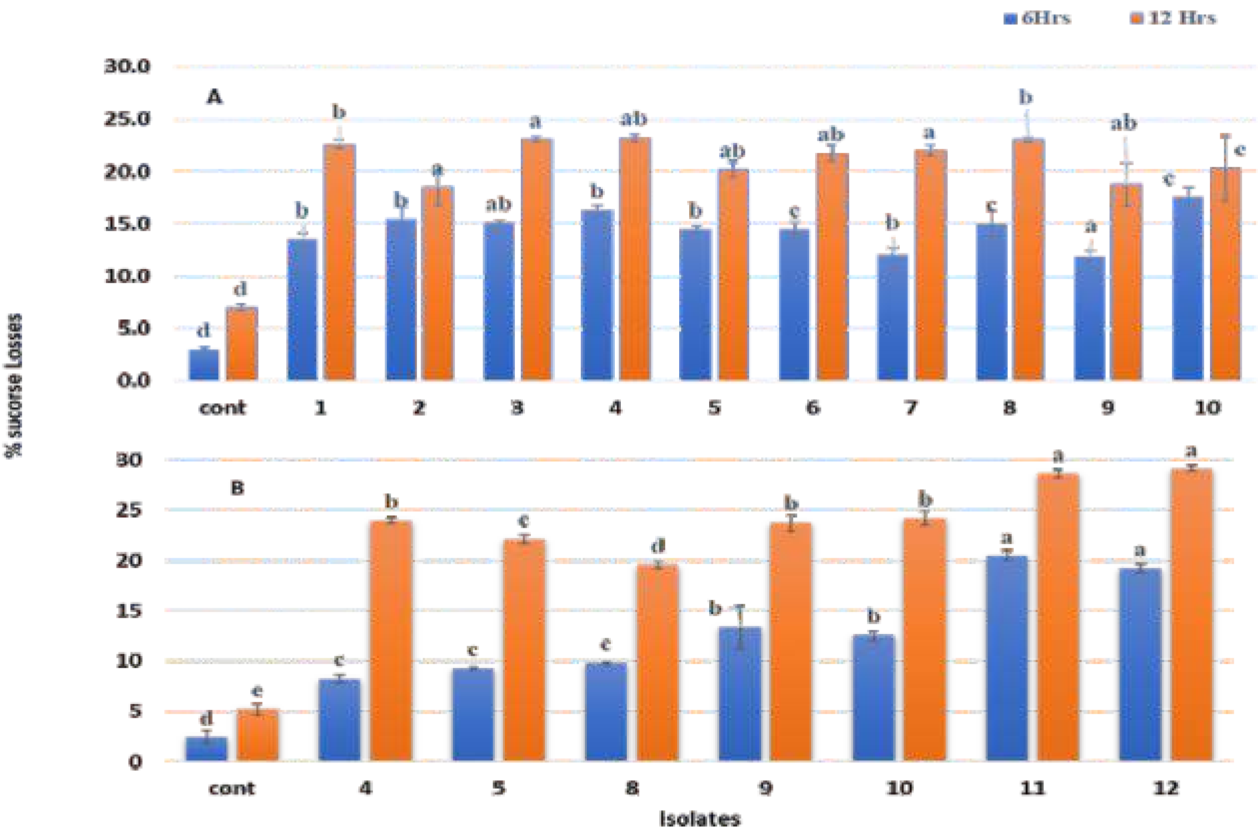


Fig. 8.11 Sucrose degradation potentials of gum-producing (A) and sucrose-degrading (B) bacterial isolates

Survey and surveillance of insect pests and diseases of sugarcane in the tropical area (Maharashtra).

Survey and surveillance were conducted in the command areas of Pravara, Korpewadi, Sanjeevani, Ashok, Sangmner, and Rahuri Cooperative Sugar Mills of the district Ahmednagar and sugarcane growing area of the district Nashik and Jalgaon, Maharashtra for the seasonal prevalence of diseases and pests in the sugarcane fields.

a. **Incidence of diseases:** The major incidences of disease *viz*., brown spot, rust and pokkah boeng were observed in the range of 75 to 97%, 40 to 80%, and 25 to 45%, respectively in the sugarcane fields surveyed. The incidence of yellow leaf disease (YLD) was recorded to be 20 to 30% in CoM 0265 and ratoons of Co 86032 and a minor incidence of sugarcane leaf scorch (10% to 20%) was also reported in both varieties. The smut incidence of 50-80% was observed on VSI 8005 variety in Chopda Tahsil of the district Jalgaon (Fig. 8.12).

b. **Identification and pathogenicity of *Fusarium* species associated with pokkah boeng of sugarcane in Maharashtra:** In this study, twenty isolates of *Fusarium* sp. associated with sugarcane pokkah boeng from top rot and knife cut symptoms and eight isolates from VSI 8005 and CoM 0265 were isolated, purified, and maintained at IISR-BCC, Pravaranagar (Fig. 8.13). Pathogenicity test indicated that all the isolates produced disease symptoms in CoM 0265 cultivar with disease

Fig. 8.12 Incidence of diseases a: Brown spot-reddish brown to dark brown oval shape spot; b- Pokkah boeng, top rot and puncture leaves with necrosis symptoms; c- Brown rust- mass of uredospore on sub-epidermal uredinia; d-yellow leaf – yellowing of midrib; e-Smut- whip tail symptoms.

severity index ranging from 14.30 to 26.89 and 10 to 68.89 in leaf axil inoculated and sett inoculated plants respectively (Table 8.4, 8.5). The colony color, growth pattern, and pigmentation were also recorded and the growth rate of these isolates varied from 1.18 to 2.88 mm per day. Symptoms reported during the pathogenicity test are chlorosis and necrosis of leaves, punctured lesions, twisted leaves, reduction of the total leaf area, death of the plan top, and stalk rot. The PCR amplification conditions were optimized for translation elongation factor 1 alpha gene (EF1aF- 5' -ATC AAC CTC GTC GTT ATC GGC CAG G-3'& EF1aR-5' -TCA GAC TTC ACG TTG TCG AGG ACC C-3'), β-tubulin gene (Bt2aF-5' -GGT AAC CAA ATC GGT GCT GCT TTC-3'& Bt2aR-5' -ACC CTC CGT GTA GTG ACC CTT GGC-3'), actin gene (ACT-512F-5' -ATG TGC AAG GCC GGT TTC GC-3' & ACT-783R-5'-TAC GAG TCC TTC TGG CCC AT-3') and MAT-1 allel (MAT1F- 5' TCT GCC ATC GAA ACC CTC AC3' & MAT 1R- 5' GAC GGT GAC ATA GTA GCG GG3') in *Fusarium* sp. isolates. All the isolates of *Fusarium* sp. contain the MAT-1 allele of the mating type locus.

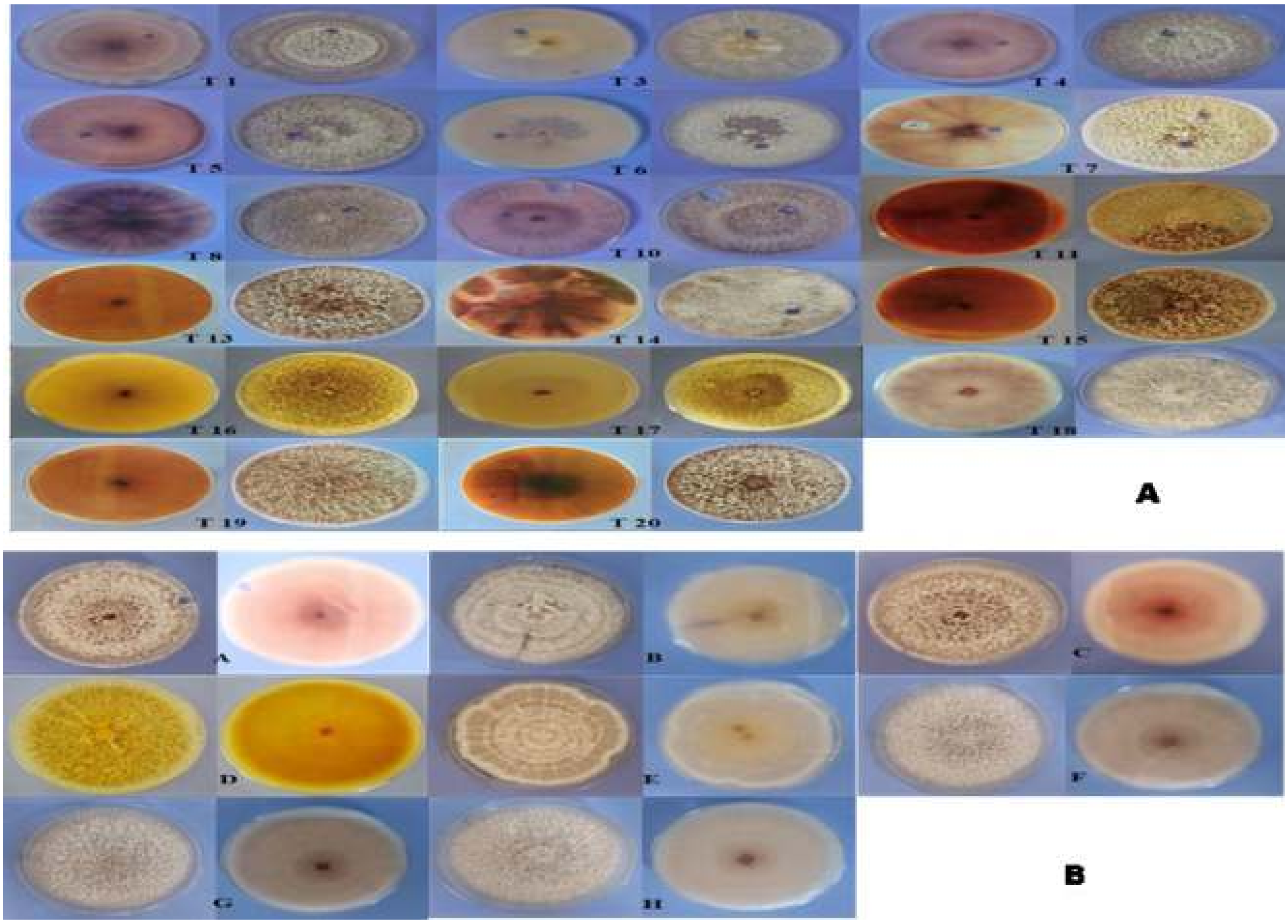


Fig 8.13 Axenic cultures of Fusarium *sp. isolated from top rot and knife cut stage symptoms (A) isolates from different locations (B)*

Table 8.4 *Fusarium sp.* isolates with their growth rate and disease severity index.

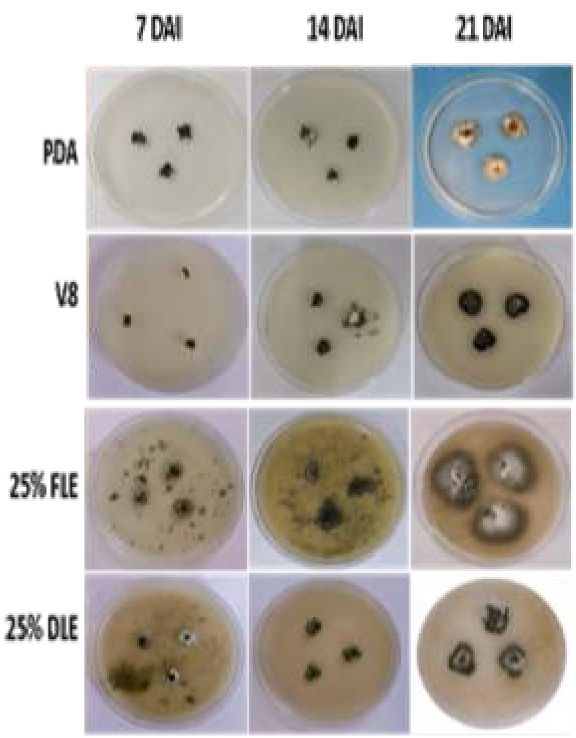
Isolate No.	Growth rate /day (mm)	Disease Severity Index	
		Leaf axil	Setts
T1	2.657 ± 0.20	20.42	48.05
T2	1.176 ± 0.16	21.25	10.00
T3	2.661 ± 0.16	26.89	14.17
T4	2.592 ± 0.09	25.03	15.83
T5	2.134 ± 0.15	22.68	50.55
T6	2.883 ± 0.11	18.22	18.05
T7	2.749 ± 0.26	19.45	59.72
T8	2.840 ± 0.19	14.30	18.61
T9	2.472 ± 0.12	21.78	46.94
T10	2.721 ± 0.21	23.84	53.61
T11	2.911 ± 0.03	20.40	29.44
T12	2.477 ± 0.20	17.51	24.72
T13	2.503 ± 0.39	19.90	19.44
T14	1.827 ± 0.24	24.61	62.50
T15	2.684 ± 0.21	21.85	28.61
T16	2.799 ± 0.12	21.40	26.66
T17	2.669 ± 0.33	22.96	37.89
T18	2.631 ± 0.39	14.77	68.89
T19	2.631 ± 0.39	19.65	25.00
T20	2.520 ± 0.36	19.93	21.11

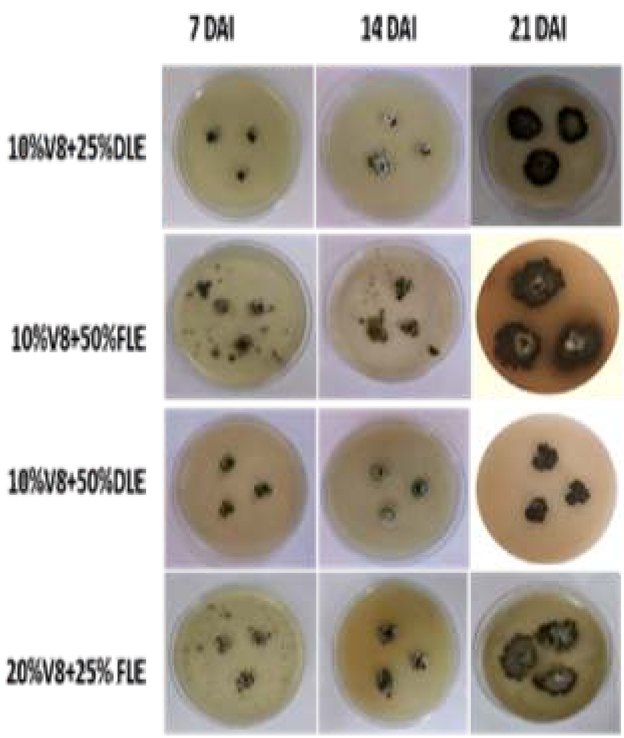
Table 8.5 The growth rate and disease severity index of *Fusarium sp.* isolated from different locations.

Isolates	Variety/origin	Growth rate (mm/day)	DSI (Leaf Axil inoc.)
A	VSI 8005 Bahal I	2.38 ± 0.05	14.21±3.07
B	VSI 8005 Bahal II	2.21 ± 0.06	26.93±2.27
C	VSI 8005 Bahal III	2.30 ± 0.01	13.15±3.59
D	VSI 8005 PB Bahal IV	2.04 ± 0.11	19.62±1.98
E	VSI 8005 PB Pimperkhed	1.88 ± 0.05	13.64±2.96
F	CoM 265 PB 2 A- I (Sang)	2.43 ± 0.09	16.96±1.85
G	CoM 265 PB 2 A II(Sang)	2.42 ± 0.03	19.78±4.75
H	Co 265M PB 2 A III(Sang)	2.41 ± 0.09	19.94±5.25

c. Isolation and pathogenicity of *Cercospora* sp associated with brown spot disease of sugarcane

The *Cercospora* sp. associated with the brown spot was isolated from the conidia collected from the symptomatic leaves of CoM0265 and Co86032 varieties using single spore isolation techniques. Artificial media was developed and standardized for maximum growth and sporulation using the different combinations of culture media and sugarcane leaf extract, pH, temperature, and light hours. The culture media containing 25% green leaf extract supplemented with 20% V8 at 25 °C produced a higher number of conidia as compared to PDA, V8 alone, and dry leaf extract in combination with other media (Fig. 8.14, 8.15). The PCR amplification conditions were optimized for translation elongation factor 1 alpha gene (EF1aF- 5' -ATC AAC CTC GTC GTT ATC GGC CAG G-3'& EF1aR-5' -TCA GAC TTC ACG TTG TCG AGG ACC C-3'), β-tubulin gene (Bt2aF-5' -GGT AAC CAA ATC GGT GCT GCT TTC-3'& Bt2aR-5' -ACC CTC CGT GTA GTG ACC CTT GGC-3'), actin gene (ACT-512F-5' -ATG TGC AAG GCC GGT TTC GC-3' & ACT-783R-5'-TAC GAG TCC TTC TGG CCC AT-3') and ITS region (ITS1 (F)- 5' -TCC GTA GGT GAA CCT GCG G-3' & ITS4 (R)- 5' -TCC TCC GCT TAT TGA TAT GC-3').





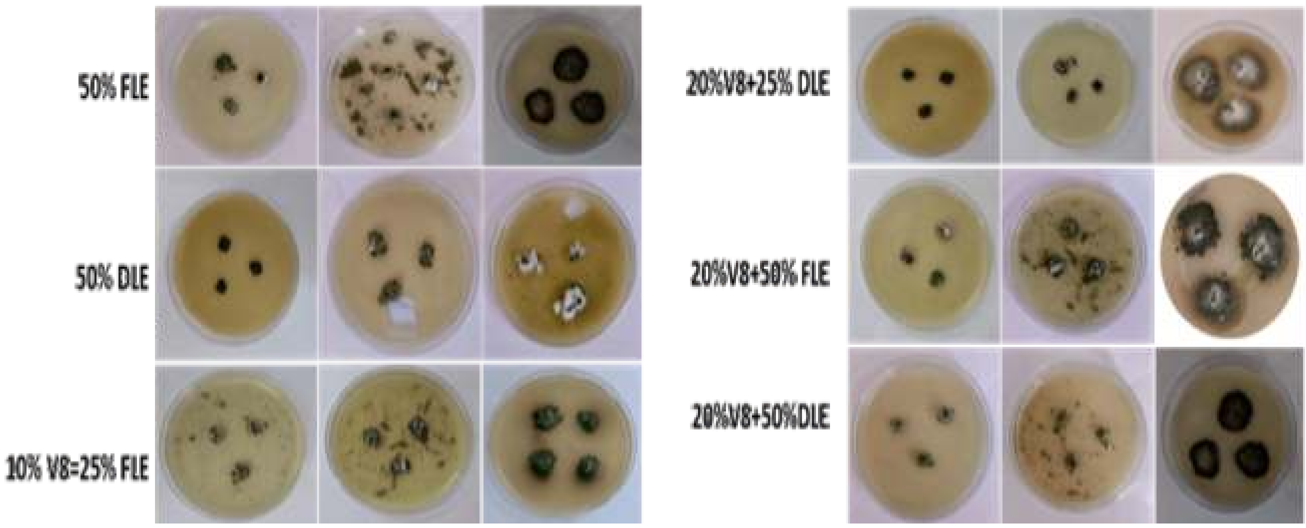


Fig. 8.14 Growth pattern of Cercospora *sp. on different media and its combination at 7, 14, and 21 days after inoculation. PDA-Potato dextrose agar, V8- V8juice agar, FLE- Fresh leaf extract, DLE- Dry leaf extract.*

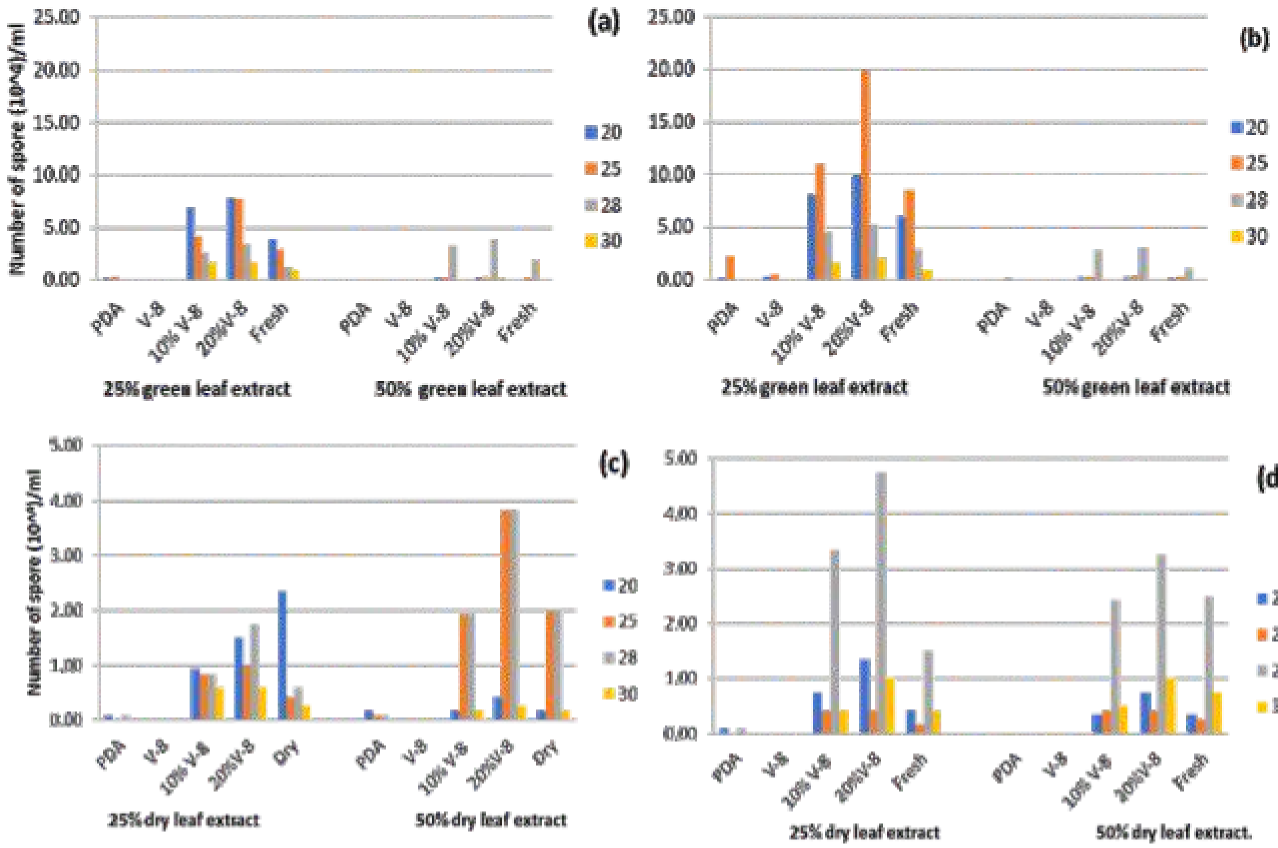


Fig. 8.15 Sporulation in green leaf extract at 25%, 14 DAI (a), 50% 21 DAI (b) and in dry leaf extract 25% 14 DAI (c), 50% 21 DAI (d) at different temperature temperatures.

