# वार्षिक प्रतिवेदन
# Annual Report
## 2022

भाकृअनुप–भारतीय गन्ना अनुसंधान संस्थान, लखनऊ – 226 002

ICAR-INDIAN INSTITUTE OF SUGARCANE RESEARCH, LUCKNOW - 226 002

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**ICAR-Indian Institute of Sugarcane Research**

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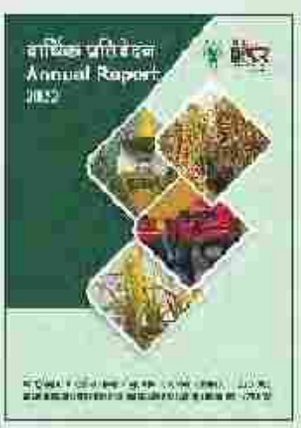
**Front Cover:**

1. Sugarcane variety CoLk 14201
2. IISR combo trap for management of sugarcane insect pests
3. ICAR-IISR two row disc type RMD
4. Yellow leaf disease of sugarcane

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# From the Director's Desk

The country produced a record more than 500 million metric tonnes (MMT) sugarcane during the 2021-22 sugar season, out of which 357.4 MMT was crushed by sugar mills to produce 39.4 MMT of sugar (sucrose). Around 3.6 MMT of sugar was diverted to ethanol production and 35.9 MMT sugar was produced by sugar mills for consumption and exports. India emerged as the world's largest producer and consumer of sugar as well as world's 2nd largest exporter after Brazil in the sugar season (Oct-Sep) 2021-22. India exported the highest ever quantity of sugar of more than 11.1 MMT during 2021-22, and earned about ₹ 40,000 crores in foreign exchange, which helped the country in making timely cane price payment to farmers and, also the sugar mills to carry out their operations more smoothly. The total sugar production is expected to be the highest ever at 41.0 million tonnes (before diversion) in 2022-23, with 4.5 million tonnes of sugar diversion towards production of ethanol and 36.5 million tonnes of net sugar production after factoring in the diversion. The cumulative ethanol production in the country has increased from was a meagre 280 crore litres at the start of the ethanol mission to about 618 crore liters overall ethanol production capacity in the country. The country has achieved the target of 10% ethanol blending with petrol by 2022. The next target is 20% ethanol blending which is though ambitious but achievable. In order to achieve this target by 2025-26, about 1016 crore litres of ethanol would be required. Around 100 lakh tonnes of sugar will have to be diverted for achieving production of 1000 crore litres. This would require higher ethanol production capacity, more distilleries, and conducive government policies to boost sugarcane and sugar production in the country. It highlights that around 4.5 to 5 million tonnes of sugar will have to be diverted for ethanol production in the ensuing period of 3 to 4 years. It thus, emphasize the need for ever increasing levels of sugarcane production as well as a revolution in the sugar industry by transforming it into "Green Energy Hub" in the country. Higher cane yields will increase sugarcane and sugar production, wherein more sugar could be diverted towards ethanol production. The unprecedented success in sugar production could be possible due to the existence of a strong research and extension network in the country. The ICAR-Indian Institute of Sugarcane Research, Lucknow is one of the main links in this network which carries out basic and strategic research work on sugarcane production, protection and improvement aspects, technology development and capacity development particularly in the sub-tropical region. The present Annual Report of the Institute highlights the significant research and extension related efforts in this direction made at the Main Institute campus, at its regional centres/stations and KVKs as well as its outreach programmes in various sugar mill command areas during the year 2022.

Under Crop Improvement programme, two sugarcane varieties, *viz.*, CoLk 15201 (early) and CoLk 15207 (mid-late) for North West Zone and one early maturing sugarcane variety, CoLk 15466 for North Central and North Eastern Zones of India were released and notified for commercial cultivation. In addition, two sugarcane varieties, *viz.*, CoLk 14201 (Early) and CoLk 15206 (Mid-late) for North West Zone and one variety CoLk 16466 (Early) for North Central and North East Zone of India were identified as suitable for release during this year. Further, six potential clones, three early maturing and three mid-late were accepted for multi-location testing in North West Zone of India. In order to support the healthy seed programme, breeder seed of 13 sugarcane varieties (805 tonnes) was produced at Lucknow main campus and that of six sugarcane varieties (1740. 8 tonnes) was produced at different sugar mills of Bihar and Institute Regional Centre, Motipur.

Crop Production research was targetted for ratoon productivity enhancement through efficient resource (nutrient) use under autumn planted intercropping as well as in spring-planted crop. Water management research was on applying irrigation water in trenches along with the use of trash mulch. Under weed management research, the yield reduction in different varieties due to *Ipomoea* spp. infestation was assessed. Suitable recommendations comprising application of silica and efficient use of K in ratoon crop were developed to substantially increase ratoon crop yields.

Under Crop Protection research, IISR continued with the work of screening of sugarcane and sugar beet germplasm against major diseases like red rot and the survey and the surveillance of major sugarcane diseases and insect pests in different sugar mill command areas of major sugarcane growing states of Uttar Pradesh, Bihar, Maharashtra and Madhya Pradesh. The studies on the incidence of red rot, pokkah boeng, wilt, smut, brown spot and rust diseases and that of top borer, stalk borer, web mite, white fly, white grub, wooly aphids, pyrilla, internode and early shoot borers were carried out in different sugar mill command areas. Different laboratory studies generated worthy information on different antiprotozoan chemicals for their efficacy against termites, efficacy of semio-chemicals towards male moth attractions, and on the evaluation of food/nutrition sources of *T. chilonis* fecundity and adult progeny populations. For efficient management of diseases and insect-pests, suitable management advisories were also issued to the sugar mills and the farmers from time to time.

Under Plant Physiology and Biochemistry, multiple abiotic stress responsive genes using transcriptomics indicated that drought caused maximum reduction in growth parameters and impacted the physiological parameters adversely while waterlogging led to maximum increase in catalase and peroxidase activities. Differential gene expression analysis of transcriptomes identified the genes associated with drought, salinity and water logging. Role of PGR on biomass accumulation revealed their relative effectiveness.

Under Agricultural Engineering, prototypes of trash mulcher having attachments for stubble shaving and chemical sprays were developed and field tested. Modifications were carried out in the metering mechanism of the already developed cane node planter. Two machines developed by IISR were modified to cater to the needs of the sugarcane farming in the tropical region. Ergonomic evaluation studies of "sett cutting machine" and "stripper cum detopper" were also carried out.

IISR carried out sugarcane extension works by developing entrepreneurship skills amongst farmers for sugarcane seed production. Besides, IISR organized number of residential capacity building programme for farmers/development personnel/entrepreneurs and students, as well as field days in different locations of the country.

For the research contribution as mentioned above, I am very much thankful to the Council for providing technical and financial support. I am also grateful to Hon'ble Secretary, DARE and DG, ICAR, Dr. Himanshu Pathak, DDG (CS), Dr. T.R. Sharma and ADG (CC), Dr. R.K. Singh for their constant support and guidance. I appreciate the efforts of all the Heads of the Divisions/Section Incharges, Drs. A.D. Pathak, J. Singh, V.P. Singh, Sharmila Roy, Pushpa Singh, R.D. Singh, Rajesh Kumar, Sangeeta Srivastava, A.K. Sah, A.K. Mall, Niranjan Lal, A.K. Dubey and D.N. Borase for providing inputs in time. I am thankful to the members of the Publication Committee, Drs. Sangeeta Srivastava, A.K. Sharma, L.S. Gangwar, C. Gupta, M. Swapna and Mr. Brahm Prakash for their praiseworthy efforts towards editing and bringing out the report in time. Last but the not the least, I am thankful to all the staff who have contributed for this report in direct or indirect form.