Pathogenicity test: In vitro pathogenicity test by cut leaf assay was standardized for *Cercospora* sp. causing brown spots in sugarcane. In this protocol, the fourth leaves of the crown were detached from a 6-month-old sugarcane plant of CoM0265. Leaves were cut into 50-cm^2 sections with a sterile scalpel, disinfected in 1% NaOCl for 1 min, washed in four changes of sterile water, blotted dry, and then injured on both sides of leaves midrib by pin-prick methods and plated on the surface of moist paper in Petri dishes (15-cm-dia). The wounded parts were inoculated by spore ($2X10^6$/mL) harvested from 20% V8+leaf extract medium and incubated at 25 ^{0}C with a 12/12 light and dark cycle. Brown spot symptoms with well-developed fascicles and conidiophores with conidia appeared 10-12 days after inoculation (Fig 8.16).

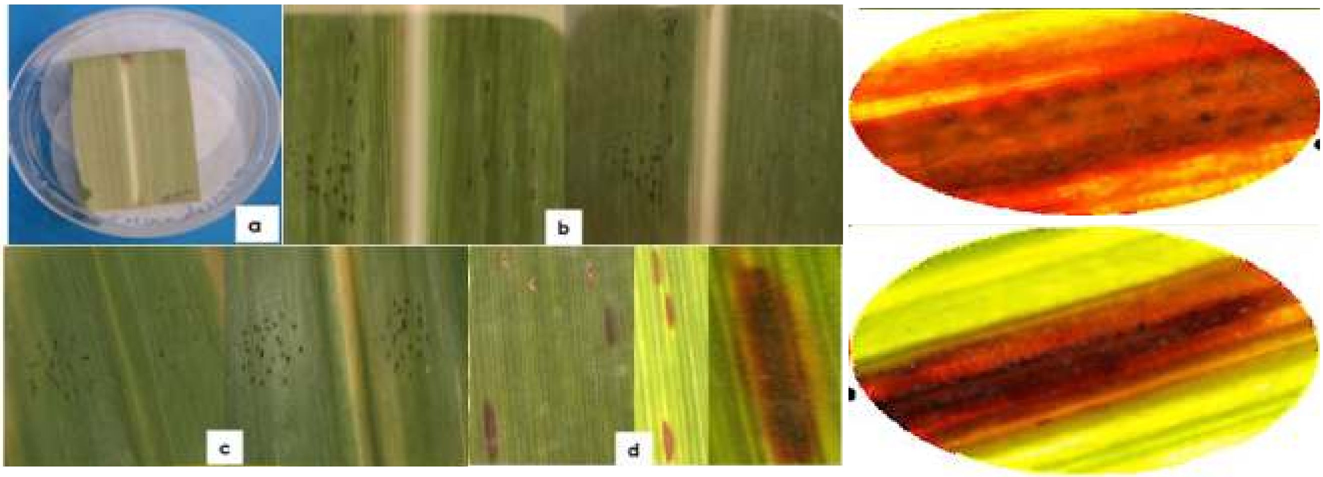


Fig. 8.16 *Cut leaf assay plates (a), leaf section inoculated with spore showing brown leaf spot (b), control (c), enlarged view of leaf section with brown spot (d), microphotographs of brown spot with well-developed fascicles and conidiophores with conidia observed in spore inoculated leaf sections (e)*

d. Isolation and in vitro bioassay of mycoparasitic fungi of brown rust of sugarcane

Mycoparasitic fungi was isolated from parasitized uredospores of brown rust of sugarcane by transfer of fungal propagules with a sterile fine point needle onto a potato dextrose agar plate. Initial studies on rust spore germination were conducted to assess the parasitization potential of mycoparasitic fungi. In *vitro*, germination assay (water agar 1% supplemented with 0.002% nonanol plus 0.1% tween 20) showed 36.45 ± 4.39 % and 57.78 ± 1.75 % increase in the germination of mycoparasitic fungi and brown rust spore over control, respectively. Co-inoculation (Mycoparasitic fungi spore X brown rust uredospores) showed a 91.85 ± 2.41 % reduction in germination percentage of brown rust spore. Bioassay showed 72.51 ± 5.55% and 74.91±4.64% parasitization of uredospores by mycoparasitic fungi at the rate of $2x10^6$ and $2x10^8$ spore per ml.

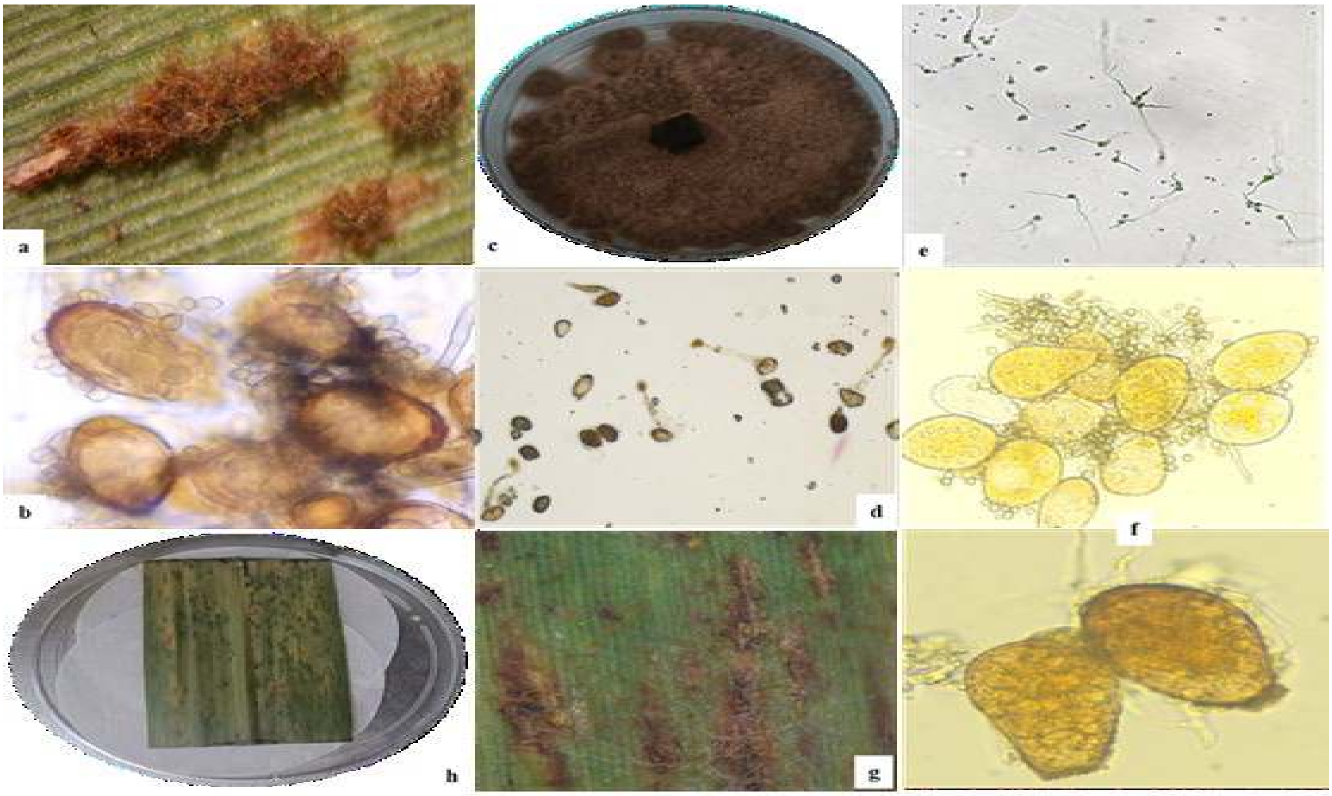


Fig. 8.17 *Mycoparasitic fungi incidence on brown rust of sugarcane reported during survey and surveillance. a parasitized pustules of rust; b- parasitized urediospore, c: Axenic culture of mycoparasitic fungi; d: urediospore germination; e: Parasitic fungi spore germination; f: microphotographs of parasitized urediospore observed under In vitro bioassay; g: Bioassay plate; h rust pustules parasitized by mycoparasitic fungi.*

e. Incidences of insect pest: Among the insect pest infestations, the white grub infestation was sporadic in the range of 40% to 70%, the infestations of woolly aphid, pyrilla, internode and early shoot borer was reported in the range of 20% to 40% and minor infestations of top borer, root borer and termite damage were also reported in the surveyed sugarcane fields. White fly *Aleurolobus barodensis* infestation was 40-90% in the sugarcane-grown area of Jalgaon, Dhule, and Nashik Districts in July, however, the increasing level of infestation of whitefly *Neomaskellia andropogonis* was observed in the sugar mills command area of Ahmednagar. Infestation of a scale insect in the range of 10-20 nymphs/leaf was observed on the lower surface, a high level of infestation causes the drying of leaf lamina, and heavy secretion of honeydew leads to blackening due to sooty mold growth. The adult females were sent for identification to the ICAR-National Bureau of Agricultural Insect Resources, Bengaluru, and identified as *Icerya pilosa* Green (Family: Monophlebidae) (Fig. 8.18).

***Fig. 8.18** Incidence of pest a: white fly* Neomaskellia andropogonis *nymph and pupae at the lower leaf surface; b- white fly* Aleurolobus barodensis *nymph and pupae at the lower leaf surface c-White grub damage; d-Scale insect Icerya pilosa damage; e- termite damage; f- Woolly aphid adult and nymphal stages on lower leaf surface; g-internode borer, exit hole with excreta and cane damage; h-Top borer damage.*

f. Parasites and Predators reported:

The predator of sugarcane pyrilla *Epiricania melanoleuca* was observed in the range of 2-3 cocoons per clump during July – January. The woolly aphid predator *Micromus igoratus* and larval predator were observed in the range of 9-10 per leaf where a high density of nymphs was present. The infestation of the parasitoid was observed in the nymphal and pupal stages of white fly and laboratory study indicated the highest emergence in pupal stage as compared to nymph. This parasitoid was identified as *Habrobacon* sp. based on 28SD subunit partial sequencing. The Coccinellidae predators were observed on whitefly *Neomaskellia andropogonis* eggs and nymph stages.

Fig. 8.19 Predators reported during survey and surveillance a- Epiricania melanoleuca *cocoon and eggs; b-Micromus igorotus and larval predators feeding on adult and nymph of woolly aphid, c- parasitoids emerged from nymph and pupae of whitefly; d- Coccinellid predator feeding on eggs, nymph of whitefly* Neomaskellia andropogonis

g. Isolation and *In vitro* bioassay of entomopathogenic fungi of sugarcane whitefly *Aleurolobus barodensis*

A total 27 isolates of entomopathogenic fungi (EPF) were isolated from parasitized nymphs and pupae of whitefly *Aleurolobus barodensis* using potato dextrose agar and axenic cultures were obtained by single spore isolation technique from the spore suspension of initial culture plates. *In-vitro* bioassay showed that entomopathogenic fungi achieved 59.09 and 82.28% parasitization in nymph and pupae of whitefly after the 4th and 8th day after inoculation. Field bioassay showed that entomopathogenic fungi achieved 28.37% and 72.62% parasitization in the nymph and pupae of whiteflies after the 4th and 8th day after inoculation (Fig. 8.20).

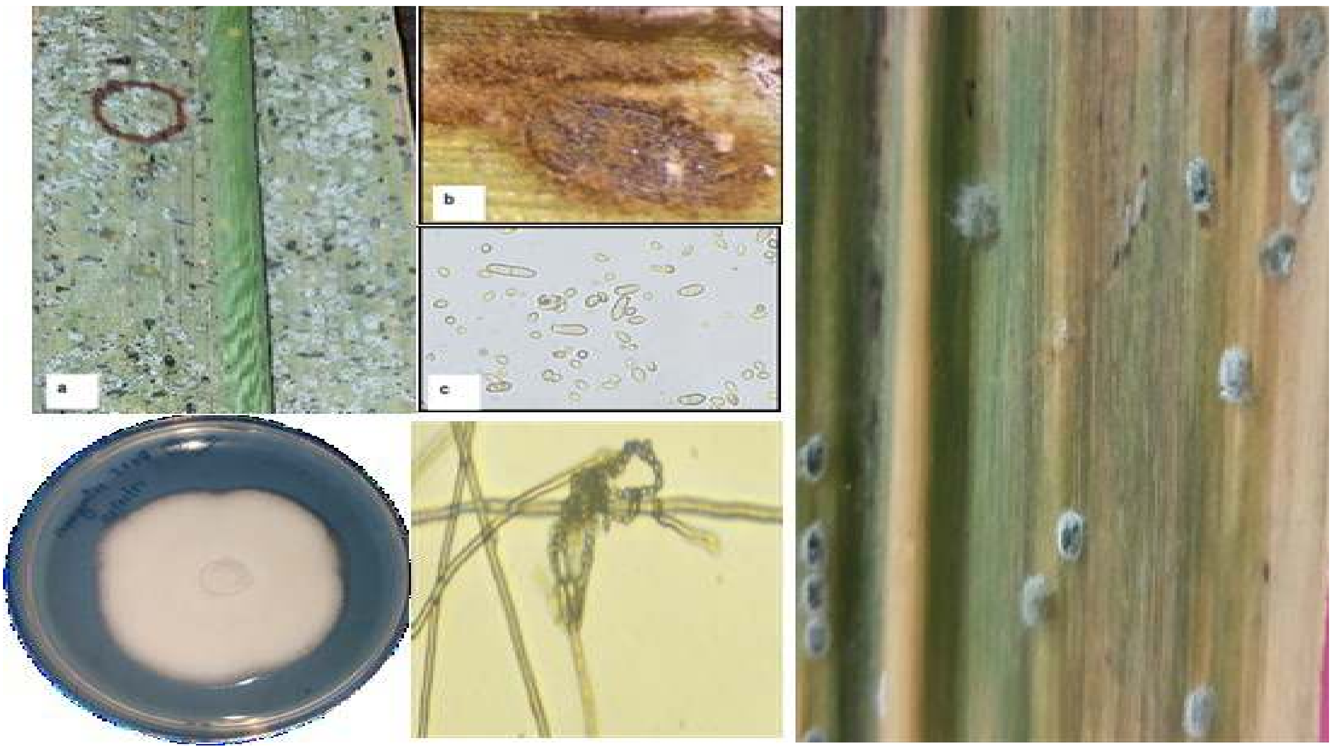


Fig. 8.20 Entomopathogenic Fungi reported during survey and surveillance a,b- EPF on white fly nymph and pupae; c- conidia; d- plate photograph of isolated culture; e- morphological character; d- parasitization in nymphs

Technology developed/ Commercialized/ Impact of IISR Technologies:

1. Technology developed:

Talc-based EPN formulation: To enhance the EPN survival and make it readily available, the infective juveniles (IJs) of *Heterorhabditis indica* were brought under anhydrobiotic conditions by slow drying technique and impregnated with talc powder to retain sufficient moisture. Approx. 1.5 Lakhs IJs per gram of talc powder would be the initial inoculum. The survivability of IJs in the talc-based formulation was found up to 3 to 4 months.

Reaching to stakeholders/Transfer of technology including FLDs/ Activities of KVKs:

Reaching to Stakeholders:

1. *Amrut kalash* program for higher cane yield: Scientific staff of the center participated in the *Amrut kalash* programme to leverage the cane productivity of the sugarcane growers in the command area of the sugar factory organised by Padmashri Dr. Vikhe Patil cooperative sugar factory Pravaranagar (MS)

2. Mass multiplication and field release of egg parasitoid, *Trichogramma chilonis* against borer complex of sugarcane

An egg parasitoid *T. chilonis* is employed for the efficient management of sugarcane borers (early shoot, internode, and top shoot borer). The egg parasitoid was reared on its natural insect host (rice mealworm, *Corcyra cephalonica*) in the laboratory. A total of 266 trichocard were distributed to 108 farmers. This intervention of the center brings 106.4 ha sugarcane growing area under the biological control of a borer complex. Recently we started mass production of *Trichogramma japonicum*

3. Mass multiplication and maintenance of host insect rice mealworm (*Corcyra cephalonica*)

In the insectary unit, we are rearing the rice mealworm as a host insect on the broken rice grains for the continuous supply of eggs for the mass production of trichocards. We are also maintaining the pure culture of *C. cephalonica* and supplying it to academicians, researchers, and entrepreneurs.

4. Mass multiplication and maintenance of greater wax moth (*Galleria mellonella*)

For the mass production, preservation, and maintenance of entomopathogenic nematodes and pupal parasitoids, we are rearing the *G. mellonella* on an artificial semisolid diet in the insectary unit, however, we are also supplying the pure culture of *G. mellonella* to researchers, academicians and entrepreneurs.

CHAPTER 9

All India Coordinated Research Project on Sugarcane

Salient achievements

Under AICRP on Sugarcane for the development of location specific high yielding sugarcane varieties with high sugar, zonal varietal trials of early and mid-late maturing varieties were conducted to screen the promising genotypes. In view of developing abiotic stress tolerant varieties, ISH & IGH programmes are being executed at certain centers for both drought as well as water-logging conditions. During the year 2023, seven sugarcane genotypes identified and nine sugarcane varieties released & notified for different zones of the Country. A brief description of developed sugarcane varieties is mentioned as below.

A. Sugarcane varieties identified

1. Co 17018 (*Karan*-17): The variety has been developed by the ICAR-SBIRC, Karnal in mid-late group for North West Zone and identified in 2023. The variety has exhibited sugarcane cane yield (90.32 t/ha), sucrose (%) in juice (18.37), CCS (11.60 t/ha) and Pol (%) in cane (13.68). Reaction against red-rot was resistant (R) and reaction against major insect-pests was also found less susceptible (LS).
2. CoPb 17215: The variety has been developed by the PAU Regional Research Station, Kapurthala in mid-late group for North West Zone and identified in 2023. The variety has exhibited cane yield (90.14 t/ha), CCS (11.27 t/ha), Sucrose (%) in juice (18.01) and Pol (%) in cane (13.50). Reaction against red-rot was Resistant (R) and the reaction against major insect-pests was found less susceptible (LS).
3. CoLk 16202 (*Ikshu*-16): The variety has been developed by the ICAR-Indian Institute of Sugarcane Research, Lucknow in early group for North West zone and identified in 2023. The variety has exhibited cane yield (93.22 t/ha), sucrose (%) in Juice (17.74), CCS (11.43 t/ha) and Pol (%) in cane (13.57). Reaction against the red rot was resistant (R) and reaction against major insect-pests was found less susceptible (LS).
4. CoLk 16470 (*Ikshu*-17): The variety has been developed by the ICAR-Indian Institute of Sugarcane Research, Lucknow in mid-late group for North Central & North Eastern Zones and identified in 2023. The variety has exhibited cane yield (82.50 t/ha), sucrose (%) in Juice (17.37), CCS (9.59 t/ha) and Pol (%) in cane (11.92). Reaction against the red rot was resistant (R) and reaction against major insect-pests was found less susceptible (LS).
5. CoS 16233 (*Roshan*): The variety has been developed by the U.P. Council of Sugarcane Research, Shahjahanpur in mid-late group for North West Zone and identified in 2023. The variety has exhibited cane yield (92.38 t/ha), sucrose (%) in juice (18.73), CCS (12.01 t/ha) & Pol (%) in cane (14.29). Reaction against red rot was resistant (R). The clone showed less susceptible (LS) in reaction of major insect-pests.
6. CoP 17437 (*Rajendra Ganna*-8): The variety has been developed by the Sugarcane Research Institute (Dr RPCAU), Pusa in early group for North Central & North Eastern Zones and identified in 2023. The variety has exhibited cane yield (89.08 t/ha), CCS (11.03 t/ha), sucrose (%) in juice (17.99) & Pol (%) in cane (13.84). Reaction against red rot was resistant (R) by plug and cotton swab methods.
7. CoP 16437 (*Rajendra Ganna*-1): The variety has been developed by the Sugarcane Research Institute (Dr RPCAU), Pusa in early group for North Central & North Eastern Zones and identified in 2023. The variety has exhibited sugarcane cane yield (86.43 t/ha), CCS (10.70 t/ha), sucrose (%) in juice (17.88) & Pol (%) in cane (13.85). Reaction against red rot was resistant (R). The clone was also less susceptible (LS) in reaction of major insect-pests.

B. Sugarcane varieties released and notified

1. MS 14082 (*Phule* Sugarcane 13007): The variety has been developed by the Central Sugarcane Research Station (MPKV), Padegaon (MS) in mid-late group for Peninsular zone and identified in 2022 and released & notified in 2023. The variety has exhibited sugarcane cane yield (128.60 t/ha), sucrose (%) in juice (19.47), CCS (17.58 t/ha) & Pol (%) in cane (14.85). Reaction against red rot was moderately susceptible (MS) and the reaction against major insect-pest was also found less

susceptible (LS).