(R. Viswanathan)
Director

# Contents

# कार्यकारी सारांश

**Qly lekjka**

- गन्ने की दो किस्में कोलख 15201 (अगेती) एवं कोलख 15207 (मध्य–देर) को उत्तर पश्चिम क्षेत्र के लिए एवं गन्ने की एक अगेती किस्म कोलख 15466 भारत के उत्तर मध्य और उत्तर पूर्वी क्षेत्रों के लिए सीवीआरसी द्वारा वाणिज्यिक खेती के लिए संस्तुत की गईं एवं भारत के राजपत्र अधिसूचना दिनांक 31 अगस्त, 2022 के द्वारा अधिसूचित की गईं।
- गन्ने की कोलख 14201 (अगेती) और कोलख 15206 (मध्य–देर) किस्मों को उत्तर पश्चिम क्षेत्र एवं कोलख 16466 (अगेती) किस्म को उत्तर मध्य और उत्तर पूर्वी क्षेत्र के लिए अखिल भारतीय समन्वित अनुसंधान परियोजना (गन्ना) की *वैराइटल आइडेंटिफिकेशन* समिति द्वारा चिन्हित की गई।
- शीघ्र पकने वाले तीन कृंतक जैसे कोलख 22201 (एलजी 17137), कोलख 22202 (एलजी 17234) और कोलख 22203 (एलजी 17224) और मध्य देर से पकने वाले तीन कृंतक यथा, कोलख 22204 (एलजी 17219), कोलख 22205 (एलजी 17214) एवं कोलख 22206 (एलजी 17213) को भारत के उत्तर पश्चिम क्षेत्रों में बहुस्थानिक मूल्यांकन परीक्षण हेतु अखिल भारतीय समन्वित अनुसंधान परियोजना (गन्ना) की 2022 में आयोजित कार्यशाला में स्वीकृत किए गए।
- गन्ने के शीघ्र परिपक्व होने वाले दो कृंतकों जैसे एलजी 909 और एलजी 910, गन्ने के मध्यम देरी से परिपक्व होने वाले दो कृंतकों जैसे एलजी 911 और एलजी 912 को क्षेत्रीय किस्मीय परीक्षण में अखिल भारतीय समन्वित अनुसंधान परियोजना (गन्ना) की अक्टूबर 2022 में आयोजित कार्यशाला में परीक्षण हेतु स्वीकार किया गया।
- गन्ने के दो उच्च *जेनेटिक स्टाक्स*, एलजी 15533 और एलजी 16581 जिनमें सुक्रोज की मात्रा जनवरी माह में 20.0% थी, को भाकृअनुप–गन्ना प्रजनन संस्थान, कोयम्बटूर में राष्ट्रीय संकरण उद्यान *(एनएचजी)* में सम्मिलित करने के लिए भेजा गया।
- *सी फाल्केटम* के पूरे *प्रोटिओम* अध्ययन से 18 कवक रोगजनन प्रोटीन का पता चला जिनमें से 13 प्रोटीन (आरएएस2, एसटीई 20, एमएपीके 17, एमएपीके–एचओजी1बी, एमएपीकेकेके–एमसीके1, एमएपीके–एमएसटी50, एमएपीकेके– सेक 1, एमएपीकेके–एमएसटी7, एमएपीके8, एमएपीकेके–एमकेके2, एमएपीकेके–एमएसटी11, एमएपीकेके 5, एमएपीके– एमपीके–सी), विशेष रूप से *सी फाल्केटम* (सीएफएस1/सीएफएस2) नमूनों में गन्ने के डंठल के साथ सह–संवर्धित थे।
- गन्ने के दो जननद्रव्य कोयी 92102 और एमएस 68/47 में 97 अत्यधिक संरक्षित और 64 माइक्रो आरएनएज सुक्रोज हेतु विषम सामग्री में दो एफ, की पहचान की गई, जिनमें से 23 विपरीत सुक्रोज सामग्री के लिए काफी भिन्न थे।
- गन्ना जीनप्ररूप के 174 विविध अनुक्रमण–व्युत्पन्न *एसएनपी मार्कर प्रोफाइल* द्वारा *जीनोटाइपिंग* का उपयोग करके *कोलेटोट्राइकम फाल्केटम* (सीएफ01, सीएफ08 और सीएफ09) के तीन प्रभेदों के विरुद्ध लाल सड़न प्रतिरोध के लिए पूर्व सूचना सटीकता का मूल्यांकन किया गया।
- गन्ने की लोकप्रिय किस्म कोशा 96268 की *सेल्फड पॉपुलेशन* का उपयोग करके एक *जेनेटिक लिंकेज मैप* विकसित किया गया और लाल सड़न प्रतिरोधी (qREDROT) से जुड़े एक *क्यूटीएल* की पहचान की गई जिसने लक्षण के लिए कुल 26% *फिनोटिपिक* भिन्नता दर्शायी। *एक्सप्रेशन एनलिसिस* से ज्ञात हुआ कि पादप रक्षा–संबंधी जीन कोडिंग 26 एस प्रोटीएज नियामक सबयूनिट लाल सड़न प्रतिरोध के साथ दृढ़ता से जुड़ा हुआ था।
- गन्ने की नई किस्मों यथा कोलख 15201, कोलख 15204, कोलख 15466, कोलख 14201 और कोलख 14204 का प्रयोगशाला में संवर्धन किया गया। बहुप्रसरण माध्यम से अग्रिम कलिका *एक्सप्लांट्स* का प्रयोग कर कक्षीय प्ररोह *प्रोलीफोरेशन* द्वारा बहुगुणित किया गया।

- मुख्य परिसर में गन्ने की 13 किस्मों का कुल 805 टन प्रजनक बीज का उत्पादन एवं क्षेत्रीय केंद्र, मोतीपुर और बिहार की विभिन्न चीनी मिलों में छह गन्ना किस्मों का 1740.85 टन प्रजनक बीज का उत्पादन किया गया।

**Q l y mRi kru**

- शरद प्रादुर्भावित गन्ने की पेड़ी की अंतर्सस्य प्रणाली में पंक्ति से पंक्ति की 90 सें.मी. और 120 सें.मी. दूरी पर पेराई योग्य गन्नों की संख्या तथा गन्ना उपज अधिक थी। गन्ने की सर्वाधिक उपज पंक्ति से पंक्ति की 90 सें.मी. दूरी पर गन्ना + प्याज (129.54 टन/हेक्टेयर) में पाई गई। इसके बाद पंक्ति से पंक्ति की 120 सें.मी. दूरी पर गन्ना + भिंडी (125.49 टन/हेक्टेयर) और गन्ना + प्याज (124.38 टन/हेक्टेयर) का स्थान रहा।
- तुलसी–स्टीविया–गन्ना (बसंत) फसल प्रणाली में गन्ने की पेड़ी फसल की सर्वाधिक उपज (85.5 टन/हेक्टेयर) प्राप्त हुई।
- शरदकालीन गन्ना आधारित समेकित कृषि प्रणाली से गन्ने के साथ सब्जी + बागवानी फसलों + मुर्गी पालन + डेयरी + मत्स्य पालन + वर्मीकम्पोस्ट + मधुमक्खी पालन + मशरूम में सर्वाधिक शुद्ध आय ₹ 4,63,023/हेक्टेयर रुपये के साथ ₹ 2,01,923/हेक्टेयर की अतिरिक्त आय और 3.26 का लाभ:लागत अनुपात पाया गया। बसंतकालीन गन्ना आधारित समेकित कृषि प्रणाली में एकीकृत गन्ने की फसल प्रणाली से ₹ 4,63,079/हेक्टेयर की शुद्ध आय के साथ ₹ 2,06,879/हेक्टेयर की अतिरिक्त आय और 3.41 के लाभ:लागत अनुपात प्राप्त हुआ।
- परंपरागत जुताई (194.3 टन/हे.) की तुलना में फसल अवशेष प्रबंधन के साथ *जीरो टिलेज (जेडटीसीआरएम)* से गन्ना उपज (224.49 टन/हेक्टेयर) में 15.54 प्रतिशत की वृद्धि के साथ 2.05 का लाभ:लागत अनुपात दर्ज किया गया। गन्ने की फसल में फसल अवशेष प्रबंधन में बिना फसल अवशेष प्रबंधन की तुलना में गन्ने और पेड़ी की उपज में 17% की उपज वृद्धि दर्ज की गई। *जेडटीसीआरएम* ने परंपरागत जुताई की तुलना में मृदा जैविक कार्बन सामग्री, अंत: स्पंदन दर, *एसएमबीएन, एसएमबीसी* और संरंध्रता में उच्चतम वृद्धि दर्ज की गई।
- नाइट्रोजन फास्फोरस पोटाश की संस्तुत मात्रा को *ड्रिप फर्टिगेशन* के माध्यम से कई बार में प्रयोग करने से उर्वरकों तथा पानी के छिड़काव के परंपरागत तरीकों (35.87 टन/हे.) की तुलना में तीसरी पेड़ी गन्ना की उपज 85.62 टन/हेक्टेयर तक पायी गई। उर्वरक और पानी के प्रयोग के परंपरागत तरीकों के तहत तीसरी पेड़ी गन्ना की उपज में लगभग 49% का नुकसान दर्ज किया गया जबकि *ड्रिप फर्टिगेशन* के माध्यम से लागू नाइट्रोजन फास्फोरस पोटाश की शत प्रतिशत संस्तुत मात्रा के प्रयोग से गन्ना उपज में मात्र 11% का नुकसान हुआ। परंपरागत विधि की तुलना में इस उपचार से खरपतवारों के प्रकोप में 21.8% और सिंचाई की आवश्यकता में 58% की कमी आई।
- फरवरी में प्रारंभ की गई पेड़ी फसल में पेराई योग्य गन्नों की संख्या, गन्ने की लंबाई, गन्ने की मोटाई एवं गन्ने का वजन अधिक पाया गया। इसके पश्चात मार्च, अप्रैल तथा मई प्रादुर्भावित पेड़ी का स्थान रहा।
- नाइट्रोजन फास्फोरस व पोटाश के प्रयोग को बिना *आईपीएनएस* के *एसटीसीआर* के साथ प्रयोग से गन्ना उपज 69.2 टन/हेक्टेयर प्राप्त हुई और इसके बाद *एनपीके* का प्रयोग *एसटीसीआर* का *आईपीएनएस* के साथ प्रयोग करने से गन्ना उपज 68.5 टन/हेक्टेयर प्राप्त हुई। नाइट्रोजन फास्फोरस पोटाश की अनुशंसित मात्रा में गन्ना उपज 65.9 टन/हेक्टेयर प्राप्त हुई। यद्यपि, एट्राज़िन 2,000 ग्राम/हेक्टेयर निर्गमन के पूर्व प्रयोग किया गया साथ ही जब एमेट्रिन 1,500 ग्राम/हेक्टेयर के साथ–साथ 2,4–डी 725 ग्राम/हेक्टेयर का उपयोग निर्गमन के बाद फरवरी और मार्च के दौरान पेड़ी के रूप में किया गया तो गन्ने की अधिकतम उपज (108.3 टन/हे.) प्राप्त हुई। सभी चार प्रादुर्भावित पेड़ी फसलों में *ट्रैश मल्चिंग* ने बेहतर परिणाम दिए।
- पोषक तत्व प्रबंधन के विभिन्न स्तरों के अंतर्गत *माइक्रोबियल कंसोर्शिया* के प्रयोग ने *माइक्रोबियल कंसोर्शिया* (सी 2) के बिना उर्वरकों की शत प्रतिशत संस्तुत मात्रा की तुलना में जैविक और फास्फोरस

सामग्री अधिक पायी गई। पहली पेड़ी फसल की तुलना में दूसरी पेड़ी फसल की गन्ना उपज में औसतन 13.5% की कमी आई। रासायनिक उर्वरक के साथ *माइक्रोबियल कंसोर्शिया* के प्रयोग से उपज में सुधार हुआ।