2. Co 14005 (*Arunima*): The variety has been developed by ICAR-Sugarcane Breeding Institute, Coimbatore in mid-late group for Peninsular Zone and identified in 2022 and released & notified in 2023. The variety has exhibited sugarcane cane yield (118.77 t/ha), sucrose (%) in juice (20.15), CCS (16.61 t/ha) & Pol (%) in cane (15.35). Reaction against red rot and other major diseases were resistant (R). The clone showed less susceptible (LS) to moderately susceptible (MS) for major insect-pests.
3. Co 11015 (*Atulya*): The variety has been developed by ICAR-Sugarcane Breeding Institute, Coimbatore in early group for Peninsular Zone and identified in 2022 and released & notified in 2023. The variety has exhibited sugarcane cane yield (109.29 t/ha), sucrose (%) in juice (21.29), CCS (16.32 t/ha) & Pol (%) in cane (16.31). The clone is marginally superior in CCS (t/ha) by 0.68% over the best check Co 09004. Reaction against red rot and other major disease like smut, wilt and YLD were resistant (R).
4. CoLk 14201 (*Ikshu*-10): The variety has been developed by ICAR-Indian Institute of Sugarcane Research, Lucknow for North West Zone in early group and identified in 2022 and released & notified in 2023. The variety has exhibited cane yield (91.65 t/ha), sucrose (%) in juice (18.11), CCS (11.43 t/ha) & Pol (%) in cane (13.69). Reaction against red rot was moderately resistant through plug method and resistant through cotton swab method.
5. CoLk 15206 (*Ikshu*-14): The variety has been developed by ICAR-Indian Institute of Sugarcane Research, Lucknow for North West Zone in mid-late and identified in 2022 and released & notified in 2023. The variety has exhibited cane yield (89.81 t/ha), sucrose (%) in juice (18.42), CCS (11.64 t/ha) & Pol (%) in cane (14.32). Reaction against red rot was resistant (R) through plug and cotton swab methods. The clone showed less susceptible (LS) in reaction of major insect-pests.
6. CoLk 16466 (*Ikshu*-15): The variety has been developed by -Indian Institute of Sugarcane Research, Lucknow for North Central & North Eastern Zones in early group and identified in 2022 and released & notified in 2023. The variety has exhibited cane yield (85.35 t/ha), sucrose (%) in juice (17.33), CCS (10.27 t/ha) & Pol (%) in cane (13.31). Reaction against red rot was resistant (R) through plug and cotton swab methos. The clone showed less susceptible in reaction of major insect-pests.
7. Co 16030 (*Karan*-16): The has been developed by ICAR-SBI Regional Center, Karnal (Haryana) for North West Zone in mid-late group and identified in 2022 and released & notified in 2023. The variety has exhibited cane yield (94.97 t/ha), sucrose (%) in juice (17.90), CCS (11.96 t/ha) & Pol (%) in cane (13.89). Reaction against red rot was moderately resistant (MR) through plug method and resistant (R) through cotton swab method.
8. CoA 17321 (2012 A 319): The variety has been developed by the Regional Agricultural Research Station (ANGRAU), Anakapalle (AP) for East Coast Zone in early group and identified in 2022. The variety has exhibited cane yield (114.37 t/ha), sucrose (%) in juice (16.93), CCS (13.44 t/ha) & Pol (%) in cane (11.72). Reaction against red rot was resistant (R) through plug method and cotton swab methods.
9. CoP 11438 (*Rajendra Ganna*-5): This variety has been developed by SRI, Pusa under Dr Rajendra Prasad Central Agricultural University, Pusa, Distt. Samastipur (Bihar) in early group for North Central & North East zones and identified in 2021 released & notified in 2023. The variety has exhibited cane yield by 78.20 t/ha, CCS yield 9.46 t/ha and sucrose 17.37 % in juice. Reaction against red rot was moderately resistant & moderately susceptible through plug method and resistant through cotton swab method. The clone showed less susceptible in reaction of major insect-pests.

CHAPTER 10

IISR Regional Station, Motipur, Muzaffarpur

All India Coordinated Research Project (Sugarcane) Trials

IISR Regional Centre, Motipur conducted all the Zonal Varietal Trials as per AICRP (S) Technical programme of Plant Breeding. All the trials were sown in the second fortnight of February, 2023 and ratooning was initiated before 15th March, 2023. Recommended cultural practices were followed for raising good and healthy crop. The newly selected clones for ZVT trials were also sown in time so that the required seed was available for sowing in coming season 2024-25.

Eight AICRP (S) trials, namely Initial Varietal Trial (Early), Initial Varietal Trial (Mid-late), Advanced Varietal Trial (Early-II Plant), Advanced Varietal Trial (Early-Ratoon), Evaluation and identification of climate resilient commercial clones (Normal & Water Logging conditions) for Waterlogging Tolerance (II Plant Crop) and Evaluation for Waterlogging Tolerance (Ratoon) were conducted during 2023-24.

Furthermore, five ZVT trials *viz.*, Advanced Varietal Trial (Early-I Plant); Advanced Varietal Trial (Early-II Plant); Advanced Varietal Trial (Early-Ratoon); Advanced varietal Trial (Mid-Late–II Plant) and Advanced Varietal Trial (Mid-Late-Ratoon) were successfully conducted and all observations were recorded on various yield and quality parameters as per technical programme during 2022-23.

Advanced Varietal Trial (Early-I Plant):

A total of eight clones were tested including three checks for high sugar and cane yield. *viz.*, CoP 18436, CoP 18437, CoP 18438, CoP 18451, CoP 18452, three clones from PUSA and two clones from Seorahi. Among the five, CoP 18437 maintained its superiority for cane yield (108.04 t/ha) while, CoSe 18452 was a superior performer for Brix and Sucrose (18.27, 16.29, respectively). However, on an overall basis, check variety CoSe 01421 maintained its superiority for juice quality.

Advanced Varietal Trial (Early-II Plant):

Seven clones, namely CoSe 16454, CoP 17436, CoP 17437, CoP 17438, CoP 17440, CoP 17441, CoSe 17451, were subjected to evaluation for their high sugar and yield quality attributes in comparison to three reference checks, viz., CoLk 94184, CoSe 95422, and CoSe 01421. Among the tested clones, CoSe 16454 exhibited the highest cane yield at 112.73 t/ha and commercial cane sugar (CCS%) at 13.06%. Conversely, the check variety CoSe 01421 displayed high sucrose content at 17.58%, accompanied by a Brix value of 20.51 at harvest.

Advanced Varietal Trial (Early-Ratoon):

Seven clones, namely CoSe 16454, CoP 17436, CoP 17437, CoP 17438, CoP 17440, CoP 17441, CoSe 17451, underwent evaluation to assess their high sugar and yield quality attributes in comparison to three reference checks: CoLk 94184, CoSe 95422, and CoSe 01421. Among the seven tested clones, CoP 17436, CoP 17437, and CoSe 16454 displayed notable sucrose content levels at 17.33%, 17.28%, and 17.16%, respectively. However, when compared to the standard variety CoSe 01421, which exhibited a sucrose content of 17.34% and 19.98, they fell slightly short. Furthermore, CoSe 01421 demonstrated the highest cane yield of 121.73 t/ha and commercial cane sugars (CCS%) at 14.47%.

Advanced varietal Trial (Mid-Late–II Plant):

A trial of three clones namely CoSe 16455, CoP 17446, CoSe 17542, with three standard varieties, viz., BO 91, CoP 9301, CoP 06436 was investigated for high yield and sucrose content. Among all, CoP 9301 exhibited the highest CCS% (10.59%), Sucrose % (17.52%), and Brix value (20.0). Following closely, CoP 17466 displayed the second highest CCS% (9.77%), Sucrose % (17.01%), and Brix value (19.15) at the time of harvest. Conversely, the highest cane yield was recorded in CoP 06436 (89.53 t/ha), trailed by CoP 9301 (87.83 t/ha) and CoP 17466 (82.74 t/ha).

Advanced Varietal Trial (Mid-Late-Ratoon):

An experiment of three clones namely CoSe 16455, CoP 17446, CoSe 17542, with three standard varieties, viz., BO 91, CoP 9301, CoP 06436 was investigated for high yield and sucrose content. Among all, CoP 06436 exhibited the highest CCS% (11.77%). Moreover, CoP 06436 exhibited the greatest cane yield (117.73 t/ha), followed by CoSe 17446 (91.88 t/ha). Regarding sucrose and brix levels, CoP 9301 recorded the highest values with 16.82% sucrose content and 19.02% brix, followed by CoSe 17542 with 16.14% sucrose content and 17.83% brix, respectively.

The AICRP (S) monitoring team visited at Motipur during 5th December, 2023, and appraised the crop health, husbandry, and sanitation of the trials.

CHAPTER 11

Sugar beet Outpost, Mukteshwar

Seed production and maintenance of sugar beet germplasm

The Sugar beet Breeding Outpost in Mukteshwar is actively involved in the meticulous maintenance and evaluation of sugar beet germplasm. This extensive endeavour serves as a crucial component in advancing sugar beet breeding efforts, with a focus on enhancing the adaptability and performance of these germplasm resources. LS 6, LKC 2020, and IISR Comp-1, are being produced for need-based supply to sugar beet cultivators nationwide. In the month of September, 2023, fresh seeds varieties/germplasm were produced of 53 sugar beet. The sugar beet germplasm yielded a combined seed weight of >24.0 kg. Besides, the seed yield of IISR Comp 1 was 1.474 kg, and LS 6 was 16.7 kg (Table 11.1). The sugar beet germplasm is being maintained with utmost care and precision. Considering this, 149 germplasm accessions of sugar beet are being preserved in cold storage facilities at IISR, Lucknow. To ensure the viability of the seeds, seeds are sown every alternative year. One-third of the sugar beet germplasm has been sown this year at Sugar beet Breeding Outpost, Mukteshwar by transplanting /direct sowing methods.

Table 11.1 Sugar beet germplasm seeds produced during September 2023

7112 (157 g)	LK 0503 × LK 27 (618 g)	Shubra × LS 6 (740 g)
DRFB 4 (593 g)	LKC 11 (1173 g)	SR 97 (998 g)
FC 712 (420 g)	LKC 2000 (999 g)	SYT/06/10 (55 g)
IN 7 (1140 g)	LKC 2006 (998 g)	SYT/06/11 (410 g)
IN 9 (94 g)	LKC 2007 (649 g)	SYT/06/12 (500 g)
7112 × BTS 605 (860 g)	LKC 95 (1.15 Kg)	SYT/06/13 (708 g)
IN 13 × LK 4 (556 g)	LKC HB (496 g)	SV 894 (60 g)
Indus Prasada (317 g)	LKC LB (623 g)	SYT/06/02 (71 g)
L 33 (857 g)	LKS 10 (448 g)	Shubra (710 g)
FD IND 2 (257 g)	Mangolia (411 g)	SV 894 (30 g)
LK 4 (900 g)	PAC 60002 (602 g)	SV 887 (86 g)
LK 7 (885 g)	PAC 60006 (389 g)	USKPS-24 (70 g)
LK 8 (553 g)	PAC 60008 (44 g)	Calixta (86 g)
Ariba (98 g)	R06 (168 g)	Cauvery (96 g)
BTS 604 (110 g)	Rasoul (87 g)	SV 893 (38 g)
BTS 605 (101 g)	SB EB 621 (570 g)	UKFB (52 g)
LKC 2020 (1120 g)	LKC 2010 (1050 g)	

Identification of sugar beet varieties/germplasm for water-limiting conditions

To identify the better-performing sugar beet germplasm for water-limiting conditions having high yield potential and drought tolerance, an experiment was laid out with sixteen treatments and two checks (LS 6 and IISR Comp-1) in three replications in randomized block design. Drought was imposed by the withdrawal of irrigation and was regularly monitored. Meanwhile, the irrigated plot was well saturated with desired irrigation. The genotypes namely LKC 11, LKC 2000, and LKC HB had high single root weight, root length, and root diameter under both environments against checks (LS 6 and IISR Comp-1). Relative water content, and chlorophyll content were measured, and variability for these attributes was observed among the investigated germplasm under both conditions. Under drought stress environments, malionaldehyde was increased in all the genotypes. The checks, LS 6 and IISR Comp-1 maintained their superiority for this trait. The proline content was increased significantly in genotypes under drought stress conditions. Furthermore, LKC 2006 and LKC 95 had the highest sucrose content, Brix, and purity coefficient against check varieties under drought conditions.

Screening of diseases and insect pests in sugar beet

To screen out the various foliar/root diseases and insect pests under natural condition and to identify the tolerant/resistant germplasm of sugar beet for Indian climatic conditions, a trial of 50 sugar beet genotypes was conducted at IISR, Lucknow farm. Higher incidence of *Cercospora* leaf spot disease and fusarium and sclerotium root rots were observed. Incidence of viral infection in most of the sugar beet germplasm was also observed. The minor incidence of leaf minor, spiders, beetles, and *Myzus* was noticed during February to April while Bihar hairy caterpillar and grasshoppers during March. Among the insects, *Spodoptera* spp. (army worm) was the major insect seen in sugar beet. Incidence of *Spodoptera* spp. began after two months of germination. During April to May, higher incidence rate of *Spodoptera* (80-95%) was noticed. Among the 50 germplasm, SYT/06/10, L 33, LKC 2000 showed considerable resistance to *S. litura*. Furthermore, LKC 2020, LK 4, LK 7, LKC HB, LKC 11 showed considerable susceptible to *S. litura*.

Sugar beet performance at different locations

Performance of sugar beet in high temperature and hot conditions

An experiment with eight germplasm, namely LKS 10, LK 27, LKC 2000, LKC 2007, LKC 2006, LKC 2020, IISR Comp 1 and LS 6 was sown at Agricultural Research Station Basanthpur (Table 11.2). Sucrose content varied from 17.4 to 18.9% among these sugar beet genotypes. Dry matter production varied from 12.3 to 18.0% among these sugar beet genotypes, with the highest production in LS6 and the lowest in LK 27. Furthermore, the highest yield was seen in LS 6 (73.9 t/ha) and the least in LK 27 (21.1 t/ha).

Table 11.2 Dry matter production, yield and sucrose content in sugar beet germplasm at ARS, Basanthpur

Varieties	Days to maturity (days)	Dry matter production (g)	Yield (t/ha)	Sucrose (%)
LKS 10	126	12.5	65.9	18.1
LK 27	110	12.3	21.1	17.6
LKC 2000	120	16.6	59.8	17.4
LKC 2006	125	15.3	58.1	18.3
LKC 2007	130	16.4	63.9	18.2
LKC 2020	129	12.6	62.2	18.1
IISR Comp 1	125	16.7	73.9	18.8
LS 6	122	18.0	73.9	18.9

Estimation of sugar beet for high ethanol recovery

The ethanol content of five sugar beet germplasm namely LS 6, IISR Comp-1, LKC 2020, LKC 2006 and LKC 2010, was estimated at National Sugar Institute, Kanpur. The highest ethanol content was observed in LKC 2020 (8.5%) followed by LKC 2010 (8.2%).

Performance of sugar beet germplasm under saline stress conditions

An experiment to check the performance of eleven germplasm, viz., LS 6, IISR Comp-1, LK 4, LK 7, LKS 10, LKC 11, LKC 95, LKC 2000, LKC 2006, LKC 2007, LKC 2020, LKC HB, LKC LB, L 33 for saline stress condition, was conducted at ICAR-CSSRI Regional Research Station, Lucknow (Table 11.3). The soil was moderately sodic with a pH of 8.5 and EC of 0.69 dS/m. Results showed that LKC 2006 had the highest root length of 28.89 and LS 6 with the highest root diameter of 9.31.

Performance of sugar beet germplasm under tropical conditions

An experiment to check the performance of nine germplasm namely LS 6, IISR Comp-1, LKC 2006, LKC 2020, L 33, LKC 11, LK 4, LKC HB, LKC 95 for tropical conditions, was carried out at Vasantdada Sugar Institute, Pune. Results showed that root length and root girth varied from 19.11 to 26.33 and 33.77 to 38.44 respectively. Furthermore, sucrose and brix ranged from 16.06 to 18.36 and 15.77 to 17.48 respectively with the highest sucrose content in LKC HB followed by LS 6 (Table 11.4).

Table 11.3 Performance of sugar beet germplasm under saline stress condition at CSSR RRS, Lucknow

Variety	Fresh leaves weight (g)	Fresh root weight (g)	Dry root weight (g)	Root length (cm)	Root diameter (cm)
LS 6	143.33	791.67	183.78	25.00	9.31
IISR Comp-1	73.89	758.33	211.27	24.22	6.95
LK 4	113.33	847.22	160.75	21.78	8.32
LK 7	119.44	700.00	147.44	27.78	7.82
LKS 10	121.11	566.67	203.50	25.00	7.34
LKC 11	178.89	588.89	143.35	26.89	7.93
LKC 95	118.33	533.33	109.06	24.78	7.68
LKC 2000	150.00	841.67	246.62	27.33	8.70
LKC 2006	135.56	1072.22	178.42	28.89	8.70
LKC 2007	90.00	583.33	168.60	25.33	7.96
LKC 2020	103.33	833.33	188.59	28.17	8.81
LKC HB	121.67	566.67	243.19	25.00	7.15
LKC LB	66.44	769.44	140.03	27.67	8.00
L 33	85.56	666.67	202.54	25.22	8.39

Table 11.4 Performance of sugar beet germplasm at VSI, Pune

Varieties	Root length (cm)	Root girth (cm)	Single root weight (kg)	Brix	Sucrose (%)
LS 6	26.33	36.11	0.99	18.36	16.83
IISR Comp-1	23.55	34.55	1.02	17.13	16.59
LKC 2006	22.44	36.11	0.99	18.36	16.83
LKC 2020	25.55	38.05	1.49	16.27	15.93
L 33	22.11	38.44	1.26	16.53	16.64
LKC 11	23.44	35.50	1.14	16.06	15.77
LK 4	21.11	37.11	1.04	17.19	15.81
LKC HB	19.11	35.55	0.89	19.43	17.48
LKC 95	21.77	33.77	0.90	17.95	16.62

Performance of sugar beet germplasm under drought stress at Siksha O Anusandhan University, Bhubhaneshwar

An experiment was conducted to check the performance of LS 6 under drought stress conditions at Siksha O Anusandhan University, Bhubaneshwar. Results showed that the yield of LS 6 was lowered under 7 days of drought stress compared to irrigated conditions. This yield was further reduced when drought stress was increased to a period of 14 days (Table 11.5).

Table 11.5 Performance of LS 6 under drought stress condition at SOA, Bhubaneshwar

Stress Experiment	Sugar beet Yield (t/ha)
Irrigated condition	100.4
7 days drought stress	90.07
14 days drought stress	60.0

For the season of 2023-24, sugar beet sowing was performed for 56 germplasm *via* transplanting method for the seed production at Sugar beet Breeding Out Post, Mukteshwar. Furthermore, forty-eight germplasm were sown for disease and insect pests screening and sowing of sugar beet germplasm for experiment trial on the performance of sugar beet germplasm under water limiting conditions with 14 germplasm and two checks as done. Five research institutes have received the same set of materials to generate data on diverse fields.

CHAPTER 12

Krishi Vigyan Kendra, ICAR-IISR, Lucknow

1. **On Farm Testing/Trials (OFTs):**

OFTs are most important mandatory component of KVK under which evaluation of recently developed technologies or varieties in specific agro climatic condition is done for future recommendations or popularization. Six OFTs pertaining to various disciplines as per identified major thrust areas were conducted during the year as per the details given below:

I) Integrated pest management in paddy crop:

OFT was conducted on evaluation of IPM for overcoming the insect pest problems in paddy crop. The Result showed that treatment T2-Profenophos 50EC@1ml./lit water+ Yellow sticky trap (10 No.) + Pheromone trap (10 No.) showed insect incidence up to 4.5% and yield was 68.98 q/ha . Cost benefit ratio of demonstration plot and farmers practice were 2.44:1 and 2.65:1.

II) Performance evaluation of broccoli varieties:

Broccoli is one of the most important and popular vegetable crops in many countries of the world due to its good organoleptic and high nutritive value. As an unconventional vegetable "Broccoli" is yet to gain the desired popularity in our country. The results revealed that the treatment T2 (Sakhi) recorded maximum plant height at 45 DAT (40.8 cm), number of leaves at 45 DAT (13.8), average curd weight (690g), average circumference of head (48.8cm) and yield per hectare (230.0 q). While maximum plant height at harvest (75.7 cm), number of leaves at harvest (23.5) and maximum plant spread at 45 DAT [E-W (49.4 cm) and N-S (50.1 cm)] and at the stage of head harvest [E-W (64.6 cm) and N-S (65.2 cm)], minimum days taken for head initiation (62.5 days) and for first head harvest (77.8 days). Results revealed that broccoli variety Sakhi fetches maximum remuneration. The best results for gross return (Rs 276000.00), net return (Rs 169666.00) and output: input ratio (1:2.60) was observed with broccoli variety *Sakhi*.

III) Evaluation of different methods of button mushroom composting:

KVK, ICAR-IISR, Lucknow conducted an OFT programme to assess the method of button mushroom composting at village Rambagh (Amethi) of Goshaiganj block of Lucknow district. Results showed that short duration of compost preparation is economically viable. In this method compost prepared 18 days and button mushroom yield was also higher i.e. 7.50 q. along with mushroom production duration 125 days in comparison to farmer practices i.e. 6.50 q. and 6.25 q with production duration 100 days.

IV) Assessment and feasibility of preservation of vegetable pea:

Green peas are very popular and they are used along with other vegetables in many vegetarian and continental dishes. Thus apart from household demand, there is a continuous demand from restaurants, dhabas, caterers and canteens. Green peas are available for around 5 months during winter season only. Hence, if they are made available even during off-season, there is a good market for them. A small scale unit with lower overheads can offer competitive prices. Keeping in view of the above points, KVK, ICAR-IISR, Lucknow was conducted on farm trial to assess the feasibility of preservation of vegetable green pea through blanching techniques compared with marketing of green pod of vegetable pea. The on farm trial was conducted at ten farmer's household at Lucknow district. The results highlighted that, blanching pea was attaining olive green colour and it was stored in deep freezer for one year with original test.

V) Assessment of different canopy management system in mango tree:

Orchards of Lucknow district do not follow the canopy management practices, so they may get unsatisfactory production. KVK, ICAR-IISR, Lucknow conducted an OFT to assessment of different canopy management system in mango tree. OFT has been conducted at farmers field and results are awaited.

VI) Performance of Artificial Insemination through Sex sorted semen in cows to increase the female calving ratio and milk production of Lucknow district:

An OFT has been conducted to evaluate the performance of different types of sex sorted semen with particular reference to Gir and Sahiwal breed semen. Results are awaited.

Table 12.1 Frontline Demonstration Conducted

Crop	Them-atic Area	Technology demonstrated	Variety	No. of Farmers	Area (ha)	Yield (q/ha) Demo High	Demo Low	Demo Average	Check	% Increase in yield	Economics of demonstration (Rs./ha) Cost Gross	Return Gross	Net Return	BCR (R/C)	Economics of check (Rs./ha) Cost Gross	Return Gross	Net Return	BCR (R/C)
Mustard	ICM	Improved variety	Giriraj	76	20	22.5	15.7	19.4	16.2	16.49	38500	105730	67230	2.74:1	33500	88290	54790	2.63:1
Sunflower	ICM	Improved variety	NSFH-145 (Swathi)	46	10	17.2	13.6	15.2	12.4	18.4	28500	102752	74252	3.60:1	27500	83824	56324	3.04:1
Sesamum	ICM	Improved variety	GJT-5	103	20	5.6	4.8	5.1	3.8	25.5	24084	44038	19954	1.82:1	18509	26768	8259	1.45:1
Mustard	ICM	Improved variety	Giriraj	50	20	Result Awaited												

2. Frontline demonstrations:

Total FLDs were conducted as 1209 demonstrations in 175.125 ha area, where oil seed covered in 70 ha, pulses covered is 65 ha. under national food security mission (NFSM), cereals crop in 7.5 ha and horticultural crops in 7.5 ha while 25.125 ha. area was covered under fodder crops with 100 demonstrations on nutrational kitchen gardening and 54 demonstrations under rooftop kitchen gardening.