- कोलख 09204 पेड़ी फसल के लिए तीन लक्षित उपज समीकरण विकसित किए गए। इन समीकरणों का उपयोग उपोष्ण दशाओं की सभी जलोढ़ मृदाओं में पेड़ी फसलों में स्थान–विशिष्ट उर्वरक प्रयोग की सिफारिश के लिए किया गया। प्रारंभिक मृदा परीक्षण मान और निश्चित लक्षित उपज के आधार पर *यूरिया, डीएपी* और *एमओपी* की गणना के लिए एक मोबाइल ऐप "उर्वरक *कैलकुलेटर*" विकसित किया गया।
- भाकृअनुप–भारतीय गन्ना अनुसंधान संस्थान के अनुसंधान प्रक्षेत्र के लिए मृदा के पीएच, विद्युत चालकता, जैविक कार्बन, उपलब्ध नाइट्रोजन, फास्फोरस, पोटाश, गंधक और जस्ता, तांबा, लौह तथा मैंगनीज जैसे सूक्ष्म पोषक तत्वों के स्थानिक वितरण मानचित्र विकसित किए गए।
- 100% एनपीके+*बायोस्टिम्यूलेटर डेरिवेटिव* @ 5 मिली/लीटर पानी की *ड्रेंचिंग+ग्लूकोनएसीटोबैक्टर डायजोट्रोफिकस + बैसिलस सबटिलिस* और *बैसिलस सिरेलस* के साथ *ड्रेंचिंग* और बुवाई के 90, 120 व 150 दिनों पश्चात 35 *पीपीएम* की दर से जीए$_3$ के पर्णीय छिड़काव के साथ प्रयोग किए जाने पर उच्चतम गन्ना उपज (73.64 टन/हैक्टेयर) प्राप्त हुई।
- एक धीमी *रिलीज, हाइड्रोफोबिक,* घर्षण प्रतिरोधी *कोटिंग* सामग्री विकसित की गई। यह विकसित सामग्री यूरिया *कोटिंग* में सामान्य लेपित यूरिया की तुलना में *रिलीज* की अवधि बढ़ाएगी जिससे धीमी गति से *रिलीज* उर्वरक को प्रतिपादित करके इसका प्रयोग सभी प्रकार की मृदाओं में किया जा सकेगा।
- 0.8 *आईडब्ल्यू/सीपीई* अनुपात पर गन्ने की सिंचाई करना पानी की बचत और बहुत कम उपज के साथ गन्ने में पानी की उत्पादकता में वृद्धि के लिए सबसे प्रभावी पाया गया। कूँड़ों में सिंचाई करने से जलप्लावित के समान उपज प्राप्त करना प्रभावी रहा जिसके परिणामस्वरूप सिंचाई के पानी की काफी बचत हुई। उपोष्ण क्षेत्रों में बसंतकालीन गन्ने का जल *फुटप्रिंट* 118–130 लीटर/कि.ग्रा. के बीच होता है जो सिंचाई व्यवस्था और नमी प्रबंधन प्रक्रियाओं पर निर्भर करता है।
- गन्ने की कोपीके 05191 (अगेती) और कोलख 11206 (मध्य–देर) किस्में उपोष्ण भारत में सूखे की स्थिति के लिए उपयुक्त पाई गईं।
- *आइपोमिया* की तीन प्रजातियों में पौधे की ऊँचाई, जड़ की लंबाई, पत्तियां/पौधों की संख्या, तने और जड़ के शुष्क जैवभार के संबंध में काफी भिन्नता पाई गई। *आइपोमिया हेडेरिफोलिया* और *आई. ट्रिलोबा* में पौधों की वृद्धि काफी अधिक हुई। तने की ऊँचाई, जड़ की लंबाई, तना, जड़ और पत्ती का शुष्क जैवभार *आई. निल* से अधिक है, जो गन्ने की फसल के लिए अधिक प्रतिस्पर्धा पैदा कर सकता है।
- पोटैशियम का प्रयोग *पोटाशिक ऑर्गनो मिनरल फर्टिलाइजर (ओएमएफ)* के माध्यम से करने से गन्ने की उपज और गुणवत्ता में सुधार होता है।

### Qly ijkk

- वर्ष 2022 में कीटों एवं रोगों के सर्वेक्षण के दौरान किस्म को 0238 में लाल सड़न रोग का प्रकोप अधिक देखा गया। मध्य प्रदेश के दतिया जिले में पेड़ी फसलों में *पाइरिला परपुसिला* देखा गया। पश्चिमी उत्तर प्रदेश में चोटी बेधक का प्रकोप काफी पाया गया। जबकि, सर्वेक्षण क्षेत्र में अन्य रोगों और बेधक कीटों का प्रकोप कम था।
- अहमदनगर जिले के प्रवरा, कोलपेवाडी, संजीवनी, अशोक, संगमनेर और राहुरी सहकारी चीनी मिलों के अधीनस्थ क्षेत्रों और महाराष्ट्र के नासिक और जलगाँव जिलों के गन्ना उत्पादक क्षेत्र में गन्ने के कीटों और रोगों के सर्वेक्षण और निगरानी की गई। उत्तर महाराष्ट्र की चीनी मिलों के क्षेत्रों में भी कोम 0265 और को 86032 में भूरा स्पॉट, रतुआ, *पोक्का बोएग* और पीली पत्ती रोगों का प्रकोप बढ़ा देखा गया।
- बिहार के, एचपीसीएल, सुगौली के अधीनस्थ क्षेत्र, एमएसई, नरकटियागंज, हरिनगर शुगर मिल्स लिमिटेड, हरिनगर और भाकृअनुप–भागअनुसं, क्षेत्रीय