Table 12.2 Frontline demonstration on pulse crops

Crop	Them-atic Area	Technology demonstrated	Variety	No. of Farmers	Area (ha)	Yield (q/ha) Demo High	Demo Low	Demo Average	Check	% Increase in yield	Economics of demonstration (Rs./ha) Cost Gross	Return Gross	Net Return	BCR (R/C)	Economics of check (Rs./ha) Cost Gross	Gross Return	Net Return	BCR (R/C)
Chickpea	ICM	Improved Variety	RVG-202	56	10	17.5	11.3	14.91	10.4	30.25	29500	85508	56008	2.89:1	26800	59644	32844	2.22:1
Fieldpea	ICM	Improved Variety	IPFD:12-2	126	20	23.7	15.6	19.73	16.8	14.85	26800	98650	71850	3.68:1	24700	84000	59300	3.40:1
Blackgram	ICM	Improved variety	Vallabh urd-1	134	30	8.5	6.9	7.5	5.2	30.6	32775	52125	19350	1.59:1	23659	36140	12481	1.52:1
Pigeon pea	ICM	Improved variety	IPA-203	40	5						Result Awaited							

Table 12.3 FLD on Other crops

Crop	Thematic Area	demonstrated technology	Variety	No. of Farmers	(ha) Area	Yield (q/ha)				% Increase in yield	Economics of demonstration (Rs./ha)				Economics of check (Rs./ha)			
						Demo			Check		Cost Gross	Return Gross	Net Return	(R/C) BCR	Cost Gross	Return Gross	Net Return	(R/C) BCR
						High	Low	Average										
Cereals																		
Wheat	ICM	Improved variety	DBW-187 & HD-3226	10	7.5	57	42	49.5	39	21.2	30000	10023	70237	3.34:1	32000	70200	38200	2.1: 1
Vegetables																		
Tomato	ICM	Improved variety NPK@ 120:80:80 kg/ha	NS-4266	12	1.0	612	573	560	480	14.3	91663	182000	90337	2.0:1	93330	156000	206140	1.7:1
Vegetable pea	ICM	Improved Variety Sulphur 10 kg/ha	Kashi Uday	28	2.0	95	82	88	73	17.1	56700	132000	75300	2.3:1	61200	109500	46850	1.8:1
Onion	ICM	Combined application of 110:40:60:20 kg NPKS along with 15 t FYM,	Agrifound Light Red	34	1	295.5	265.8	272.8	215.8	20.9	65500	136400	70900	2.1:1	69000	107900	142040	1.6:1
Broccoli	ICM	Improved variety NPK:100:80:60 along with 15 t FYM	Fantasy F-1	10	0.5	224	208	215	177	17.7	115500	264450	148950	2.3:1	125400	217710	92310	1.7:1
French Bean	ICM	Improved Variety	Poorva	21	1.0	195	173	189	127	32.8	87850	283500	195650	3.2:1	95650	177800	82150	1.9:1
Nigela	ICM	Improved variety NPK@ 40:20:20 kg/ha with 10 t/ha FYM	AN-20	5	1.0	9.1	7.5	8.2	5.9	28.1	55350	164000	108650	3.0:1	69500	118000	48500	1.7:1
Red cabbage	ICM	Improved variety NPK:100:100:60 with 10 t/ha FYM	Red Jewel	12	0.5	305	275	285	210	26.3	107250	285000	177750	2.7:1	120450	210000	89550	1.7:1
Mango	IPM	Spray of Lamdacylothrien 5%	--	4	2	124.2	116.3	120.15	103.7	13.7	82500	180225	97725	2.18:1	83800	155550	71750	1.8:1
Cow pea	ICM	Improved variety	Kashi	09	0.5	133	121	130	108..5	19.8	89500	195000	105500	2.18:1	95800	162750	66950	1.7:1

Commercial Crops																		
Potato	IPM	Yellow sticky trap, spray of insecticide (Acetamepride 20%), Fungicide (Propeneb 70 WP)	--	7	2	355.6	325.8	339.9	305.0	10.2	125000	408000	283000	3.26:1	155000	366000	211000	2.36:1
	IPM	Yellow sticky trap, Insecticides and fungicides	--	04	02	352.2	339.5	346.73	323.5	6.7	135000	346730	211730	2.57:1	155000.0	323500	168500	2.09:1
	ICM	Improved variety	Fry Sona	18	0.625	336	272	301.3	239.1	20.6	105455	207897	102442	2.0:1	107595	164979	57384	1.5:1
Fodder Crops																		
Barseem	ICM	Improved variety	Farm sona NSCBL-42	46	2	488.2	410.6	459.4	402.7	12.3	27300	50534	23234	1.9:1	26980	40270	13290	2.0:1
Perennial grasses	ICM	Improved variety	Napier-3108	103	4	860	795	843	--	--	29410	29730	63320	3.2:1	--	--	--	--
Oat	ICM	Improved variety	Kent	19	5	480	390	435	340	21.8	30000	282750	252750	9.4:1	30000	221000	141000	7.3:1
Cowpea	ICM	Improved variety	BL-4	15	2	350	290	310	270	12.9	27500	93000	65500	3.4:1	26200	81000	54800	3.1:1

Table 12.4 FLD on Other Enterprise: Kitchen Gardening

Category and Crop	Thematic area	Name of the technology demonstrated	No. of Farmer	No. of Units	Yield (Kg)		% change in yield	Other parameters		Economics of demonstration (Rs./ha)				Economics of check (Rs./ha)			
					Demonstration	Check		Demo	Check	Gross Cost	Gross Return	Net Return	BCR (R/C)	Gross Cost	Gross Return	Net Return	BCR (R/C)
Kitchen Gardening	ICM	NKG	100	100	Result Awaited												
rooftop Gardening	ICM	RTG	54	54	Result Awaited												

3. Training Pogrammes:

Krishsi Vigyan Kendra conducted 29 training programmes for participating farmers and farm women, rural youth and extension funtioneries on various topics with an objective to improve skill and upgrade their knowledge about developed and potent product. All training programmes were fully skill oriented and were conducted following the principles of "Learning by doing".

Clientele	No. of Courses	Male	Female	Total participants
Farmers & farm women	25	547	71	618
Rural youths	1	20	0	20
Extension functionaries	1	13	3	16
Sponsored Training	2	59	12	71
Total	**29**	**639**	**86**	**725**

4. Other Extension activities conducted by KVK:

Activities	No. of programmes	No. of farmers	No. of Extension Personnel	TOTAL
Advisory Services	3259	49199	0	49199
Field Day	7	215	25	240
Group discussions	4	137	3	140
Kisan Ghosthi	7	538	35	573
Film Show	7	963	35	998
Exhibition	2	1165	16	1181
Scientists' visit to farmers field	125	1230	21	1251
Farmers' seminar/workshop	1	468	30	498
Method Demonstrations	29	638	67	705
Celebration of important days	3	389	42	431
Special day celebration	5	225	20	245
Others	118	2378	253	2631
Total	**3567**	**57545**	**547**	**58092**

6. Seed and planting material production:

Seed production	Quantity (q)
Oilseed (Mustard)	20.0
Cereal (Wheat & Paddy)	53.0
Sugarcane (CoLK-14201)	272.0
Vegetable pea (*Kashi Uday*)	3.0
Total	**348 q**
Planting material production	**Quantity (no.)**
Fruit saplings	3500
Production of bio-products and produce	**Quantity (kg. or liter)**
Vermicompost (kg.)	70
Cow milk (lit.)	8203

On Farm Trials


Installation of Yellow sticky trap and Pheromone trap in OFT on Rice crop

OFT on Broccoli Crop

FLD on Tomato

FLD on French bean

CHAPTER 13

ICAR-Krishi Vigyan Kendra-II, IISR, Lakhimpur Kheri

Technology testing/Technology developed/ Commercialized/Impact of IISR Technology:

On farm trails (OFT):

A total six OFTs were conducted during the reported year. The details of trails are as given below:

i) Sustainable Management of *Sclerotinia* stem rot in Mustard:

The On Farm Trail (OFT) was conducted for the field evaluation of Bioagents *viz. Trichoderma viride* and *T. harzianum* through seed treatment and soil application

while Carbendanzim applied as seed treatment and foliar application for sustainable management of *Sclerotinia* stem rot in mustard caused by *Sclerotinia sclerotiorum*. Four treatments along with control as farmers practices were conducted in randomized block design with five multi location trails at five farmer fields. The result from the trails revealed that lowest stem rot incidence 16.77 % along with highest yield 18.11q./ha was recorded in seed treatment with *Trichoderma viride* and *T. harzianum* @ 10 gm/kg seed + Carbendazim @ 2 gm/kg seed at the time of sowing + Soil application of *Trichoderma viride* and *T. harzianum* 2.5 kg/ha pre-incubated in 300 kg FYM/ha in 10 days prior to sowing + spray of Carbendazim @ 2g/lt of water in standing crop followed by 23.31% disease incidence and 16.82 q./ha yield in soil application of *Trichoderma viride* and *T. harzianum* 2.5 kg/ha pre-incubated in 300 kg FYM/ha in 10 days prior to sowing over farmer practices (Use of different fungicide at standing crop) maximum disease incidence 29.89% and lowest yield 13.19 q./ha were recorded.

ii) Evaluation of different combination of casing materials for growth and yield of button Musrhroom (*Agaricus bisporus*):

Five different combination of casing materials were evaluated through On Farm Trails to improve growth and yield of button mushroom. Pinhead initiation differed with respect to different casing materials and yield attributing characters like stalk length, stalk diameter, pileus diameter and yield also were recorded. Pinhead initiation was fastest (12.35 days) in bag TO III which had Vermicompost + Rice husk ash + Cocopeat (1:1:1) casing material followed by Cow dung+ Cocopeat + Rice husk ash (1:1:1) (13.99 days) TO II, vermicompost + Cocopeat + Soil (1:1:1) (14.87 days), and Cow dung+ Soil + Rice husk ash (1:1:1) (15.73 days) and whereas it was delayed (17.42 days) in only cow dung as farmer practice. Stalk length, stalk diameter and pileus diameter varied from 2.67 - 3.54cm, 1.52 – 1.71 cm and 3.84 – 4.86 cm respectively. The maximum (19.85 kg/q compost) fresh yield obtained from technical option III (Vermicompost + rice husk ash + Cocopeat) (1:1:1) with highest (3.63) BC ratio.

iii) Evaluation of high yielding variety of Cowpea (Var- *Kashi Kanchan*):

OFT was carried out because non availability of quality seeds and unawareness of scientific cultivation practices to the farmers. Trial was taken through adopting scientific cultivation practices in which farmers were given advice's regarding use of HYVs, trainings to improve yield per unit area and quality planting material in the district. Farmers are very happy with the results as BC ratio of trial was observed 2.98:1 in comparison to local 2.23:1.

iv) Assessment of high yielding variety of Tomato var- Arka Abhed:

On Farm Testing on "Evaluation of high yielding variety of Tomato (Var- *Arka Abhed*)" to increase tomato production of the district was carried out. Here, this OFT was carried out because of non availability of quality seeds and unawareness of scientific cultivation practices to the farmers. Therefore the trial was taken through adopting scientific cultivation practices in which farmers were advised regarding used of HYVs, and method demonstration to the farmers, so that they can get the higher yield per unit area and quality planting material in the district itself. Farmers were very happy with the result in which the BC ratio of trial was observed as 2.09:1 in comparison to local 1.71:1.

v) Assessment of feeding of balance ration and on mineral mixture to buffalo heifers for early onset of heat:

On farm testing on assessment of feeding of balance ration and mineral mixture to buffalo heifers for early onset of heat was done. The problem was identified as slow weight gain and late onset of heat in buffalo heifers which ultimately imposes the economic losses to the farmers. Here in, farmers practice of only green fodder was offered to the animals while in technology under assessment the animals were offered green fodder, 1.5 kg concentrate feed and 50 gm mineral mixture per day for one year. The final results of the trial are still awaited.

vi) Assessment of feeding of linseed cake to repeat breeder buffaloes:

On farm testing on assessment of feeding of linseed Cake to repeat breeder buffaloes was done. The problem identified in the field was that the buffaloes are not conceiving after getting the service *i.e.* repeat breeding happens. This increases the inter-calving period ultimately imposing the economic losses to the farmers. Here in, the farmers practice of only green fodder and concentrate feed was offered to the animals while in technology under assessment the animals were offered green fodder, 1.5 Kg concentrate feed and 1 Kg linseed cake per day for 20 days. The final results of the trial are awaited.

vii) Transfer of Technology including FLDs/ Activities of KVKs

Front Line Demonstrations (FLDs): In order to demonstrate the production potential of technology of agriculture and allied sector as many as 06 Front Line demonstrations FLD were conducted with participation of 25 farmers including farm women over 5.50 ha. area.

Table 13.1 Front Line Demonstration on Plant Protection:

Crop	Thematic Area	Name of the technology	No. of Farmers	Pest infestation (%)	Control (%)	Yield (q/ha)	% increase	Cost of cultivation (Rs./ha)	Gross return (Rs/ha)	Net return (Rs./ha)	BC ratio
Maize	IPM (Integrated Management of fall army worm in Maize)	Farmer practices: Only chemicals	4	49.89	-	22.36	-	33429	44988	11559	1.34
		Technology Demonstration: Seed treatment with Cyantraniliprole 19.8% + Thiamethoxam 19.8% FS @ 6 ml/kg of seed + Installation of pheromone traps @ 5/acre + 5% NSKE / Azadirachtin 1500ppm @ 5ml/l of water+ Installation of pheromone traps @ 5/acre + Chlorantraniliprole 18.5% SC + *Bacillus thuringiensis* v. *kurstaki* formulations @ 2g/l		15.82	68.29	26.48	18.42	34987	53278	18291	1.52
Pigeon pea	IPM (Integrated management of pod borers in Pigeon pea)	Farmer practices	4	41.79		14.34		16220	71700	55480	3.42
		Technology Demonstration: Carbendazim 25%+ Mencozeb 50% WS (3g/kg seed) + Imidacloprid 48 FS@ 1.25 ml/kg seed+ *Trichoderma viride* @ 8 - 10g/kg + *Rhizobium* and PSB @ 10g/kg seed + spraying of Emamectin benzoate @ 0.4g/lit at flowering times.		10.82	71.10	17.11	16.18	16220	85550	69330	4.27
Lentil	IDM (Integrated management of wilt disease in Lentil)	Farmer practices	45	29.43		9.73	-	12170	60326	48156	3.95
		Technology Demonstration: Seed treatment with *Trichoderma viride* and *T. harzianum* @ 10 gm/kg seed + carbendazim @ 2 gm/kg Seed at the time of sowing		5.24	82.19	11.84	17.82	12170	73408	61238	5.03

Front Line Demonstration on Horticulture:

i. FLD on "Popularization of Broccoli Var *Saki*" was done to popularize the broccoli cultivation in the district. Broccoli Var- *Saki* planted during rabi season. Now farmers get aware and it is a beneficial crop for Lakhimpur Kheri farmers. Total ten (10) number of farmers directly benefited. Under FLD the BC ratio was recorded 1.65:1 at demonstration plot.

ii. **FLD on** Popularization of Pointed Gourd var *Kranti*" also done to demonstrate the high yielding varieties of Pointed Gourd at farmers field with recommended spacing. Usually farmers cultivate local cultivars and do not maintain the proper spacing in the district. Variety is being grown successfully and farmers are showing great interest to adopt the technology. Total Six (06) number of farmers were directly benefited.

Front Line Demonstration on Animal Science:

In order to demonstrate the production potential of technology of animal husbandry and allied sector, as many as 100 demonstrations were conducted on deworming of buffalo calves with participation of 100 farmers and 80 FLDs on fodder production in 4 hectare area. A total of 180 demonstrations were conducted under animal science discipline.

Table 13.2 Front Line Demonstration on Animal Science:

Animal / Crop	**Thematic Area**	**Name of the technology demonstrated**	No. of Farmers / Animals	Weight gain after 3 months in Kg)	% change in major parameter	Other parameter (Mortality %)	**Gross Cost (Rs.)**	**Gross Return (Rs.)**	**Net Return (Rs.)**	**BCR**
Buffalo Calf	Health Management	Farmer practices: No Deworming	100	67.34	-	16	2500	3500	1000	1.4
		Dewor ming with Albendazole @ 2 ml/5 Kg body weight		75.67	12.37	7	2535	5000	2465	1.97

Cluster Front Line Demonstrations (CFLDs): In order to increase the pulse and oil seed production in the district demonstration on improved variety of oil seed and pulses were conducted which covered 271 farmers over 77 ha. area.

Table 13.3 Cluster Front Line Demonstrations on Integrated Crop Management

Crop	**Thematic Area**	**Name of the technology demonstrated**	No. of Farmers	Area (ha)	Yield (q/ha)	% increase	Cost of cultivation (Rs./ha)	Gross return (Rs/ha)	Net return (Rs./ha)	BC ratio
Greengram	ICM	Farmer practices:	75	20	6.9	-	35250	45540	10289.8	1.2
		IPM410-03 (*Shikha*)			9.3	25.8	34675	61380	26705	1.7
Groundnut	ICM	Farmer practices	25	03	9.3		35300	54405	19105	1.5
		GJG -22			13.80	32.6	37500	80730	43230	2.1
Sesamum	ICM	Farmer practices	68	10	5.4	-	29509	42282	12772.3	1.4
		GJT 5			8.1	33.3	28085	63423	35338	2.3

Table 13.4 Cluster front line demonstrations on integrated disease & pet management:

Crop	Thematic Area	Intervention	Area (ha)	Number of trails	Pest infestation		Yield (q/ha)	Percent increase	Gross cost of cultivation (Rs.)	Gross income ratio	Net income	BC
					Wilt incidence (%)	Disease control (%)						
Lentil (L-4717)	IDM	Farmer practices	20	45	29.43	-	9.73	-	12170	60326	48156	3.95
		Seed treatment with *Trichoderma viride* and *T. harzianum* @ 10 gm/kg seed + carbendazim @ 2 gm/kg Seed at the time of sowing			5.24	82.19	11.84	17.82	12170	73408	61238	5.03
Mustard ((DRM RIJ 31)	IDM	Farmer practices	20	58	29.89	-	13.32		15689	59940	44251	2.82
		Seed treatment with *Trichoderma viride* and *T. harzianum* @ 10 gm/kg seed + carbendazim @ 2 gm/kg Seed at the time of sowing			19.82	33.69	18.98	29.82	15689	85410	69721	4.44

CFLD on Lentil (L-4717)

CFLD on Mustard ((DRMRIJ 31)

Training Organized:

Capacity building of Farmers, Farm women, rural youth, extension functionaries and other stake holders: To upgrade the knowledge of farm and farm women and rural youth KVK organized 38 no of training program benefitting 1299 farmers including farm women and rural youth which cover plant protection, horticultural and animal science aspects.

Discipline	Trainings	Male	Female	Total
Plant Protection	13	310	114	424
Horticulture	13	287	87	374
Animal Science	12	175	326	501
Grand Total	**38**	**772**	**527**	**1299**

Other Activities

Achievements under TSP Scheme:

For improving the agricultural practices among tribal communities our KVK distributed power sprayer, vermin bed, farm tools, sugarcane variety and improved breed of goat by covering 500 nos of Tharu tribal farmers at Belabursua under Nighasan Block Indo-Nepal Border.The detail of the activities are as given.

SL. No	Name of Input	Quantity	Number of Farmer benefited
1	Power sprayer	200 nos	200
2	Vermin bed	100 nos	100
3	Farm tool (Sickle and spade)	150 nos	150
4	Sugarcane variety, CoLk -14201	400 Nos. bags	50
5	Goat of Sirohi breed	100 nos	100
	Total		500

Glimpses of TSP activities at Belapursua

Distribution of 200 nos. sprayers and 100 nos. vermibed among ST farmers

Distribution of 200 nos. sprayers and 100 nos. vermibed among ST farmers

Distribution of 150 nos. spade and sicke among ST farmers

Achievements under SCSP Scheme:

Input distribution:

- Successfully introduced 360 Qt. of wheat seed of variety DBW-187 and 4 Qt. of fodder oat variety Kent among 1500 SC farmers under SCSP.
- Successfully introduced newvarieties 15 Qt. of Potato (*Kufri-mohan*, *K. Bahar*, *k. chipsona*, *K.frysona* were introduced at19 farmers fields.

Training under SCSP

Discipline	Trainings	Male	Female	Total
Agronomy	8	317	88	405
Plant Protection	2	43	47	90
Horticulture	2	80	0	80
Animal Science	2	34	75	109
Grand Total	**14**	**474**	**210**	**684**

Other Extension activities:

A total 1104 other extension programmes ware conducted by covering 9088 farmers including farm and farm women and rural youth and extension personal from line department for mass awareness through, kisan mela, kisan ghosthi, celebration of important days etc.

Glimpses of TSP activities at Belapursua

Distribution of 360 Qt. of wheat seed of variety DBW-187 and 4 Qt. of fodder oat variety Kent among 1500 SC farmers

Distribution of 15 Qt. potato seed among 19 SC farmers under SCSP

Activities	No. of programmes	No. of farmers	No. of Extension Personnel	TOTAL (farmers + Extn Personnel)
Advisory Services	448	448	0	448
Diagnostic visits	36	261	8	269
Group discussions	15	305	7	312
Kisan Ghosthi	14	364	9	372
Film Show	17	451	10	461
Self -help groups	15	170	10	180
Kisan Mela	3	310	11	321
Exhibition	4	261	17	278
Scientists' visit to farmers field	430	2408	11	2419
Animal health camps	3	162	6	168
Farmers' seminar/workshop	4	285	5	290
Swachha Bharat Abhiyan	11	416	9	425
Method Demonstrations	15	456	0	456
Celebration of important days	7	364	3	369
Special day celebration	3	225	2	227
Others- Lectures delivered	79	2045	48	2093
Total	**1104**	**8931**	**156**	**9088**

Planting Material Production

Name of crop	Name of Variety	Quantity (No.)	Value (Rs)	Distributed to No. of farmers	No of Village Covered
Brinjal	*Kashi Sandesh*	9225	18450	100	
Chilli	*Kashi Anmol*	8705	17410	86	22
Tomato	*Arka Abhed & Arka Rakshak*	11000	22000	105	27
Cabbage		1890	3780	32	
Cauliflower		1940	3880	32	
Broccoli		8680	17360	16	9
Capsicum		1380	2760	18	5
Others		10805	21610	13	6
Others (Sugarcane)	CoLk 14201	625	312500	150	9
Grand Total		**54250**	**419750**	**552**	**78**

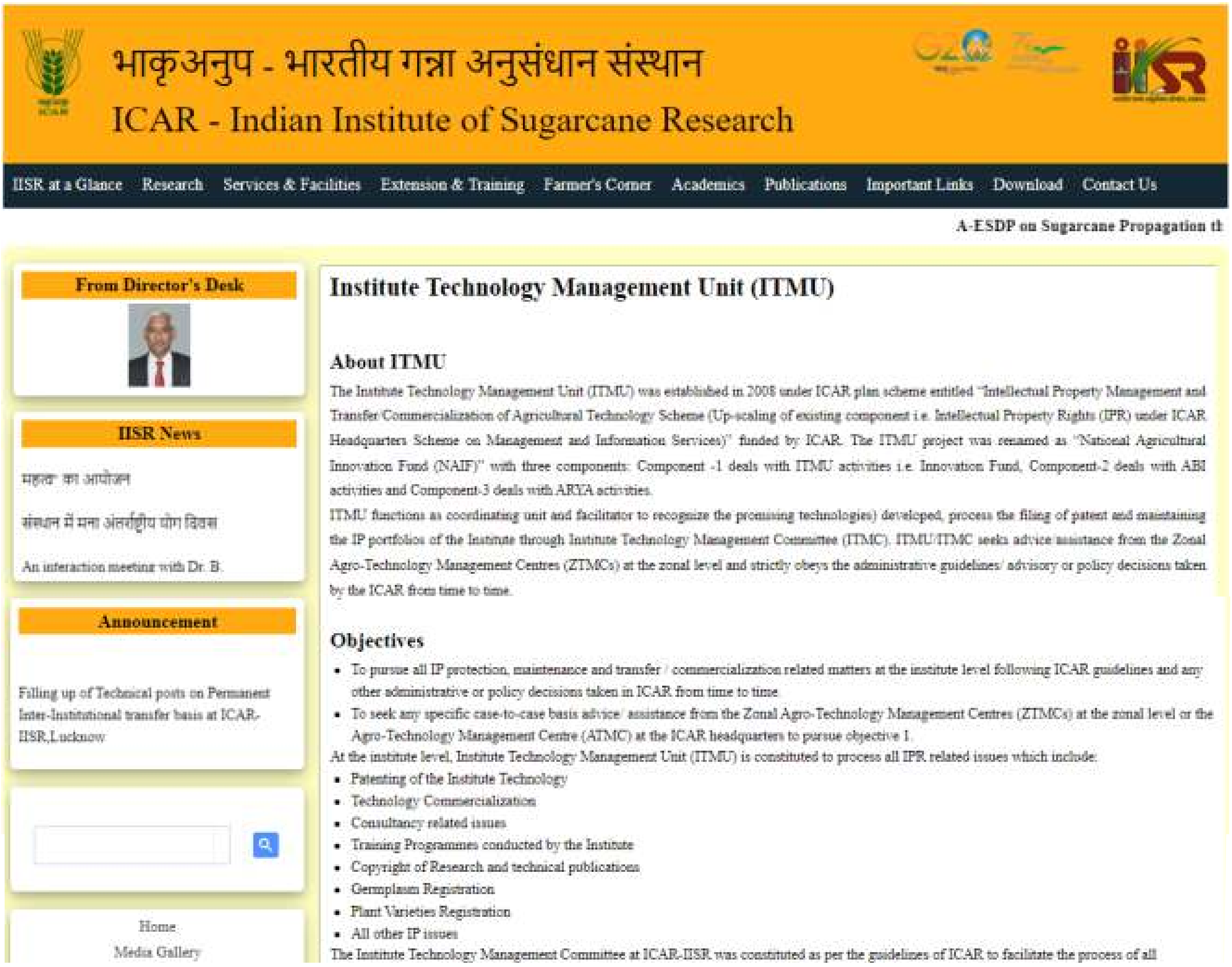
CHAPTER 14

Institute Technology Management Unit

The Institute Technology Management Unit (ITMU) was established in 2008 under ICAR plan scheme entitled "Intellectual Property Management and Transfer/Commercialization of Agricultural Technology Scheme (Up-scaling of existing component i.e. Intellectual Property Rights (IPR) under ICAR Headquarters Scheme on Management and Information Services)" funded by ICAR. The ITMU project was renamed as "National Agricultural Innovation Fund (NAIF)" with three components: Component -1 deals with ITMU activities i.e. Innovation Fund, Component-2 deals with ABI activities and Component-3 deals with ARYA activities.

Visibility of ITMU page: Visibility of the ITMU page on our institute's website plays a crucial role in fostering innovation, managing intellectual property, and promoting technology transfer and commercialization. It will not only improve our internal communication but also strengthen our outreach to external partners, collaborators, and the general public.

ITMU webpage link:
https://iisr.icar.gov.in/iisr/pages/itmu.jsp



ITMC meeting organized during 2023:

Three meetings of Institute Technology Management Committee of ICAR-IISR, Lucknow were convened under the Chairmanship of the Director, ICAR-IISR, Lucknow. Following decisions were taken by the committee:

Months	Decisions
November 03, 2023	➢ The institute has to identify their professional service functions such as trainings, consultancy, contract research, contract services and advertise it on Institute's website for wider publicity. ➢ Institute has to file application to NBPGR for registration of all the sugarcane varieties released by the CVRC/SVRC or notified varieties for their released, before distribution of cane seed to farmers/sugar mills for its commercial cultivation. ➢ The ITMC suggested that the technology pricing/valuation for its commercialization/licensing may be finalized through the proper survey on its market demand, cost involved in technology development, comparative saving advantages or ease of doing farm operation over existing technology. ➢ The institute has to work on the policy of 'One IP, One project' and 'at least One IP per scientist and the RPP-III has submitted for identification of technologies for the IPR filing and its commercialization
August 04, 2023	➢ The committee decided that all the HODs to discuss with their scientists and identify potential technologies along with details should be shared with ITMU. These technologies may be further categorised and potential technologies and should be uploaded on the Krishi portal ➢ The committee decided that the Institute technologies having potential to earn more than ₹ 1 lakh as one time licence fee and royalty should be submitted to the Agri-innovate Pvt Ltd for selling technologies to the potential buyers/firms. ➢ One IP expert, as non-official from outside ICAR system should be opted as member. ➢ The committee decided that the training programme organised by the institute for the students including RAWE student has to be pay fee of ₹ 5000/- (Rupees five thousand per month) to the institute. The fee has to be paid in favour of Director, Indian Institute of Sugarcane Research, Lucknow through demand draft or online mode.
May 22, 2023	➢ The committee decided the price of the Tricho card prepared by IISR-BCC, Pravaranagar, containing 30,000 parasitized eggs as ₹ 60 per card. ➢ The committee decided the price of Manual Multi Crop Planter/Seed Drill for sowing intercrops in sugarcane designed and developed under UPCAR funded project as ₹ 5,000/- per unit for prototype to be sold by the Institute. The price rate will be periodically revised based on the actual market prices of raw materials. ➢ All the technologies of the Institute, with pricing of ₹ 1 lakh or more should be commercialized through Agri-innovate.

Table 14.1 Details and status of IP applications submitted to Indian Patent office, New Delhi

IPRs	Application/ Registration No.	Name of Innovation/ Technology/ Product/ Variety	Date of Filing/ Registration	Application Granted/ Registered
Patent	TEMP/E-1/76657/2023-DEL	An Inventive Pre-treatment method for the development of freeze-dried sugarcane juice powder	September 26, 2023	Provisional Application
Copyright	21787/2023-CO/SW	AICRP Reporter: A software for online reporting of AICRP trials on Sugarcane	16/08/2023	Re-Scrutiny
	27675/2023-CO/L	Images of Scale Insect (Icerya pilosa Green) infestation reported in Sugarcane crop in Maharashtra	17/10/2023	Re-Scrutiny
Plant Variety Submitted to PPVFRA, New Delhi	DL 1808230001	CoLk 15201 (Ikshu-11)	August 18, 2023	Under process
	DL 1808230002	CoLk 15207 (Ikshu-12)	August 18, 2023	Under process
	DL 1808230003	CoLk 15466 (Ikshu-13)	August 18, 2023	Under process

Patent granted:

Name of Technology: A Tractor Operated Trash Mulcher-cum-stubble Shaver Device for Sugarcane Ratoon Crop

Patent No.: 526527

पेटेंट कार्यालय, भारत सरकार | The Patent Office, Government Of India

पेटेंट प्रमाण पत्र | Patent Certificate

पेटेंट सं. / Patent No. 526527

आवेदन सं. / Application No. 202211007709

फाइल करने की तारीख / Date of Filing 14/02/2022

पेटेंटी / Patentee ICAR- Indian Institute of Sugarcane Research

It is hereby certified that a patent has been granted to the patentee for an invention entitled "A TRACTOR OPERATED TRASH MULCHER-CUM-STUBBLE SHAVER DEVICE FOR SUGARCANE RATOON CROP" as disclosed in the above mentioned application for the term of 20 years from the 14th day of February 2022 in accordance with the provisions of the Patents Act,1970.

अनुदान की तारीख / Date of Grant 14/03/2024

Controller of Patents

Trademark Registered:

Institute logo has been registered as a trademark under class 30

Registration No: 4877880

भारत सरकार
Government of India
व्यापार चिह्न रजिस्ट्री
Trade Marks Registry
व्यापार चिह्न अधिनियम, 1999
Trade Marks Act, 1999

Certificate of Registration of Trade Mark, Section 23 (2), Rule 56 (1)

Trade Mark No. 4877880

Class 30

24 February 2021

Trade Mark as annexed

15th day of February, 2023

Trade Marks Registry MUMBAI

Registrar of Trade Marks

Copyrights granted:

Name of Innovation/Technology: Ikshu Kedar" mobile app for precise irrigation scheduling forsugarcane cultivation

Registration No: SW-16350/2023

Extracts from the Register of Copyrights

प्रतिलिप्यधिकार कार्यालय, भारत सरकार | Copyright Office, Government Of India

SW-16350/2023

Registrar of Copyrights

ICAR-IISR, IP Review by ADG (IP& TM)

Dr. Neeru Bhooshan, Assistant Director General, IPTM and PME, ICAR, New Delhi, visited ICAR-IISR, Lucknow, on October 04, 2023 to review the progress of ABI, and status of patents filed and technologies commercialized. She interacted with the staff of ITMU, ABI, and all the scientists of the institute. At the outset, Dr. R. Viswanathan, Director, IISR, briefed about the achievements of the institute and current status of IPRs filed and ABI activities. Dr. L. S. Gangwar, I/c ITMU, gave a brief presentation about the ITMU and ABI activities of the institute. Dr. Bhooshan delivered a sensitization talk on different aspects of intellectual property management, technology licensing and commercialization and also discussed the role of IP protection in the area of agricultural research. She also visited the ABI unit of the institute.

CHAPTER 15

Services to the Industry

Contract Research Project

ICAR-IISR, Lucknow carried out the evaluation for some new industrial products which have use in sugarcane cultivation. The evaluation of products such as insecticides, pesticides, fungicides and other chemical formulations has been carried out on sugarcane crop. The evaluation was carried out after signing a Memorandum of Understanding with the manufacturers, as per the details given in Table 15.1

Table 15.1 Memorandum of Understanding for Contract Research

Contracting party	Contract research
Agrinos India Pvt. Ltd., New Delhi	Fertility studies on AGMA energy granular AMF (Mycorrhiza) in sugarcane (V.K. Singh, M.K.Tripathi, A.D. Pathak, S.K. Shukla, Lalan Sharma and A.P. Dwivedi; 2022-2024, Budget: Rs. 12.00 lakh)
Sirius Minerals India Pvt. Ltd.	Effect of Aldor on growth, yield, quality and nutrient use efficiency in wheat-rice-sugarcane system (S.R. Singh, M.K. Tripathi, A.P. Dwivedi, V.K. Singh and A.D. Pathak; 2021-24, Budget: Rs. 48.00 lakh)
Bayer Crop Science Ltd., Mumbai	Bio-efficacy and phytotoxicity evaluation of pre- and post-emergent application of Aclonife 500 g/l+Diflufenican 100 g/l SC against complex weed flora in sugarcane and its effect on succeeding crop (Y.E. Thorat, D.N. Borase, S.K. Yadav and Dileep Kumar; 03/22-02/24, Budget: Rs. 20.00 lakh)
Bayer Pvt. Ltd. Mumbai	Efficacy, phyto-toxicity and effect on succeeding crop studies with Aclonifen 500 g/L + Diflufenican 100 g/L SC in sugarcane (V.P. Singh, K.K. Singh and Dileep Kumar, 2022-2025, Budget: Rs. 13.00 lakh)
Bayer Crop Science Ltd., Mumbai	Bio- efficacy and phytotoxicity evaluation of Solomon 300 OD against black bug infestations in sugarcane (Y.E. Thorat, D.N. Borase, and S.N. Sushil; 10/21 -09/23, Budget: Rs. 13.00 lakh)
BASF India Ltd., Navi Mumbai	Bio-efficacy and phytotoxicity evaluation of BAS 43311H against broad-leaved weeds and sedges in sugarcane and its effect on succeeding crop (D.N. Borase and Y.E. Thorat; 01/21-08/23; Budget: Rs. 20.00 lakh)
BASF India Ltd., Navi Mumbai	Bio-efficacy and phyto-toxicity evaluation of BAS 433 11 H against broad-leaved weeds and sedges in sugarcane and its effect on succeeding crop (V.P. Jaiswal, S.K. Yadav, S.K. Shukla, Lalan Sharma and Mona Nagargade; 02/21 -09/23, Budget: 20.00 lakh)
Smart Chem Technologies Ltd., Pune	Assessing bio-efficacy of bensulf superfast on growth, yield, juice quality and nutrient use efficiency in sugarcane. (S.R. Singh, Sanjeev Kumar and Dinesh Singh; 2022-24, Budget: Rs 16.00 lakh)
Smart Chem Technologies Ltd., Pune	Response of CROPTEK9 complex fertilizer grade to sugarcane crop (C. Gupta, S,R, Singh, A.D. Pathak and V.P. Jaisawal; 2022-2024, Budget: Rs. 12.00 lakh)
UPL Ltd., Mumbai	Bio-efficacy and phytotoxicity evaluation of Acetamiprid 1521 against complex weed flora of sugarcane and its effect on succeeding crop (D.N.Borase and Dileep Kumar; 2021 -23, Budget: Rs.18.00 lakh)

FMC India Pvt. Ltd	Efficacy of F4337-500 g/I SC against major insect pests of sugarcane (Y.E. Thorat, D.N. Borase, and S.N. Sushil; 7/21-6/23 Budget: Rs.15.00 lakh)
IPL Biological Ltd, Gurugram	Evaluation of *Pseudomonas fluorescens* 1.0% W.P (Strain No. IPL/PS/01) against pokkah boeng and *Trichoderma viride* 1.0% W.P (Strain No. IPL/VT/101) against red rot in sugarcane (Dinesh Singh, 04/21-03/23 Budget: Rs. 15.00 lakh)
Nanozim	Evaluate of the effect of Nanozim Xtrude on crop health yield in sugarcane. (A.P. Dwivedi; 2022/2023, Budget Rs. 5.00 lakh)
PBRI	Efficacy and Evaluation of *Patanjali Javik Kranti and Patanjali Dharti Ka Chowkidar* in sugarcane crop (V.P. Jaiswal, S.K. Shukla and Lalan Sharma), 2021-2023, Budget : Rs. 10.00 lakh)
UPL Ltd., Mumbai	Bio-efficacy and phytotoxicity evaluation of setts treatment product UPFI 116 against insect pests and diseases of sugarcane (D.N. Borase, Arun Baitha, Shweta Singh, and Y.E. Thorat, 11/22-12/24, Budget: Rs. 15.00 lakh)
UPL Ltd., Mumbai	Bio-efficacy and phytotoxicity evaluation of UPST 119 against early shoot borer, white grubs and termites infesting termites (D.N. Borase, S.N. Sushil, Arun Baitha, Y.E. Thorat, 02/21-01/23, Budget: Rs.15.00 Lakh)
UPL Ltd., Mumbai	Bio-efficacy and phytotoxicity evaluation of GPH 1521 against broad-leaved weeds and sedges in sugarcane and its effect on succeeding crop (D.N. Borase, S.K. Yadav, Dileep Kumar and Y.E. Thorat, 03/21-02/23, Budget: Rs. 18.00 Lakh)
UPL Ltd., Mumbai	Bio-efficacy and phytotoxicity evaluation of GPI 1820 against early shoot borer, white grub and termite infesting sugarcane (D.N. Borase, Arun Baitha, S.N. Sushil, and Y.E. Thorat; 01/21-08/23, Budget: Rs. 13.00 lakh)
U.S. Borax / RIO	Efficacy and evaluation of various sources of boron grades in sugarcane crop (V.P. Jaiswal, S.K. Shukla and Lalan Sharma; 2022-2024, Budget : Rs.15.00 lakh)
VSI, Pune	Bio-efficacy testing of entomopathogenic fungi as a biopesticide against white grubs and whitefly in sugarcane (Y.E. Thorat, D.N. Borase and S .N. Sushil, 20/21-01/23, Budget: Rs. 5.00 lakh)
Rashtriya Chemical and Fertilizer Ltd., Mumbai	Evaluation of nano urea on sugarcane yield and quality. (K.K. Singh, N.P. Singh, and Dileep Kumar 2023-25, Budget: Rs. 15.00 Lakh)
UPL Ltd., Mumbai	Bio-efficacy and phytotoxicity evaluation of GPH 1020 against complex weeds flora of sugarcane and its effect on succeeding crop. (D.N. Borase and Y.E. Thorat 2023-25, Budget: Rs. 15.00 Lakh)
UPL Ltd., Mumbai	Bio-efficacy and phytotoxicity evaluation of setts treatment product UPFI 116 against insect pests and diseases of sugarcane. (D.N. Borase, Arun Baitha, Shweta Singh and Y.E. Thorat, 2023-25, Budget : Rs. 15.00 Lakh)
UPL SAS Limited	Evaluation of the coromandel international-nano dap on sugarcane crop. (V.K. Singh, M.K. Tripathi, V.P. Singh and Rajeev Kumar 2023-25, Budget: Rs. 15.00 Lakh)

CHAPTER 16

Human Resource Development

Capacity building programme for all the staff of the Institute

A three days "Capacity Building Programme" for all the staff of the Institute (scientific, technical, administrative and supporting) was organized at the ICAR-Indian Institute of Sugarcane Research, Lucknow under HRD Cell in online mode on Zoom platform from March 23-25, 2023. Dr. Sangeeta Srivastava, HRD Nodal Officer acted as Course Director and Dr. Sukhbir Singh, HRD Co-Nodal Officer and Sri S.K. Singh, CAO acted as Course Co-ordinators. The training programme was inaugurated by Dr. R. Viswanathan Director, ICAR-IISR, Lucknow on March 23, 2023. Issues related to Intellectual Property Rights (IPR), significant role of private sectors in filing patents, and four basic criterion for patent filing viz., patentability, novelty, non-obviousness and industrial applicability were discussed during these three days. The resource persons included Dr. R.V.S. Rao, Ex. Head, HRD, ICAR-NAARM, Hyderabad delivered a lecture on motivation and teamwork. He highlighted that, with team spirit, herculean tasks can be successfully achieved. All the scientists, technical, administrative and supporting skilled staff participated in the training.

Capacity building of ICAR-IISR Officials

Name	Training Programme	Venue	Date
Dr Rajesh U Modi	Airborne Hyperspectral Remote Sensing for Agricultureorganized by the Division of Agricultural Physics, ICAR-IARI, New Delhi.	Online mode	January 16-25, 2023
Dr. Sangeeta Srivastava	Online workshop on 'Current status and future plans of Agrinnovate India Limited'	ICAR, New Delhi	Feb. 20, 2023
Dr. T K Srivastava	Toolified approach for Competency Development of Government Officials for developing Climate Projects'	ICAR- NIASM, Baramati	13-17 March 2023
Dr. Swapna M	On-line training programme organized by NAARM, Hyderabad	Multivariate Data Analysis	20-27 March 2023.
All officers/officials of IISR and KVK	Three days' Capacity Building Programme	ICAR-IISR, Lucknow	23-25 March 2023
Dr. T K Srivastava	Crop Simulation modelling for managing agriculture under changing climate' under the UN Environment –GEF project 'Mainstreaming Agricultural Biodiversity Conservation and Utilization in Agricultural Sector to Ensure Ecosystem Services and Reduce Vulnerability'	ICAR- IARI, New Delhi	22-26 May 2023
Dr. Swapna M and Dr. Chandramani Raj	Training Course on "Enhancing pedagogical competencies for agricultural education	NAAS, New Delhi	31 July-5 August 2023.
Dr. Aalok Shiv	Data Analysis with 'R'" organized by Centre for eLearning in collaboration with Dept. of Agricultural Statistics, College of Agriculture, Vellanikkara,	Kerala Agricultural University, Thrissur	07-11 August, 2023
Dr. Sayanti Guha Majumdar	Professional Attachment Training for three months on "Deciphering Drought Tolerance Mechanisms in Sugarcane (Saccharum spp.): Transcriptome Profiling and Pathway Identification"	CSIR- National Botanical Research Institute, Lucknow.	September 15 - December 14, 2023
Dr. Sangeeta Srivastava	Biological Science Sessions of NASI DBT STAR Webinar &Fourth Hybrid Lecture Workshop on Women in Science and Engineering (WISE)	National Academy of Sciences, India (NASI) – Delhi	October 31, 2023 to November 04, 2023 in online mode
Dr. Y. E. Thorat	Studies on Nematode taxonomy'	ICAR-NBAIR, Bengaluru	18-30 December 2023

Dr. Dileep Kumar	FPOs, Farmers and Start-Ups Immersion Program	ICAR-IISR, Lucknow	August, 2023
Dr. Dileep Kumar	Bio-Manufacturing Subsector: Functional Foods August, 2023	Online	August, 2023
Mr. K Srinivas	Professional Attachment Training (PAT) for 3 months	ICAR-NBAIR, Bangalore	Oct 18 2023 to Jan 17 2024
Mrs. Mithilesh Tiwari	Online short course on recent advances in millets crop production, processing, value addition and marketing.	Online	August 2023
Mrs. Mithilesh Tiwari Dr. Vinika Singh	Online Refresher course on Millets (Shri Ann) model crops for sustanable farming, value addtion, entrepreurship development and nutrition security.	Online	September 2023
Dr. Vinika Singh	Online short course on recent advances in millets crop production, processing, value addition and marketing	Online	September 2023
	crops for sustanable farming, value addtion, entrepreurship development and nutrition security.	Online	September 2023
Mr. Rajiv Ranjan Rai	Food Processing, Packaging and Value Addition of Agricutural and Livestock produce.	CIPHET, Ludhiana	14-25, November 2023
Dr. VK Pandey	Mushroom Production Technology for Scientists/SMSs of KVKs by	Solan, Himachal Pradesh	11-15, December 2023

Sponsored sugarcane extension trainings organized for farmers and students

Duration	Topic	Sponsoring Agency	No. of Participants
Jan 16-20, 2023	Ganne Se Gud Nirmit Karne Ki Unnat Taknik	ATMA Gaya (Bihar)	20 Farmers
Feb 15-17, 2023	Ganna Utpadan Taknik	ATMA, Aurangabad (Bihar)	33 Farmers
April 25-27, 2023	Ganna Utpadan hetu unnat Krishi taknik	Agricon Samiti, Chhattisgarh	15 Farmers
Aug. 01, 2023 – 30 Sept., 2023	RAWE and AIA Programme for B.Sc. (Ag.) (Hons.) Student	Galgotias University, Gautam Budha Nagar (U.P.)	01 students
September 14, 2023	Value added jaggery Training programme of State Agricultural Management Institute Rehmankhera at IISR, Lucknow	-	35 farmers
October 04, 2023	"Improved technologies for sugarcane Mechanisation" at village Dashrathmau, Block - Rudauli, District Ayodhya	ICAR-IISR Lucknow and Balrampur Chini mill	150 farmers
Oct. 16-20 , 2023	"Sugarcane Technology and management" Training program	B.Sc. (Hons.) IAS, BHU, Varanasi (U.P.)	09 students
October 9-13, 2023	5-days Farmer's training program on, " Mechanization of sugarcane based cropping system for small holdings"	ICAR-IISR Lucknow	19 farmers
Nov. 07, 2023	One day training on "Sugarcane seed multiplication techniques for developing seed entrepreneurs for enhancing income of the farmers" at Kotwadham, District –Barabanki, UP	ICAR-IISR, Lucknow	100 Farmers
Nov. 08, 2023	One day training on "Integrated Insect Pests and Disease Management in Sugarcane" at Kotwadham, District – Barabanki, UP	ICAR-IISR, Lucknow	100 Farmers
Dec. 21, 2023	One day Gosthi cum -training on "Scientific Sugarcane Cultivation" at Jadvapur, District –Barabanki, UP	ICAR-IISR, Lucknow	150 Farmers
Dec. 21, 2023	One day Gosthi cum -training on "Scientific Sugarcane Cultivation" Maraucha, District –Barabanki, UP	ICAR-IISR, Lucknow	150 Farmers
Dec. 01-31, 2023	"RAWE training" for B.Sc. (Ag.) Students	Narayan Institute of Agricultural Science, GNSU, Sasaram, Bihar	45 students

One day training-cum-visits organized

During the period, a total of 110 one-day trainings and visit programmes were organized at the institute in which 2051 farmers, 196 officials, 2761 students, 10 Scientist and 102 teachers acquired latest know-how in scientific cane cultivation practices, jaggery making, bio-fertilizer production, tissue culture and sugarcane machines, macrobial and microbial bioagents and their mass production for biological control of insect-pest and diseases of sugarcane.