केंद्र, मगध शुगर एंड एनर्जी लिमिटेड (भारत शुगर मिल्स), गोपालगंज, बिहार; सासा मूसा शुगर वर्क्स लिमिटेड, गोपालगंज, बिहार; विष्णु शुगर मिल्स लिमिटेड, गोपालगंज, बिहार में विभिन्न रोगों के लिए सर्वेक्षण किया गया।

- सर्वेक्षण किए गए 50 से 70% क्षेत्रों में गन्ने की लोकप्रिय किस्म को 0238 लाल सड़न से संक्रमित पाई गई। सर्वेक्षण किए गए सभी क्षेत्रों में किस्म सीओपी 16437 उकठा रोग से लगभग 10–20% संक्रमित पाई गई। को 0238 किस्म के अन्तर्गत अधिकांश क्षेत्रों में लाल सड़न का प्रकोप 70% तक देखा गया। कोलख 94184 (5–15%), कोपी 16437 (5–10%) और को 0238 (5–10%) किस्मों में पीली पत्ती रोग का गंभीर प्रकोप देखा गया।
- *ट्राइकोग्रामा किलोनिस* (चोटी बेधक स्ट्रेन) के 15♀, 14♀, 13♀, 12♀ उपचारों में सबसे अधिक जनन क्षमता (139.2) पायी गई। मादा का अनुपात बढ़ने पर जनन क्षमता भी बढ़ती पाई गई। 7♀ और 14♀ के परीक्षण में वयस्क निर्गम 89.8 से 120.2 प्रतिशत तक पाया गया। विकसित भोजन की उपलब्ध मात्रा के लिए परजीव्याभ के सामान्य विकास को रोकने के लिए प्रतिस्पर्धा कारक के रूप में दिखाई देता है। *ट्राइकोग्रामा किलोनिस* की प्रजनन क्षमता *कोरसाइरा सिफेलोनिका* के धूल उपचार में काफी बढ़ गई थी।
- उच्च आरंभिक मृदा जैविक कार्बन वाले भूखंडों में *बर्गर–पार्कर इंडेक्स* में प्रचुर मात्रा में फसल के भव्य विकास अवस्था में प्रजातियों की संख्या अधिकतम पायी गई। उच्च विविधता (*चाओ* संसूचकांक) परिपक्वता पर देखी गई जहां प्रारंभिक मृदा जैविक कार्बन 0.9 से अधिक था लेकिन 0.5 से कम मृदा जैविक कार्बन वाले भूखंडों में फसल की भव्य विकास अवस्था के दौरान विविधता अधिक पायी गई।
- मृदा में अनुशंसित खुराकों पर क्लोरपाइरीफॉस और क्लोरेट्राइनिलिप्रोल के प्रयोग के प्रभाव से ज्ञात हुआ कि मृदा के *माइक्रोआर्थोपोड्स* की कुल संख्या उनके संबंधित नियंत्रण की तुलना में कम हो गई। हालांकि, फसल की परिपक्वता से क्लोरेट्राइनिलिप्रोल का नकारात्मक प्रभाव कुछ हद तक कम हो गया।
- *बैक्टीरियल फीडर* सूत्रकृमि तथा बहुतायत में परभक्षियों और पादप परजीवी सूत्रकृमियों की अधिकतम संख्या भूमि उपयोग और पोषक तत्व प्रबंधन में भिन्न पाई गई। यद्यपि, मृदा के विभिन्न पोषण संबंधी समूहों से सूत्रकृमि वंश के प्रकोप में मृदा के नमूने जैविक कार्बन से संबंधित हो सकते है और मृदा में पोषक स्रोत से भी प्रभावित हो सकते हैं।
- प्रयोगशाला में कृत्रिम आहार पर संरक्षित दीमकों का जैव–प्रभाविकता के विरुद्ध विभिन्न *एंटी–प्रोटोजोअन* रसायनों का मूल्यांकन किया गया, जिसमें आर्निडाजोल और टिनिडाजोल उपचार के 10 दिनों के अन्दर दीमकों की शत प्रतिशत मृत्यु दर के साथ अत्यंत प्रभावी पाया गया।
- चोटी बेधक की दूसरी और तीसरी पीढ़ी का प्रयोग कोलख 8102 में अधिक था। जबकि सग्राही किस्म (कोलख 8102, को 0238 और कोलख 14201 में चौथी पीढ़ी का प्रकोप अधिक था। कोलख 16202, बीओ 91 और कोजे 64 में जुलाई से अगस्त माह के दौरान *मिली बग* का प्रकोप अधिक पाया गया।
- कोलख 13204 (6.80), कोलख 8102 (8.51) कोलख 8102 (8.82) और कोलख 09151 (5.89) किस्मों में पहली, दूसरी, तीसरी और चौथी पीढ़ी में चोटी बेधक की मादा प्यूपा की रक्षा करने वाले *सिल्कन डिस्क* की औसत संख्या अधिक थी। कोलख 13204 (5.67), कोलख 94184 (7.08), कोलख 13204 (5.38) और कोलख 13204 (3.90) में नर प्यूपा में *सिल्कन डिस्क* था।
- गन्ने की पाँच किस्मों को 0239, कोलख 94184, कोलख 8102, कोलख 13204 और सीओपीके 05191 में चोटी बेधक की प्रथम पीढ़ी में परवीजिता का प्रतिशत 9.7 से 21.1 प्रतिशत तक पाया गया। अप्रैल 2022 में उच्च तापमान और कम आर्द्रता के कारण दूसरी पीढ़ी में कम पाया गया। उपरोक्त सभी पाँच किस्मों में चोटी बेधक के लार्वा की मृत्यु दर तीसरी पीढ़ी में 11.1–21.17 प्रतिशत और पाँचवीं पीढ़ी में 23–3–32–6 प्रतिशत दर्ज की गई।
- *कोटेशिया फ्लेविप्स* का प्रयोगशाला में बहुगुणन के लिए *काइलो पर्टेलस* अधिक परपोषी पाया गया।