One-day training program on biological control of insect pests of sugarcane

BCC, Pravranagar conducted a one-day training program on "Biological control of insect pests of sugarcane" for the participants of the National-level training program on Climate Resilient Agriculture organized by Watershed Organization Trust (WOTR)

Pune. This event was organized on September 14, 2023, and 24 participants participated in a training program.

One-day training program on Integrated management of insect pests and diseases of sugarcane for higher cane yield

BCC, Pravranagar conducted a one-day training program on "Integrated management of insect pests and diseases of sugarcane for higher cane yield" for the

participants of the training program on Adsali Sugarcane yield 110 ton/acre plantation organized by Regional Agricultural Extension Management Training Institute (RAMETI), Nashik. This event was organized on July 18, 2023, and 40 participants participated in a training program.

One-day seed distribution program training program of sugarcane for higher cane yield

The quality seed distribution program was organized under tripartite collaboration with ICAR-IISR, BCC, Padmashri Dr. Vikhe Patil Cooperative Sugar Mill, Pravaranagar and Syngenta Foundation India, Pune to provide foundation seed cane of recently released variety (*Phule* 15012) to 125 progressive farmers on 30th November 2023.

Entrepreneurship training for promoting agri-business

The entrepreneurship in agriculture has been identified as a significant contributing factor in doubling or enhancing farm income. The Institute has applied concerted efforts under its outreach extension and training programme to impart the knowledge and skills in entrepreneurship to farmers, NGO personnel, development officers, agri-graduates and extension functionaries of different state governments.

Details of the students undergone UG/PG training at ICAR-IISR, Lucknow

Details of the students	Subject	University/ College	Duration of training	Supervisor
Mr. Anuj Pandey	B.Sc. (Hons.) Biotechnology	SHUAT & S, Prayagraj	January 20 – July 19, 2023	Dr. Sangeeta Srivastava
Ms. Sujata Meena	M.Sc. (Biotechnology)	Sant Hirdaran Girls College, Bhopal	January 31 – July 31, 2023	Dr. Sanjeev Kumar (Biotech)
Ms. Bharti Daduriya	M.Sc. (Biotechnology)	Sant Hirdaran Girls College, Bhopal	February 01 – July 30, 2023	Dr. Sangeeta Srivastava
Mr. Nitin Kumar	B. Tech. (Biotechnology)	S V B Patel University & Technology, Meerut	February 23 – May 22, 2023	Dr. Sanjeev Kumar
Ms. Neelam	B. Tech. (Biotechnology)	S V B Patel University & Technology, Meerut	February 27 – May 26, 2023	Dr. M. Swapna
Ms. Pratibha Tripathi	M.Sc. (Zoology)	Maharishi University of Information Technology, Lucknow	March 14 – April 13, 2023	Dr. Arun Baitha

Mr. Ajamul Haq	M.Sc. (Genetics & Plant Breeding)	Gochar Mahavidyalaya, Rampur Maniharan, Saharanpur	March 24 - October 20, 2023	Mr. Aalok Shiv
Ms. Ankita,	M.Sc. (Chemistry)	Dr. Bhimrao Ambedkar University, Agra	April 18 – October 18, 2023	Dr. Pushpa Singh
Ms. Aparna	B.Sc. (Life Science)	Daulat Ram College, Delhi University, Delhi	May 30 – July 13, 2023	Dr. S.K. Goswami
Mr. Nikith Soby	B.Sc. (Hons.) (Agriculture)	SHUATS, Prayagraj	June 05 – July 19, 2023	Dr. Aalok Shiv
Mr. Siddhant Yadav	M.Sc. (Microbiology)	Amity University, (Lko. Campus) U.P.	June 05 – July 19, 2023	Dr. Lalan Sharma
Mr. Ambuj Dixit	B. Tech (Agr. Engineering)	M C A E T, Ambedkar Nagar, U.P.	June 06 – July 03, 2023	Dr. Sukhbir Singh
Mr. Adarsh Yadav	M.Sc. (Statistics)	University of Lucknow, Lucknow, U.P.	June 09 – July 08, 2023	Dr. S. S. Hasan
Ms. Ankita Singh	M.Sc. (Statistics)	University of Lucknow, Lucknow, U.P.	June 09 – July 08, 2023	Dr. S. S. Hasan
Ms. Pratibha Srivastava	M.Sc. (Statistics)	University of Lucknow, Lucknow, U.P.	June 09 – July 08, 2023	Dr. S. S. Hasan
Mr. Akshat Srivastava	M.Sc. (Statistics)	B. B. A. U., Lucknow	June 12 – July 11, 2023	Dr. Rajesh Kumar
Mr. Pranjal Agarwal	M.Sc. (Statistics)	B. B. A. U., Lucknow	June 12 – July 11, 2023	Dr. Rajesh Kumar
Mr. Sandeep Kumar	M.Sc. Agriculture (Entomology)	C. S. A. U. A. T, Kanpur	June 16 – August 14, 2023	Dr. Arun Baitha
Mr. Amandeep	B. Tech. (Biotechnology)	SHUAT & S, Prayagraj	June 20 - July 19, 2023	Dr. Aalok Shiv
Mr. Navnendra Yadav	B. Tech. (Biotechnology)	SHUAT & S, Prayagraj	June 20 - July 19, 2023	Dr. R.S. Gujjar
Mr. Sarvendra Giri	B. Tech. (Biotechnology)	SHUAT & S, Prayagraj	June 20 - July 19, 2023	Dr. R.S. Gujjar
Ms. Anshini Pandey	B. Tech. (Biotechnology)	NIMS University, Rajasthan, Jaipur	June 27-July 26, 2023	Dr. Ranjit Singh Gujjar
Ms. Varsha	M.Sc. (Biotechnology)	B. B. A. U., Lucknow	July10 – January 09, 2023	Dr. Swapna M.
Ms. Komal Sharma	M.Sc. (Biotechnology)	B. B. A. U., Lucknow	July 10 – September 10, 2023	Dr. Sangeeta Srivastava
Mr. Ketan Chandra	B. Tech. (Biotechnology)	UIET, Kurukshetra University, Kurukshetra	July 13 - August 11, 2023	Dr. S.S. Hasan
Mr. Nikam Mangesh Dnyaneshwar	B.Sc. (Agri. Biotechnology)	College of Agricultural Biotechnology, Loni	August 01 – December 31, 2023	Dr. D. N. Borase
Mr. Agre Swapnil Ramesh	B.Sc. (Agri. Biotechnology)	College of Agricultural Biotechnology, Loni	August 01 – December 31, 2023	Dr. Y. E. Thorat
Mr. Ayush Dixit	B.Sc. (Hons.) Agriculture	Galgotias University, Gautam Budh Nagar	August 01 October 31, 2023	Dr. Barsati Lal
Mr. Aditya Pratap Singh	B.Sc. (Agr. Engineering)	Saroj Institute of Technology and Management	August 03 – Sept. 02, 2023	Dr. A. K. Singh
Mr. Shailendra Kumar Maurya	M.Sc. (Plant Pathology)	Chaudhary Charan Singh University, Meerut	August 05 – February 04, 2023	Dr. Dinesh Singh
Mr. Mohammed Afzan	B.Sc. (Agr. Engineering)	Bansal Institute of Engineering and Technology, Lucknow	August 03 – September 01, 2023	Dr. R. U. Modi
Mr. Raj Verma	B. Tech (Agr. Engineering)	Bansal Institute of Engineering & Technology, Lucknow	August 03 – September 01, 2023	Dr. Sukhbir Singh
Mr. Sumit Kumar	M.Sc. (Plant Pathology)	CCSU, Meerut	August 05 – February 04, 2023	Dr. Dinesh Singh
Mr. Shubham Kumar	M.Sc. (Plant Pathology)	CCSU, Meerut	August 04 – February 03, 2023	Dr. Dinesh Singh
Ms. Avneesh Kumar	M.Sc. (Entomology)	Bundelkhand University, Jhansi	August 18 – February 17, 2023	Dr. Arun Baitha

Trainings organized at ICAR-IISR Biological Control Centre, Pravaranagar, Maharashtra

Name of the Programme	Details of the Programme	University/ College	Duration of training	Supervisor	No. of Students
"Sugarcane Research and Management" under RAWE programme	One-week unit attachment training of B.Sc. (Agri.) students	College of Agriculture, Loni affiliated to MPKV, Rahuri at IISR Biological Control Centre, Pravaranagar	February 01-07, 2023	Dr. Y. E. Thorat	14
			February 08-14, 2023	Dr. D. N. Borase	14
			October 30-November 5, 2023	Dr. D. N. Borase	18
			November 6-12, 2023	Dr. Y. E. Thorat	18

CHAPTER 17

Awards Honours Recognitions

Professional Society Awards

- Dr S K Yadav received Excellence in Research Award by R.S. Krishi Shodh Sansthan, Prayagraj for outstanding contribution in field of Agronomy. Recognition is given in International Conference held during 25-26th Feb. 2023 at MGCG Vishwavidyalaya, Chitrakoot, Satna, M.P.
- Dr. Dinesh Singh, Head, Division of Crop Protection, received Outstanding Award for Running the Asian PGPR Society (2023) conferred by Asian PGPR Society for Sustainable Agriculture, Auburn University, USA.
- Dr. Sangeeta Srivastava received 'VIWA 2023 Lifetime Achievement award in Genetics' on Women's Day 08th March 2023 by Centre for Women Development, Chennai.
- Drs. Sukhbir Singh and AK Singh awarded Pushpavati Blessing Garapati Gold Medal Award for Best Paper in Sugarcane presenting during SISSTA's 52nd Annual Convention, Chennai, September 29-30, 2023.
- Dr. A.K. Mall awarded with NESA Fellowship Award-2023 on 14th December, 2023 at CSIR-National Botanical Research Institute, Lucknow, Uttar Pradesh.

Institute Awards

- Dr. Y E Thorat, Shri Rajiv Ranjan, Shri R K Singh, Shri Deep Kumar, Shri A K Vishwakarma, Shri. Somnath Singh, Shri. Anuj Kumar, Shri Raja Ram, Shri Ved Prakash Tiwari, Shri Ganesh Singh Negi, Smt. Chaman Ara Siddiqui and Smt. Poonam Manish received award for outstanding contribution in Research/ Administration on the Foundation Day of the Institute on 17th Feb 2023.
- Division of Agricultural Engineering received '*Mithas* trophy' for excellent work during Hindi pakhwada Sept 14-29, 2023.
- Dr. Rajesh U Modi received first prize for '*Varsh bhar me kiye gaye hindi karya ki samiksha*' during Hindi pakhwada, September 14-29, 2023.
- Dr. Sangeeta Srivastava received First Prize for Hindi Speech and Consolation Prize for paper in '*Ikshu*' at IISR, Lucknow during Hindi fortnight, celebrations in September 14-29, 2023.
- Dr. A.K. Mall received prize for article in *Ikshu* Patrika in Hindi Pakhwada during Hindi pakhwada, September 14-29, 2023.
- Drs. Lalan Sharma, Vijay Prakash Jaiswal, Sudhir Kumar Shukla and Asha Guar awarded for publishing hindi article on "*Natragen sthirikaran karane wale sukshm jeevoan ka Krishi men mahatva*" in *Ikshu* Magazine at ICAR-IISR, Lucknow during during *Swachhta Pakhwara* (14-29 Oct, 2023) at ICAR-IISR, Lucknow.
- Drs. S. K. Goswami, Chandramani Raj and Shweta Singh awarded for hindi article "*Ganne ke pramukh kavak roag aur prabandhan*" published in *Ikshu* magazine during *Swachhta Pakhwara* (14-29 Oct, 2023) at ICAR-IISR, Lucknow.

Best Paper Award

- Drs A P Dwivedi and M.K. Tripathi received best oral paper presentation award in International conference on Futuristic Agricultural technology for Natural Farming and Global Food Marketing Policy held during 25-26th February, 2023 at MGCG Vishwavidyalaya, Chitrakoot, Satna, M.P.
- Dr S K Yadav received Best Paper Presentation award in International Conference held during 25-26th Feb. 2023 at MGCG Vishwavidyalaya, Chitrakoot, Satna, M.P.
- Dr R S Gujjar received Best oral presentation award in National Symposium on Crop Health Management: Safeguarding Crop through Diagnostics and Innovations (2023). Awarding agency: ICAR-VPKAS, Almora, Uttarakhand, India. 29-30th September 2023.
- Drs. S. K. Goswami, Dinesh Singh and S. P. Singh (2023) awarded for best oral presentation on "Endophyte Chaetomium globosum strain CGSR13 enhances sugarcane growth and bio-control of C. falcatum in the DST-SERB sponsored "National symposium on crop health management" 29-30 September 2024 at ICAR-

VPKAS, Almorah.

- Dr Rajesh U Modi received the Best Oral Paper Presentation Award in National Seminar on Natural & Organic Farming for Sustainable Agriculture held at ICAR-IISR, Lucknow on December 29, 2023.

Nomination/Recognitions/Reviewers

- Dr. A K Sharma is nominated IMC member of SBI Coimbatore for 3 years.
- Dr. Rajesh Kumar, Dr. A K Sharma, Dr. S. I. Anwar and Dr. S S Hasan were nominated as Observers of ASRB computer based online-examination NET-2023, SMS (T-6)/STO(T-6) examination during Apr.27-30, 2023.
- Dr. A K Sharma nominated reviewer of the Paper entitled "Antecedents for Circular Economy in Indian Sugar Industrial Ecology: A Way towards Sustainable Development" in Sugar Tech journal.
- Dr. S S Hasan was awarded SERB-DST Vritika sponsored Internship programme for four interns.
- Dr. S S Hasan nominated as Examiner at Integral University, Lucknow for BSc (Hons) Agriculture examination.
- Dr. S S Hasan nominated as reviewer of journals viz., New Generation Computing Journal, Journal of Super Computing, Qeios Journal, and Agrical Journal.
- Dr. Sukhbir Singh appointed as external examiner to evaluate the thesis and conduct viva-voice of M. Tech. student from Agricultural Engineering discipline from Acharya NDUAT, Kumarganj, Ayodhya.
- Dr Sukhbir Singh appointed as External Examiner to evaluate the thesis of one Ph.D. student and conduct viva-voce in Farm Machinery & Power Engineering discipline from SHUATS, Prayagraj (U.P.).
- Dr Sukhbir Singh attended the Assessment Committee Meeting as Member-expert nominated by ASRB, New Delhi.
- Dr S.I. Anwar acted as Member, Project Monitoring Committee of Ministry of Environment, Forest and Climate Change, Govt. of India.
- Dr S.I. Anwar acted as Secretary of Lucknow Chapter of Indian Society of Agricultural Engineers (ISAE).
- Dr. Y. E. Thorat was nominated as a member of the 83rd Board of Studies (BOS) meeting in Agril. Entomology including Sericulture, Zoology and Nematology, organised by Dept. of Agril. Entomology, MPKV Rahuri.
- Dr. D. N. Borase was nominated as a member of the 58th Board of Studies (BOS) meeting in Plant Pathology, Mycology, Microbiology, Bacteriology, Seed Pathology, and Virology, organized by the Department of Plant Pathology and Agril. Microbiology, MPKV Rahuri.
- Dr. D. N. Borase was nominated as a member of the 9th Scientific Advisory Committee (SAC) meeting of Krishi Vidyan Kendra, Dahigaon-Ne, Ahmednagar on October 31, 2023.
- Dr. D. N. Borase has been recognized as a research co-guide/member for the M.Sc. (Agril. Microbiology) Programme of the Department of Plant Pathology and Agril. Microbiology, MPKV, Rahuri
- Dr. D. N. Borase acted as a member secretary of the "Project Monitoring Committee" for implementation of the RKVY Project constituted by Director Quality Control, Commissionerate of Agriculture Govt. of Maharashtra
- Dr. D. N. Borase acted as an external examiner for the thesis evaluation of Mr. P. Logeshkumar, Ph.D. Entomology, Agriculture College and Research Institute, Madurai, TNAU, Tamil Nadu.

CHAPTER 18

Publications

Banerjee N, Khan MS, Swapna M, Yadav S, Tiwari GJ, Jena SN, Patel JD, Manimekalai R, Kumar S, Dattamajumder SK, Kapur R, Koebernick JC and Singh RK (2023). QTL mapping and identification of candidate genes linked to red rot resistance in sugarcane. 3 *Biotech*. 13(82): Pp. 1-21. https://doi.org/10.1007/ s13205-023-03481-7.

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CHAPTER 19

Review, Monitoring and Evaluation

Institute Technology management Committee meeting

The first meeting of ITMC during 2023 was held on 22nd May, under the chairmanship of Dr. R. Viswanatahn, Director, ICAR-IISR, Lucknow. The following decisions were taken in the meeting:

- Price fixation of Tricho card developed by IISR and BCC, Pravaranagar
- Price fixation of Multi Crop Planter/Seed Drill developed by IISR
- Brief discussion on Patent to be filed by the Institute
- Identification of new technologies developed at IISR for commercialization.

The second meeting of ITMC was held on 4th August 2023 and the following decisions were taken in the meeting:

- The committee decided that all the HDs to discuss with their scientists and identify potential technologies for uploading on the Krishi portal
- The committee decided that the Institute technologies having potential to earn more than Rs. 1 lakh as one time licence fee and royalty should be submitted to the Agri-innovate Pvt Ltd for selling technologies to the potential buyers/firms.
- One IP expert, as non-official from outside ICAR system should be opted as member.
- The committee decided fees for training programmes for the students including RAWE.

During the third meeting of ITMC held on 03rd November 2023 the decisions taken were:

- The institute has to identify their professional service functions such as trainings, consultancy, contract research and services and advertise it on Institute's website for wider publicity.
- Institute has to file application to NBPGR for registration of all the sugarcane varieties released by the CVRC/SVRC or notified varieties for their released, before distribution of cane seed to farmers/sugar mills for its commercial cultivation.
- The ITMC suggested that the technology pricing/valuation for its commercialization/ licensing may be finalized through the proper survey on its market demand, cost involved in technology development, comparative saving advantages or ease of doing farm operation over existing technology.
- The institute has to work on the policy of 'One IP, One project' and 'at least One IP per scientist , I/c PME cell to identify potential IPs from the RPP-III submitted, for identification of technologies for the IPR filing and its commercialization

Institute Research Council meeting

The Institute Research Council (IRC) meeting of the ICAR-Indian Institute of Sugarcane Research (IISR), Lucknow was held under the Chairmanship of Dr. R. Viswanathan, Director of the Institute during July 3-5, July 7, August 9, and December 20, 2023 to review and discuss the progress of on-going research projects in the Institute on sugarcane and sugar beet. Along with the Chairman 57 scientists, 05 technical officers, 01 senior technical assistant and one R.A. participated in the IRC meeting.

The research findings of 61 ongoing-Institute research projects (Crop Improvement- 11; Crop Production- 12; Crop Protection- 10; Plant Physiology and Biochemistry- 06; Agricultural Engineering- 10; Agricultural Extension- 03, AKMU- 04 and BCC Pravaranagar- 03) and the technical programme for the next year were thoroughly discussed. Seventeen new research project proposals were submitted and presented by the scientists in the IRC, which were approved after thorough discussion.

Institute Management Committee Meeting

The 51st meeting of the Institute Management Committee (IMC) was held under the chairmanship of Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow on 21st July 2023. Progress of R & D efforts was reviewed and various administrative matters were discussed in the meeting.

Annual Group Meeting of AICRP on Sugarcane

Annual Group Meeting of AICRP on Sugarcane was organized through physical mode at Dr RPCAU, Pusa, Samastipur (Bihar) during October 26 & 27, 2023. The objective of the Meet was to review the research progress of 2022-23, framing the Technical Programme for 2024-25 and deliberate on all pertinent issues relating to increasing yield of sugarcane and sugar in India with a view to arrive at actionable recommendations. Inaugural session started with welcome address by Dr. A.K. Singh, Director of Research, Dr RPCAU & Director, Sugarcane Research Institute, Pusa. Dr. P.S. Pandey, Hon'ble Vice Chancellor, Dr. RPCAU, Pusa, Bihar was the Chief Guest of the session. Dr D. K. Yadav, ADG (Seed and CC), New Delhi was the Guest of Honour. Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow and Dr. G. Hemaprabha, Director, ICAR-SBI, Coimbatore also graced the session. In his welcome address, Dr. A. K. Singh briefly mentioned on the university's achievements including grant of eight patents, development of 14 crop varieties and other technologies developed by university and SRI, Pusa. Dr Dinesh Singh, Project Coordinator (Sugarcane) extended a warm welcome to all the guests and participants and presented brief of annual report of AICRP (S) for the year 2022-23.

Monitoring of Breeder seed plots

Monitoring of breeder seed plots under Bihar Sugarcane Breeder Seed Production Programme at IISR Regional Station, Motipur; Tirupati Sugar Mills Ltd., Bagaha; New Swadeshi Sugar Mill, Narkatiaganj and Harinagar Sugar Mills, Harinagar, Bihar was held during December 05-07, 2023.

CHAPTER 20

Participation in Seminars / Webinars/ Symposia/ Conferences etc.

Name	Programme Name	Organized by	Date
Dr. Y. E. Thorat	National Conference on Plant-Parasitic Nematodes (PPNs) -2023	Bayer Crop Science Ltd. India, Bengaluru	16 - 18 January 2023
Dr AK Singh	37th Annual Workshop of AICRP	ICAR-CIAE, Bhopal	19-21 January, 2023
Dr. Pushpa Singh	National Seminar on "Functional Biology and Molecular Interactions (FBMI 2023)	University of Lucknow, Lucknow	28 January, 2023
Dr. Sangeeta Srivastava	Current status and future plans of Agrinnovate India Limited	ONLINE mode ICAR, New Delhi	20 February, 2023.
Dr A P Dwivedi, Dr. M K Tripathi, Dr S K Yadav,	International conference on Futuristic Agricultural technology for Natural Farming and Global Food Marketing Policy	MGCG Vishwavidyalaya, Chitrakoot, Satna (MP)	25-26 February, 2023
Dr. Swapna M	Multivariate Data Analysis	NAARM, Hyderabad	20-27 March, 2023
All Scientific / Technical and Administrative staff of the institute	Capacity building Programme	ICAR- IISR, Lucknow	23-25 March, 2023
Dr A K Singh, Dr. R D Singh, Dr. R Gupta, Dr. SI Anwar, Dr. Dilip Kumar, Dr. M K Singh, Dr. Sukhbir Singh, Dr. Rajesh U Modi	"Mechanization in Sugarcane: Need of the Hour-Challenges & Opportunities"	ISMA in association with IISR-Lucknow	28 March, 2023
Dr. D N Borase and Dr. Y E Thorat	Two-day National seminar on organic farming	Dept. of Geography, Arts, Science and Commerce College, Rahata	28 to 29 March, 2023
Dr. R. Viswanathan All HoDs Dr. Sangeeta Srivastava Dr Dilip Kumar Dr. A. K. Mall Dr. L.S. Gangwar	ITMC	ICAR- IISR, Lucknow	22 May; 04 August & 03 November, 2023
All Scientists of the institute	IRC	ICAR-IISR, Lucknow	3-5 July, 7 August and 20 December, 2023
Dr. R. Viswanatha and IMC members	IMC	ICAR-IISR, Lucknow	21 July, 2023
Dr. Swapna M Dr. Chandramani Raj	Enhancing pedagogical competencies for agricultural education	NAAS, New Delhi	31 July-5 August, 2023
Dr M K Singh	TeeB for Agriculture and Food UttarPradesh Stakeholder Consultation: Discussion on Draft Findings"	ICAR- IISR, Lucknow	01 August, 2023
Dr. Aalok Shiv	Data Analysis with 'R'	Centre for e-Learning in collaboration with College of Agriculture, Vellanikkara, K A U, Thrissur	07-11August, 2023
Dr. R. Viswanathan and all scientists	AGRI UDAAN 6.0 Roadshow	ICAR-NAARM, Hyderabad & NABARD, Lucknow at ICAR-IISR, Lucknow	08 August, 2023

Dr. R. Viswanathan Dr. Dinesh Singh Dr. Sangeeta Srivastava Dr. R.S. Gujjar, Dr. Dr. S.k. Goswami Dr. Rajeev Kumar Dr. M K Srivastava, Dr Radha Jain, Dr. Pushpa Singh	Sugar Sem 2023 - National Seminar on "Research Imperatives for Sustaining Sugarcane, Sugar and Ethanol Production	ICAR-Sugarcane Breeding Institute, Coimbatore, Tamil Nadu	25 August, 2023
Dr. R. Viswanathan	SUGARTECH 2023, Session 1: Sugar Cane Technology: Technology, Mechanization, Water Conservation, Drip irrigation, Research & Development for sustainable cultivation and how to rejuvenate Co 238	CII & UP Sugar Mills Association	04 September, 2023
Dr Rajesh U Modi	National Webinar on "Applications of AI and ML in Agricultural Engineering-Unleashing the potential for Food Security"	Dr. NTR College of Agricultural Engineering and Technology, Acharya NG Ranga Agricultural University, Bapatla, Andhra Pradesh	4-5 Sept., 2023
अभिषेक कुमार सिंह	राजभाषा सम्मेलन	राजभाषा विभाग, भारत सरकार, गृह मंत्रालय	14-15 September, 2023
Dr. T K Srivastava	Brainstorming Session on Soil Resources	Remote Sensing Application Centre UP, Lucknow	15 September, 2023
Dr. R. Viswanathan	The India Sugar & Bio-energy Conference 2023	JW Marriot, Aerocity, New Delhi	21-22, September, 2023
Dr. S K Goswami, Dr. Dinesh Singh, Dr. S P Singh	National symposium on crop health management	ICAR-VPKAS, Almorah	29-30 September, 2023
Dr. Sukhbir Singh	Advanced mechanization for sugarcane crop production	Integral Institute of Agricultural Science and Technology, Integral University, Lucknow	30th October, 2023
Dr. T K Srivastava	Global Micronutrient Summit	The Fertilizer Association of India	5-6 October, 2023
Dr. Dinesh Singh All scientists of the institute	Sugarcane Technology and management for B. Sc. Ag students of IASc, BHU, Varanasi	ICAR- IISR, Lucknow	16- 20 October, 2023
Dr. Sangeeta Srivastava	High-Throughput Data Analysis And Artificial Intelligence In Biological Research	ONLINE mode Amity Institute of Biotechnology	19-20 October, 2023
Dr. Sangeeta Srivastava	Biological Science Sessions of NASI DBT STAR Webinar & Fourth Hybrid Lecture Workshop on Women in Science and Engineering (WISE)	ONLINE mode National Academy of Sciences, India (NASI) – New Delhi	31October – 04 November, 2023
Dr. Rajesh U Modi	57th Annual Convention of the Indian Society of Agricultural Engineers on Agri-food Systems	University of Agricultural Sciences, Raichur, Karnataka	06-08 November, 2023
Dr. Dinesh Singh	Sugarcane seed multiplication techniques for developing seed entrepreneurs for enhancing income for the farmers under farmers Rauzagaon Sugarmill Zone	Under SCSP project at Kotwadham, Barabanki, UP.	07-08 November, 2023
Dr. Dinesh Singh	State level GANNA KISAN GOSHTHI	Sugarcane Industry Department, Government of Bihar at Bettiah	08 December, 2023
Dr. Dinesh Singh	BIMSTEC country	Virtual mode ICAR-Indian Agricultural Research Institute, New Delhi 110 012	06 – 17 November, 2023

Dr. Sukhbir Singh	Farm mechanization in India: Status and Future needs	Mahamaya College of Agricultural Engineering & Technology, NDUAT, Akbarpur, Ambedkar nagar, U.P.	22 December, 2023
Dr. T K Srivastava Dr. R Gupta, Dr. R R Verma Dr. V K Singh Dr. V P singh Dr. K K Singh Dr. A K Mall Dr. Dileep Kumar Dr. S R Singh Dr. V P Jaiswal Dr. Arun Baitha Dr. S K Shukla Dr. A P Dwivedi Dr. M K Tripathi	XXII Biennial National Symposium on Climate Smart Agronomy for Resilient Production Systems and Livelihood Security	ICAR - Central Coastal Agricultural Research Institute, Goa, India	22–24 November, 2023
Dr. R. Viswanathan, Dr. M K Tripathi, Mr. Abhishek Srivastava, Mr. P K Srivastava, Mr. A K Srivastava	संसदीय राजभाषा समिति की दूसरी उप–समिति की बैठक	राजभाषा विभाग, भारत सरकार, गृह मंत्रालय द्वारा प्रयागराज में बैठक	27-28 November, 2023
Dr. Radha Jain	Brain storming workshop on “Trends in the application of Artificial Intelligence for sustainable Agriculture”	ICAR-SBI, Coimbatore.	29 November, 2023
Dr. Dinesh Singh All scientists of the institute	Rural Agricultural Work Experience for B. Sc. (Ag) students of NARYAN Institute of Agricultural Sciences, GNSU, Sasaram, Rohtas, Hibar	ICAR- IISR, Lucknow	01-31December, 2023
All scientists of the institute	National seminar on “Natural & Organic Farming for Sustainable Agriculture”	ICAR- IISR, Lucknow	29 December, 2023
All scientists of the institute	Prof Kirti Singh Memorial lecture and national seminar on organic and natural farming for sustainable agriculture	ICAR-IISR, Lucknow in collaboration with RASSA, New Delhi, and SSRP, New Delhi	29 December, 2023

CHAPTER 21

Events Organized

Farmer-Scientific Discussion on Importance of Coarse Cereals

On the occasion of the International Year of Millet-2023 being celebrated all over the world, ICAR-IISR, Lucknow inaugurated the International Millet Year by cutting a millet cake on 18 January 2023. On this occasion a farmer-scientific discussion was organized in which farmers were made aware of the importance of coarse grains. Speaking on the occasion, Dr. R. Viswanathan, Director of the Institute said that by promoting the production of millet crops, problems like climate change, energy crisis, ground level health and food crisis can be easily controlled. He also focused on coarse cereal crops farming which require less water, chemical fertilizers and pesticides, which do not adversely affect the fertility of the soil and ground water level. The cost of production is also low in growing coarse cereals, besides being drought resistant, these crops can be easily grown on less fertile and marginal lands. Due to the low glycemic index in millets, millets are an ideal ingredient of food for diabetic patients.

The Breeders and Plant Protection Scientists Meet-2023 of All India Coordinated Research Project (AICRP) on Sugarcane

The Breeders and Plant Protection Scientists Meet - 2023 of All India Coordinated Research Project (AICRP) on Sugarcane was organised at the ICAR-IISR, Lucknow on January 20, 2023 to shortlist the promising sugarcane clones in the Initial Varietal Trials (IVT) for their further evaluation in Advanced Varietal Trials (AVT) and finalise the technical programme of varietal development for four sugarcane growing zones viz., North-West Zone, North-Central Zone, East Coast Zone and North-Eastern zone of the country.

The Chief Guest, Dr. R.K. Singh, Assistant Director General (Commercial Crops), ICAR expressed his satisfaction on India's excellent performance in sugarcane and sugar production and 10% ethanol blending in petrol.

Dr. G. Hemaprabha, Director, ICAR-SBI, Coimbatore & Principal Investigator (Crop Improvement) highlighted the rosy picture of sugarcane and sugar production in India. She expressed her pleasure on India's surpassing Brazil in sugar production and attaining 10% ethanol blending in petrol in India. Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow expressed his deep concern on the knocking down of the most popular sugarcane variety Co 0238 by red rot and emphasized on the integrated management of the disease. The performance of sugarcane clones under Initial varietal trials were presented by centres and after critical discussion of the breeders, pathologists and entomologists, the technical Programme for 2023-24 of North-West Zone, East-Coast Zone, North-Central Zone and North-East Zone was finalized.

74th Republic Day Celebration

The 74th Republic Day was celebrated at ICAR-IISR, Lucknow on January 26, 2023 with pride, great fervour and enthusiasm. At the outset, Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow along with Heads of the Divisions offered floral tributes to the Father of the Nation, Mahatma Gandhi. The Indian flag was unfurled by Dr. R. Viswanathan which was followed by recitation of the National Anthem by all the staff of the Institute. In his message, Dr. Viswanathan narrated the recent developments made in India in various fields. He urged to take the pledge to carry out the assigned duties with full sincerity, devotion and dedication for enhancement of sugarcane production, productivity, profitability and sustainability to meet future sugar and energy requirement in India.

The 72nd Foundation Day of the ICAR-IISR, Lucknow celebrated

The 72nd Foundation Day of the ICAR-IISR, Lucknow was celebrated with great fervour and enthusiasm. At the outset, Dr. R. Viswanathan, Director, ICAR- IISR welcomed the Chief Guest, Guests of Honour and presented a brief overview of research and developmental activities of the Institute during year 2022, He expressed his satisfaction that the newly developed sugarcane variety CoLk 14201 is showing great promise in Uttar Pradesh.

The Chief Guest of the function, Sh. Sanjay R. Bhoosreddy, IAS, Additional Chief Secretary, Sugar Industry and Cane Development, Govt. of Uttar Pradesh congratulated the scientists of the Institute for the unparalleled success achieved in sugarcane production and sugar sector.

The Guest of Honour, Dr. S. Solomon, Ex. Vice-Chancellor, CS Azad University of Agriculture and Technology, Kanpur lauded the R & D work of the IISR, Lucknow for making the country self-reliant in sugar production by developing more than 70 technologies since the establishment of the Institute. The Guest of Honour, Dr. R.K. Singh, ADG (CC), ICAR appreciated the sincere R & D efforts done by the Institute which are being reflected through 2.5 times increase of sugarcane productivity in India and significant increase in sugar recovery.

The best staff appreciation awards were given under for different categories for their outstanding work. Two books, entitled Sugarcane Management Practices in India and Ikshu and one folder KVK, ICAR-IISR, Lucknow at a Glance were also released on the occasion.

Interactive meet with foreign delegates

The foreign delegates of various countries including Brazil, USA, South Africa, Columbia, Netherlands, Mauritius, Senegal, Indonesia, Australia, France and Argentina etc, as a member of International Society of Sugar Cane Technologists (ISSCT) visited ICAR-IISR, Lucknow on February 17, 2023 during pre-congress tour and interacted with all the scientists.

National Science Day celebration

ICAR-IISR, Lucknow celebrated National Science Day under the theme of "Global Science for Global Well-being", in the light of India's G20 presidency on February 28, 2023 to commemorate the discovery of the 'Raman Effect" by Sir C.V. Raman, an Indian scientist and physicist. At the outset, Dr. Sangeeta

Srivastava, I/c, PME Cell welcomed Dr. Rasappa Viswanathan, Director; Dr. T.K. Srivastava, Principal Scientist (Agronomy) and all the participants. Congratulating the Indian Scientists for making number of scientific contributions for the betterment of mankind, Dr. R. Viswanathan highlighted a number of great Indian inventions in various spheres of science. A talk on "Climate change impact in Indo-Gangetic Plains and adaptation needs" was delivered by Dr. T.K. Srivastava on this occasion.

A Meeting of Institute Joint Staff Council

A Meeting of Institute Joint Staff Council was held on March 2, 2023 in the Director's Committee Room under the chairmanship of Dr Rasappa Viswanathan, Director, ICAR-IISR, Lucknow. From the Staff Side, Mr. Hari Lal (Member Secretary), Mr. Ganesh Singh (Member-IJSC), Mr. Ashish Singh Yadav (Member-IJSC), and Mr. Arjun (Member-IJSC) were present. From the Institute side, Sh. Saroj Kumar Singh, Chief Administrative Officer; Sh. Ravi Bhadra, Finance and Accounts Officer; Dr. V.P. Jaiswal, Senior Scientist; Mr. Adil Zubair, Chief Technical Officer, Mrs. Rashmi S. Srivastava, Private Secretary participated in the meeting. At the outset, Sh. S.K. Singh, CAO welcomed the Director, IISR and other members. Sh. Singh introduced the members of both sides to the Director and briefed about the functions of IJSC. The agenda items pertaining to staff welfare were thoroughly discussed and resolved. Mr. Adil Zubair, Member Secretary, Institute Side proposed the vote of thanks.

International Womens' day

ICAR- IISR, Lucknow celebrated the International Women's Day on 08th March 2023. Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow inaugurated the programme by lighting the lamp. Dr. Sharmila Roy, Principal Scientist & Chairperson, Women Cell welcomed the Director, the guest speakers-Ms. Divya Mishra and Ms. Suman Rawat and the participants. Delivering a talk on The Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act 2013, Ms. Divya Mishra, Advocate, Family Court, Lucknow highlighted the major points of the Act. Ms. Suman Rawat, Chairperson, Power Wings Foundation, Lucknow delivered a talk on Women Welfare and Empowerment and urged everyone to help in making the workplace as gender neutral. Citing the examples of Ramayan and Mahabharat, Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow narrated that villain as well as savior were present even in the ancient era. He highlighted that women are associated in every sphere of life today and are contributing a lot for the welfare of society. All the staff of the Institute participated in the event

National Seminar on "Mechanization in Sugarcane Agriculture – Challenges and Solutions"

National Seminar on "Mechanization in Sugarcane Agriculture – Challenges and Solutions" was organized on March 29, 2023 jointly by Indian Sugar Mills Association and ICAR-IISR, Lucknow. Prof. Vijay Paul Sharma, Chairman, Commission for Agricultural Costs and Prices, Ministry of Agriculture and Farmers Welfare, Government of India termed mechanization of sugarcane cultivation as the need of the hour.

Appreciating the contribution of ICAR-IISR, Lucknow for the development of number of farm machinery for performing various farm operations in sugarcane cultivation, Shri Sanjay R. Bhoosreddy, Additional Chief Secretary, Sugar Industry and Sugarcane Development, Government of Uttar Pradesh discussed the significant progress made in the area, production and productivity of sugarcane, sugar production and sugar recovery in Uttar Pradesh.

Discussing the cyclical nature of sugar production prevailing in India, Sh. Subodh Kumar Singh, Additional Secretary (Sugar), Ministry of Food, Govt. of India said that sugar production in India has been increasing continuously for the last 5-6 years and India is also exporting sugar for the last few years. Expressing concern over only 4 per cent of sugarcane being harvested in India by mechanical harvesters, Sh. Singh expressed the need for mechanization in sugarcane farming to increase the income of sugarcane farmers and sugar industry.

Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow highlighted various farm machineries developed by the Institute for planting, weeding, earthing-up, spraying of pesticides, harvesting and ratoon management for the mechanization of sugarcane cultivation. He advised the farmers to reduce the cost of cultivation of sugarcane and increase their income by adopting them. At the outset, Mr. Aditya Jhunjhunwala, President, Indian Sugar Mill Association (ISMA) welcomed all the guests and participants and highlighted the importance of mechanical harvesters in India for sugarcane harvesting. Dr. A.K. Singh, Principal Scientist and Organizing Secretary of the National Seminar gave detailed information about various agricultural machinery developed by the Institute for mechanization of sugarcane agriculture. About 300 delegates from different parts of the country including various office bearers of the Indian Sugar Mills Association, officials of sugar mills, leading manufacturers of agricultural machinery and sugarcane scientists from across the country participated in the seminar.

Visit of Secretary DARE & DG, ICAR to IISR Lucknow and Inauguration of the Post- harvest Engineering Laboratory.

Dr. Himanshu Pathak, Hon'ble Secretary, Department of Agriculture Research and Education, Govt. of India and Director General, Indian Council of Agricultural Research, New Delhi visited ICAR-IISR, Lucknow on April 14, 2023. He inaugurated the Post-harvest Engineering Laboratory in the Division of Agricultural Engineering and discussed about the various jaggery-based value-added products.

At the outset, all the dignitaries paid floral tributes to Bharatratna, Dr. Bhimrao Ambedkar on the occasion of his 132th birth anniversary. Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow welcomed the Secretary, DARE & DG, ICAR, the guests and other participants and presented the sugar scenario of the country. He highlighted about the major technologies and achievements of the Institute. Dr. J.K. Jena, Deputy Director General (Fisheries), ICAR, in his remarks, highlighted about the sharing of research and other facilities among all the ICAR Institutes located at Lucknow.

Hon'ble Prime Minister vision of developing India as the most developed country by the next 25 years. Hon'ble DG highlighted the constitution of an Education Hub as a part of IARI Mega University in which ICAR Institutes of Lucknow are also the participants. Dr. Uttam Sarkar, Director, ICAR-NBFGR, Lucknow; Dr. R.K. Yadav, Director, ICAR-CSSRI, Karnal; Dr. T. Damodaran, Director, ICAR-CISH, Lucknow, Dr. A.D. Pathak, Ex. Director, ICAR-IISR, Lucknow and all the scientists were also present during the interactions.

International Workshop on "Strategies to boost farmers' income through intervention of CGIAR technologies"

A International Workshop on "Strategies to boost farmers' income through intervention of CGIAR technologies" was jointly organized by U.P. Council of Agricultural Research, Lucknow, International Crop Research Institute for Semi-Arid Tropics (ICRISAT), Hyderabad, and ICAR- IISR, Lucknow at ICAR-IISR, Lucknow on April 24, 2023. The crop-wise specific technological interventions from the perspective of CGIAR Institutions, benefits for agriculture sector to be achieved in the state with the activities of CGIAR and expectations of CGIAR organizations in terms of policy intervention by the State Government were discussed in detail. Sh. Surya Pratap Shahi, Hon'ble Agriculture Minister, UP graced the occasion and participated in the discussions.

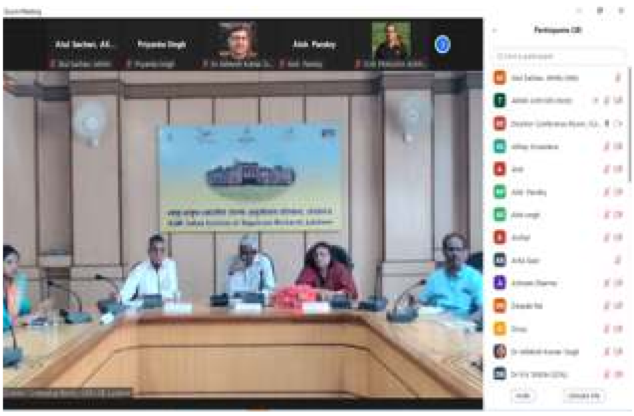
At the outset, Dr. Sanjay Singh, Director General, UPCAR, welcomed the guests and gave an overview of the programme. Dr. Panjab Singh, Ex. Secretary, DARE & DG, ICAR and Ex. VC, BHU, Varanasi and Chairman of the programme highlighted the need of developing a module of all the technologies for adoption by the farmers, Mr. Manoj Kumar Singh, Agriculture Production Commissioner, Govt. of UP, highlighted the major achievements and major challenges being faced by the farm sector in the state.