- किस्म को 0238 में अनुपचारित भूखंडों में चोटी बेधक की पाँचवीं पीढ़ी, पोरी बेधक और तना बेधक का प्रकोप क्रमश: 17.15%, 7.80% और 13–42% की तुलना में उपचारित भूखंडों में क्रमश: 9.90%, 3.44% और 8.8% पाया गया। अगस्त 2022 के महीने में उपचारित भूखंड में 61.7% और उपचारित भूखंड में 36.3% गुलाबी *मिली बग* देखा गया।
- संक्रमित बाल्यावस्था *(आईजेएस)* के उत्पादन के अध्ययन से ज्ञात हुआ कि *गैलेरिया* (11,286 *आईजेएस*) में संक्रमित बाल्यावस्था *(आईजेएस)* की अधिकतम संख्या निकली है, जिसके बाद प्रारंभिक प्ररोह बेधक (9,940 *आईजेएस*) का स्थान रहा। जबकि जड़ बेधक (4,948 *आईजेएस*) की न्यूनतम संख्या देखी गई। *आईजेएस* / सूँडी की खुराक में वृद्धि के साथ *होलोट्राइचिया सेराटा* के आरंभिक भृंग *इंस्टार* पर *आईजेएस* का उत्पादन बढ़ा। *एच. सेराटा* के वयस्क भृंग को संक्रमित करने के लिए *एच. इंडिका आईआईएसआरबीसीसीएच* 01 में तनाव देखा गया (कीट विकारी सूत्रकृमि संक्रमण के बाद 6 से 7 दिनों में मृत्यु दर 39% से 69%), हालांकि, वयस्क भृंग के अंदर सूत्रकृमि का विकास प्रभावित हुआ साथ ही मृत भृंग से निकले कुछ *आईजेएस* पाए गए।
- लाल सड़न (सीएफ08 और सीएफ13) तथा कंडुआ के विरुद्ध 62 जीनप्रारूपों का मूल्यांकन किया गया। एलजी 19063 को लाल सड़न रोगाणुजनक (सीएफ08 और सीएफ13) के विरुद्ध प्रतिरोधी पाया गया, जबकि ए–8 को सीएफ08 के विरुद्ध प्रतिरोधी पाया गया। ए–8, ए–19, एलजी 19006, एलजी 19104, एलजी 19049, एलजी 19109 और एलजी 19101 को सीएफ13 के मुकाबले मध्यम प्रतिरोधी *(एमआर)* पाया गया। उकठा और पीली पत्ती रोग का प्राकृतिक प्रकोप भी देखा गया। 27 जीनप्रारूप कंडुआ के विरुद्ध प्रतिरोधी पाए गए। 49 उकठा के प्रति और 44 पीला पत्ती रोग के विरुद्ध प्रतिरोधी पाए गए।
- *सी. फाल्केटम* के सभी *आइसोलेट्स* के उग्रता पैटर्न का अध्ययन किया गया। इस क्षेत्र में सीएफ07, सीएफ08, सीएफ09 और सीएफ13 के मौजूदा रोगाणुजनक लगभग मेल खाते थे। इस क्षेत्र में कोई भी नया रोगाणुजनक नहीं दिखाई पड़ा।
- परीक्षण किए गए सभी 24 *आईसीएच* जीनप्रारूपों में से 14 जीनप्रारूप उपचार की *प्लग* विधि के अंतर्गत सीएफ08 तथा सीएफ13, दोनों रोगाणुजनकों के विरुद्ध मध्यम प्रतिरोधी *(एमआर)* तथा उपचार की *नोडल* विधि के अंतर्गत प्रतिरोधी पाए गए।
- महाराष्ट्र में कोएम 0265 और को 86032 किस्मों से पृथक किए गए गन्ने के पोक्का बोएंग से जुड़े *प्यूजेरियम स्पे.* के बारह *आइसोलेट्स* को *टेफा 1 जीन* अनुक्रम और वाहा गुणों का उपयोग करके *प्यूजेरियम सैकरी* के रूप में पहचाना गया। इन *आइसोलेट्स* का *जीन* अनुक्रम *जीन बैंक, एनसीबीआई* और *कल्चर* को *आईसीएआर–एनबीएआईएम*, मऊ उत्तर प्रदेश के राष्ट्रीय कृषि महत्वपूर्ण *माइक्रोबियल कल्चर* संग्रह में जमा किया गया।
- गन्ने में रोगों और कीटों का पता लगाने के लिए *आर्टिफिशियल इंटेलिजेंस* आधारित अध्ययन किया गया। कीटों, स्वस्थ एवं कीटों से क्षतिग्रस्त लक्षणों, रोगों तथा कार्यिकी विकारों की कुल 13,919 आरजीबी अलग–अलग प्रकाश स्थितियों के तहत नियंत्रित और वास्तविक समय की स्थितियों में खींचे गए। छवि *डेटासेट* विकसित करने के लिए एकत्रित छवियों को आगे 50 विभिन्न वर्गों में वर्गीकृत किया गया।
- बसंत 2021 में पीली पत्ती रोग के लिए 29 जीनप्रारूपों का मूल्यांकन किया गया। ये सभी पीली पत्ती रोग से संक्रमित थे, जिसमें मध्य शिरा लक्षण का पीलापन दिखा। इनमें से 10 जीनप्रारूप अर्थात को 8102, कोलख 14201, कोलख 94184, को 7701, को 7717, को 148, को 0238, को 997, कोलख 11203, कोलख 11206, कोलख 13204 पीली पत्ती रोग के लिए अतिसंवेदनशील पाए गए जिनको *इनोकुलम* के रख–रखाव हेतु उपयोग किया गया। *डीएएस–एलिसा* के लिए कुल 37 रोगसूचक नमूने लिए गए थे, जहां सभी नमूनों का परीक्षण गन्ने की पीली पत्ती के विषाणु के लिए नकारात्मक था, लेकिन नमूनों ने *नेस्टेड पीसीआर* जांच के अंतर्गत *फाइटोप्लाज्मा यूनिवर्सल प्राइमर* के साथ *फाइटोप्लाज्मा* की उपस्थिति के लिए सकारात्मक प्रवर्धन दिखाया। यद्यपि, *आरटी–पीसीआर* जांच से *एससीवाईएलवी* की पुष्टि नहीं हुई।