Dr. Arvind Kumar, DDG (Research), ICRISAT highlighted the altered hydrological cycles, mono-cropping system leading to land degradation, salinity and various abiotic and biotic stresses resulting in decline in productivity, increasing cost of cultivation with high water-energy-carbon footprints. Dr. K.V. Raju, Economic Advisor to Hon'ble Chief Minister, Govt. of Uttar Pradesh highlighted the need for strong linkages and collaborations among UPCAR, SAUs, ICAR Institutes, KVKs and CGIAR Institutes. Dr. Arun Kumar, VC, SKRAU, Bikaner emphasized on the need of scientific dissemination of technologies developed by the research institutes or organizations. Highlighting the prospects for sugarcane cultivation in UP, Dr.R. Viswanathan, Director, ICAR-IISR, Lucknow presented the sugarcane scenario of UP and proposed Vote of thanks at the end of the introductory session.

The Hon'ble Minister for Agriculture in his address, urged the research scientists and managers from different SAUs, ICAR Institutes and CGIAR organizations to collaborate with UPCAR, to develop a blueprint for agricultural development in the state, which will ultimately lead to the prosperity of the farmers.

World Intellectual Property Day" celebration

The "World Intellectual Property Day" was celebrated on 26th April, 2023 at ICAR-IISR, Lucknow with the theme of "*Women and IP: Accelerating Innovation and Creativity*". This event was organized by Institute Technology Management Unit (ITMU) and Agri Business Incubation Centre (ABIC) by conducting awareness programme on IP rights. Dr. L.S. Gangwar, Principal Scientist and I/c, ITMU delivered his lecture on role of WIPO in IP regime. Dr. Sangeeta Srivastava, Principal Scientist & I/c, PME Cell delivered her talk on "Participation of Women in Science & Technology" and discussed about gender inequality and other issues and challenges faced by women in educational and professional field on this occasion. Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow gave a brief overview on the women empowerment at various scientific institutions including ICAR. Dr. Viswanathan highlighted about the contributions of women scientists in the fields of science and technology including sugarcane research and urged the scientists to protect the technologies developed by them. The programme was organized in hybrid mode and attended by 97 participants.



International Yoga Day celebrated

With the prime objective of creating, awareness about the importance of yoga for mental and physical fitness among the officers and employees of the Institute, International Yoga Day was celebrated on June 22, 2023 at ICAR-IISR, Lucknow. A detailed yoga session was organized in front of the administrative building of the Institute. More than 20 different *asans* of yoga demonstrated by Yoga Instructor were performed by all the participants effortlessly. KVK, Lucknow and KVK-II, Lakhimpur Kheri under the Administrative control of IISR, Lucknow also celebrated International Yoga Day with the farmers, students and villagers.

77th Independence Day celebration

ICAR-Indian Institute of Sugarcane Research, Lucknow celebrated 77th Independence Day. The Independence Day celebrations started with the hoisting of the National Flag by Dr. Rasappa Viswanathan, Director, followed by singing of the National Anthem. In his address, Director appreciated the efforts of all the staff members and lauded good work rendered during this year. A drawing and speech competition was organized under the aegis of "Azadi Ka Amrit Mahotsav" on this occasion. The staff's children participated and showed their enthusiasm towards the topic "Nation First Always First".

Promotion of official language (Hindi)

Hindi workshops organized at the institute as follows:

- On March 21-23, 2023 with 177 administrative and finance personnel associated with the institute participated.
- On May 30, 2023, with 157 personnel of the institute.
- On September 25, 2023, with 55 personnel of the institute.
- On December 22, 2023, with 30 personnel of the institute.

Hindi Fortnight Celebrations (14th September to 29th September, 2023)

Hindi fortnight was organized at IISR, Lucknow from 14-29 September, 2023. During this period, various competitions were organized such as Hindi typing in Unicode, note form writing, essay competition, antyakshari competition, speech competition, quiz based on general knowledge of Hindi short speech and Hindi workshop on any topic based on sugarcane or official language Hindi etc. About 150-170 employees of the Institute participated in the competitions. The valedictory function held on October 04, 2023 in the auditorium of the institute.

A lecture was delivered by Dr. Sarvesh Kumar Singh, Head of Department, Department of Hindi, Baba Saheb Bhimrao Ambedkar University, Lucknow on the topic "Future of Hindi as a Global Language". A Kavi Sammelan was also organized on 27 September 2023.

Meeting of NARACAS (Office-3)

On June 28, 2023, a meeting of NARACAS was organized in which the office heads of NARACAS Office-3 and Shri Narendra Singh Mehra from the

Department of Official Language participated. Eleven offices were awarded for excellent work in Hindi and 03 offices were awarded for Rajbhasha magazine.

On November 21, 2023, a meeting of the Town Official Language Implementation Committee was organized in which the office heads and Hindi officers of NARACAS Office-3 participated. Ten offices were awarded for excellent work in Hindi and 03 offices were awarded for Rajbhasha magazine.

Two-day National seminar cum Awareness program on "Beekeeping" on September 21-22, 2023

A two-day National seminar cum Awareness program on "Beekeeping" was organized at the ICAR-IISR, Lucknow from September 21 to 22, 2023 by Krishi Vigyan Kendra, Lucknow and Small Farmers Agribusiness Association. 450 honey beekeeper women/men farmers/entrepreneurs from Sitapur, Lucknow, Basti, Hardoi, Deoria, Siddharthnagar, Kanpur and Unnao districts participated in the seminar. The programme was inaugurated by Dr. Shantanu Kumar Dubey, Director, ICAR-ATARI, Kanpur. Highlighting the need and formation of the Farmer Producers Organization (FPO), the Chief Guest said that due to decreasing land holdings in our country and state, the use of advanced agricultural techniques and machines is decreasing. The seminar was graced by the distinguished guests, Dr. Dhananjay M. Bakhale, Former National Advisor, Beekeeping & Marketing (FPO). Dr. Ranjit Singh Rajput, Deputy Director, SFAC, New Delhi, Smt. Sujana Krishnamurthy, Scientist Beekeeping, ED, UTMT, Mumbai Society, Dr. Balram Verma, Deputy Director, Agriculture, Lucknow and Dr. Reetika Bhaskar, APEDA addressed the farmers and discussed about beekeeping and other farmer friendly schemes and programs being run by the department for them.

Vigilance Awareness Week-2023 observed

The Vigilance Awareness Week-2023 was observed on the CVC declared theme. Corruption free India for a developed Nation, during October 31- November 6, 2023. The week commenced with the taking of the "Integrity Pledge" by the staff in the Institute on October 31, 2023 Special posters were prepared and displayed in all the notice boards in all the Divisions. A "lecture on Salient Feature of Purchase Procedures in ICAR" was delivered by Shri Saroj Kumar Singh, Chief Administrative Officer, IISR, Lucknow on October 27, 2023. A lecture on "Salient Features of TA, LTC and Medical Procedures in ICAR" was delivered by Sh. Ajay Kumar Tondon, Finance & Accounts Officer, ICAR-IISR, Lucknow on November 09, 2023.

Commencement of Undergraduate and Postgraduate Academic Programs of Indian Agriculture Research Institute (IARI), Lucknow

The commencement of the Undergraduate (UG) and Postgraduate (PG) academic programs for the Academic Year 2023-2024 on November 21, 2023 under IARI Mega University Lucknow hub at ICAR-IISR, Lucknow in coordination with ICAR-CISH, and ICAR-NBFGR. The Institute welcomed a new cohort of students who will embark on a transformative academic journey in the field of agriculture. The inauguration program, held to mark the beginning of the academic session, featured distinguished speakers from renowned agricultural research institutions Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow; Dr. T. Damodaran, Director, ICAR-CISH, Lucknow; Dr. A.K. Dubey, Head, ICAR-CSSRI-Regional Centre, Lucknow; and Dr. L.K. Tyagi, on behalf of Director Dr. U.K. Sarkar, ICAR-NBFGR, Lucknow.

Certification of Breeder Seed Plots in Bihar

A team of scientists from ICAR-IISR, Lucknow along with representatives from the Sugarcane and Seed Certification Department of Bihar inspected the Sugarcane Breeder Seed Production centres funded by Sugarcane Industries Department, Patna. The team members visited IISR Regional Center, Motipur, NSSM, Narkatiyaganj, HSM, Harinagar and TSL, Bagha for certification of Breeder Seed plots from 5th to 7th December, 2023. The team was happy with the good results and appreciated the performance.

Invited lecture at Graduate School IARI-Lucknow, under the "Lecture by Eminent Scientist" Program.

An invited lecture was organized on December 8, 2023 at Graduate School IARI-Lucknow, under the "Lecture by Eminent Scientist" Program. The lecture was delivered by Prof. P.V. Vara Prasad, Distinguished Professor and Director, Sustainable Intensification Innovation Lab, Kansas State University, USA on the topic "Use of Artificial Intelligence for Sustainable Agricultural Intensification: Trends and Opportunities", which was attended by all the students, faculties of IARI-Lucknow.

Prof. Prasad in his talk emphasized upon the use of artificial intelligence tools and their utilization in different agricultural sector such as crop physiology, climate change, animal husbandry, dairy, etc. lecture. He also mentioned about the utility trends of artificial intelligence tool at global level and highlighted the Indian efforts on this context. The formal vote of thanks was presented by Dr. Rajeev Kumar, Coordinator of this guest lecture.

The World Soil Day

The World Soil Day was observed on December 5, 2023 at the Library Conference Hall of IISR, Lucknow, under the chairmanship of Dr. Rasappa Viswanathan, Director, ICAR-IISR, Lucknow. Dr. K.N. Tiwari, former Professor and Head of the Department of Soil Science and Agricultural Chemistry at CSAU A&T, Kanpur, was the chief guest and speaker on this occasion. About 100 scientists and students participated in this program. At the outset of the program, Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow, welcomed Dr. K.N. Tiwari, Chief Guest and Key Speaker of this program, followed by Dr. S.R. Singh, Principal Scientist (Soil Science) and convener of this program. Dr. Manoj K. Srivastava, Principal Scientist and Head, Division of Plant Physiology and Biochemistry, gave a valuable talk on the balanced nutrition of macro- and micronutrients for sustainable management of crop productivity and soil quality. Dr. V.P. Singh, Principal Scientist and Head Division of Production, elaborated on the role of conservation agriculture, crop diversification, and natural farming in soil health improvement. Dr. T.K. Srivastava, Principal Scientist (Agronomy), Division of Crop Production, gave a valuable talk on the key theme of Word Soil Day, "Soil and Water: A Source of Life." The concluding talk was given by the Director, ICAR-IISR Lucknow, in which he emphasized upon the proper use of sugarcane by-products as organic manures for the management of soil.

Monitoring of AICRP (S) ZVT at Motipur, Bihar

An AICRP (Sugarcane) monitoring team consisting of Drs. Gulzar S. Sanghera, VK Birader, YP Bharti, and Naveen Kumar visited the AICRP (S) ZVT Trials of IISR RC, Motipur on 20th December 2023 and appreciated the performance of crop and its husbandry.

Farmers' Day organized

Krishi Vigyan Kendra, ICAR-IISR, Lucknow celebrated December 23, 2023 as "Farmers' Day" to commemorate the birth anniversary of the fifth Prime Minister of India, late Chaudhary Charan Singh. The Chief Guest, Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow while appreciating the work being done by Krishi Vigyan Kendra, Lucknow, assured the farmers that our centre will always keep the farmers informed of the new technologies. On this occasion, the progressive farmers were felicitated and given certificates. Dr. Akhilesh Kumar Dubey, Head, KVK, ICAR-IISR, Lucknow proposed the vote of thanks. Seventy Eight participants including 70 farmers participated in the Farmers' Day.

National Campaigns/Events Organized

1. Swachhata Campaign 3.0 (September 15 to October 31, 2023)

Swachhata Campaign 2023 was organized in two phases. The first phase was a preparatory phase 15 to 30 September, 2023 during which the plans for the implementation phase were prepared and Swachhata pledges were organized. The second phase was Implementation phase (Oct 2 - 31, 2023) during which the Swachhata activities in the campaign were carried out under six headings, viz., Pending references identified, record management, cleanliness drives (indoor and outdoor), office scrap disposal, easing of rules/processes. Awareness creation and cleanliness drive was also organized. Swachhata Shapath, Swachhata Run and Swachhata March were undertaken by Institute staff. Indoor cleanliness drives were also undertaken at Institute premises. Outdoor awareness creation was carried out at different villages like Dashrath Mau, Block Rudauli in Ayodhya,

Bahadurpur village in Sultanpur, UP. Dr. Anamika Srivastava, Programme Executive, All India Radio, Lucknow delivered an expert talk on Swachhata as Chief Guest on this day.

2. Swachhata Pakhwada (December 16-31, 2023)

Number of swachhata activities were planned and executed during Swachhta Pakhwada organized in December, 2023. Cleanliness Awareness was created amongst around 1700 school-going and college students from 3 schools and 5 colleges/universities, around 200 Institute staff and around 300 farmers from four villages. One Exposure visit organized to students

at modernized waste water disposal system in a sugar mill. Organized one WOW-Zero-Waste Workshop and waste management related activities by involving NGO Prithvi Innovations, Lucknow and the residents in a selected residential area. Two Outdoor and number of indoor cleanliness drives were under taken. Swachhta Surveys were conducted in two villages to assess the status of sanitation in the villages. Events such as debates, cycle race, cycle rally, swachhta run, Nukkad Natak (Street Play) were organized by involving students of different schools/colleges. Events were organized by visiting schools, villages, sugar mills and at their sites by involving the concerned stakeholders/staff. Prize distribution function was organized for the winners and the participants.

CHAPTER 22

Distinguished Visitors

Sl. No.	Name and address of the visitors	Date of visit
1.	Dr. R.K. Singh, Assistant Director General (Commercial Crops), ICAR, New Delhi	January 20, 2023; February 16, 2023
2.	Dr. G. Hemaprabha, Director, ICAR-Sugarcane Breeding Institute, Coimbatore	January 20, 2023
3.	Dr. Bakshi Ram, Ex. Director, ICAR-Sugarcane Breeding Institute, Coimbatore	February 13, 2023
4.	Sh. Sanjay R. Bhoosreddy, IAS, Additional Chief Secretary, Sugar Industry and Cane Development, Govt. of Uttar Pradesh	February 16, 2023; March 29, 2023
5.	Dr. Sushil Solomon, Ex. Vice-Chancellor, C S A University of Agriculture and Technology, Kanpur	February 16, 2023
6.	Prof. H.B. Singh, Ex. Professor, Banaras Hindu University, Varanasi	March 23-25, 2023
7.	Dr. R.V.S. Rao, Ex. Head, HRD, ICAR-NAARM, Hyderabad	March 23-25, 2023
8.	Prof. Vijay Paul Sharma, Chairman, Commission for Agricultural Costs and Prices, Ministry of Agriculture and Farmers Welfare, Government of India	March 29, 2023
9.	Sh. Subodh Kumar Singh, Additional Secretary (Sugar), Ministry of Food, Govt. of India	March 29, 2023
10.	Ms. Sushma Singh, Hon'ble Member of ICAR Governing Body	March 31, 2023
11.	Dr. Himanshu Pathak, Hon'ble Secretary, Department of Agriculture Research and Education, Govt. of India and Director General, Indian Council of Agricultural Research, New Delhi.	April 14, 2023
12.	Dr. Uttam Sarkar, Director, ICAR-National Bureau of Fish Genetic Resuources, Lucknow	April 14, 2023
13.	Dr. R.K. Yadav, Director, ICAR- Central Soil Salinity Research Institute, Karnal	April 14, 2023
14.	Dr. T. Damodaran, Director, ICAR -Central Institute for Subtropical Horticulture, Lucknow	April 14, 2023
15.	Dr. Major Singh, Member, Agricultural Scientists Recruitment Board, New Delhi	May 31, 2023
16.	Dr. Narendra Mohan, Director, National Sugar Institute, Kanpur	September 09, 2023
17.	Dr. P. K. Singh, Director Research, Chandra Shekhar Azad University of Agriculture and Technology (CSAUAT), Kanpur	December 05, 2023
18.	Prof. P.V. Vara Prasad, Distinguished Professor and Director, Sustainable Intensification Innovation Lab, Kansas State University, USA	December 8, 2023
19.	Dr. D.R. Singh, Vice Chancellor, Bihar Agricultural University, Sabour, Bhagalpur, Bihar	December 8, 2023

CHAPTER 23

Personnel

(As on December 31, 2023)

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	Appointment	
Name of Official	**Designation**	**Date of joining**
Dr. K. Srinivas	Scientist (Agricultural Entomology)	10.05.2023
Dr. Manoj Kumar Srivastava	Principal Scientist (Biochemistry - Plant Science)	20.06.2023
Shri. Ajay Kumar Tandon	FAO	20.06.2023
Dr. Dinesh Singh	Principal Scientist (Plant Pathology)	13.07.2023
Dr. Sayanti Guha Majumdar	Scientist (Bioinformatics)	21.07.2023
Dr. Rahul Kumar Tiwari	Scientist (Plant Pathology)	18.12.2023
Dr. Indu	Scientist (Plant Breeding)	29.12.2023

	Promotions	
Name	**Promoted to the post of**	***w.e.f.***
Shri. Dinesh Chandra Mishra	LDC to UDC	21.07.2023
Shri. Ram Sajiwan	LDC to UDC	21.07.2023
Shri. Rajeev Arora	PS to PPS	31.10.2023
Smt. Poonam Manish Mishra	UDC to Assistant	07.12.2023

	Transfer		
	From	**To**	
Shri. Arbind Kumar Verma, SMS	ICAR-DRMR, Rajasthan	ICAR-IISR(KVK, Lakhimpur)	30.12.2022
Dr Ram Prakash Sahu, SMS	ICAR-IIVR, Varanasi	ICAR-IISR(KVK, Lucknow)	31.01.2023
Ms. VA Blessy	ICAR-IISR, Lucknow	ICAR- IISWC, Dehradun Regional Centre, Udhagamandalam	17.03.2022
Sh. Ravi Bhadra	ICAR-IISR, Lucknow	ICAR-IGFRI, Jhansi	28.04.2023
Shri. Raj Kumar Yadav, AO	ICAR-IISR, Lucknow	ICAR-NBAIM, Mau	12.05.2023
Shri. Sanjeev Kumar Singh	ICAR-IISR, Lucknow	ICAR-IISR(KVK, Lakhimpur)	22.05.2023
Dr. Sanjay Kumar Yadav	ICAR-IISR(KVK, Lucknow)	ICAR-IISR(KVK, Lakhimpur)	05.06.2023
Shri. Deepak Rai	ICAR-IISR, Lucknow	ICAR-NISA (Ranchi)	31.08.2023
Dr. Rakesh Kumar Singh (SMS)	ICAR-IISR(KVK, Lucknow)	ICAR-CICR(KVK, Nagpur)	20.09.2023
Shri Saroj Kumar Singh (CAO)	ICAR-IISR, Lucknow	ICAR-IARI, Assam	31.10.2023
Shri Prem Chandra (PPS)	RC-ER, Patna	ICAR-IISR, Lucknow	09.11.2023
Shri Abhishek Srivastava (CAO)	ICAR-IASRI, New Delhi	ICAR-IISR, Lucknow	16.11.2023

	Superannuation	
Name of official	**Designation**	**Date of retirement**
Sh. Raghvendra Kumar	Assistant Chief Technical Officer	April 30, 2023
Shri Somnath Singh	Technical Officer	May 31, 2023
Smt. Manju Srivastava	Senior Technician	May 31, 2023
Shri Maikoo Kanaujiya	Technician	June 30, 2023
Shri Patandeen	Senior Technical Assistant	June 30, 2023
Shri Ashok Kumar Vishwakarma	Senior Technical Assistant	July 31, 2023
Shri Brahm Prakash	Chief Technical Officer	July 31, 2023
Shri Deep Chand	Technical Officer	July 31, 2023
Dr. Rajesh Kumar	Principal Scientist	August 31, 2023
Dr. Jyotsnendra Singh	Principal Scientist	September 30, 2023
Shri. Chandra Pal Singh	Chief Technical Officer	September 30, 2023
Shri. Ved Prakash Tiwari	Administrative Officer	September 30, 2023
Dr. Ashwini Dutt Pathak	Principal Scientist	December 31, 2023
Shri. Anil Kumar Singh	Technical Officer	December 31, 2023

	Deputation		
Name and designation	**From**	**To**	**Date of leaving**
Dr. Sudhir Kumar Shukla(Principal Scientist)	ICAR-IISR, Lucknow	UPCSR, Shahjahanpur, U.P.	14.02.2023
Shri RV Diwedi Assistant Administrative Officer	Motipur, Bihar	ATARI, Zone IV Patna, Bihar	17.06.2023
Dr. Ajay Kumar Sah (Principal Scientist)	ICAR-IISR, Lucknow	BAU, Bihar	21.07.2023
Smt. Shikha Chuner (Upper Division Clerk)	TCLCH, Kanpur	ICAR-IISR, Lucknow, U.P.	16.12.2023

CHAPTER 24

Meteorological Data

Important weather parameters during **January 2023 to December 2023** at ICAR-IISR, Lucknow are given below:

Month	Temperature (°C)		Relative Humidity (%) at		Rainfall (mm)	Rainy days (No.)	Bright sunshine (hrs/day)	Evaporation (mm/day)	Wind speed (km/hr)
	Maximum	Minimum	7:18 AM	2:18 PM					
January	20.1	6.9	94.8	56.5	5.4	2	4.3	1.1	2.4
February	28.2	11.1	90.6	35.2	0.0	0	8.4	3.1	3.8
March	31.6	16.7	85.3	36.6	56.6	4	7.5	4.5	3.8
April	36.2	19.5	64.1	26.3	21.2	3	8.8	6.9	4.3
May	37.2	22.8	64.9	34.1	60.8	6	8.7	7.1	4.1
June	39.0	28.1	62.7	40.4	51.4	4	8.2	8.7	6.9
July	34.5	27.6	88.3	69.5	314.6	12	5.4	4.0	2.2
August	33.7	27.1	87.6	69.7	305.6	12	4.4	4.1	4.4
September	34.1	26.3	90.4	67.4	288	6	5.9	3.4	1.8
October	33.6	19.8	89.8	42.7	6.6	1	7.9	3.2	1.6
November	29.4	14.2	95.6	45.3	6.8	2	4.9	1.8	1.0
December	24.0	10.1	95.3	50.1	16.2	1	5.0	1.4	1.5

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