- वर्ष 2021–2022 में पर्णीय रोगों के प्रकोप के लिए प्राकृतिक परिस्थितियों में 56 चुकंदर जननद्रव्यों की जांच की गई। *सर्कोस्पोरा बीटी बेटा फोमा स्पेशीज़* और *आल्टरनेरिया स्पेशीज़, फ्यूजेरियम येलो* और विषाणु रोग देखे गए।

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- सूखा, लवणता और जलभराव दशाओं के अंतर्गत गन्ने में जड़ अध्ययन और भौतिक–आण्विक लक्षणों ने लवणता के तहत जड़ ऊतक घनत्व में उच्चतम वृद्धि का संकेत दिया, जबकि सहिष्णु और अतिसंवेदनशील दोनों किस्मों में जड़ *इलेक्ट्रोलाइट* रिसाव में अधिकतम वृद्धि सूखे में पायी गई। *ट्रांसक्रिप्टोमिक* अध्ययनों से ज्ञात हुआ है कि प्रकाश संश्लेषक जीन अभिव्यक्ति में उच्चतम कमी लवणता उपचार के अंतर्गत थी; कुल 9 प्रकाश संश्लेषक जीनों ने लवणता के तहत अभिव्यक्ति में दो गुने से अधिक की कमी दर्शाई। जबकि, सूखे और जलभराव के अंतर्गत दो प्रकाश संश्लेषक जीनों की अभिव्यक्ति में दो गुना से अधिक की कमी देखी गई।
- पाँच *पोटैशियम ट्रांसपोर्टर जीन* जो सूखे, लवणता और जलभराव के लिए सामान्य थे, अभिव्यक्ति में लॉग 2 गुना से अधिक की कमी देखी गई और इसके परिणामस्वरूप इन तनावों के अंतर्गत पत्तियों के ऊतकों की साद्रता कम परिलक्षित हुई।
- जड़ के लक्षणों तथा पत्तियों के मुड़ने के व्यवहार भी निर्धारित किए गए और कोजे 64 और कोलख 14201 में *आरडब्ल्यूसी* में अधिकतम कमी से संबंधित थे, जो कि दर्ज किए गए थे। इसके अलावा, नमी की कमी के अंतर्गत *सिलिसिक एसिड* ने अधिकतम उत्प्रेरित गतिविधि दर्शाई जो गैर–तनाव वाले पौधों में अधिक थी। *परॉक्सीडेज* गतिविधि गैर–तनावग्रस्त स्थिति के तहत अधिकतम थी, जबकि तनावग्रस्त पौधों में यह न्यूनतम थी और गैर–तनाव वाले पौधों की तुलना में *सिलिसिक एसिड* के साथ *परॉक्सीडेज* गतिविधि काफी बढ़ गई।
- विभिन्न महत्वपूर्ण विकास चरणों में बुआई के 60–120 दिनों के बाद *पीजीआर* के प्रयोग से फसल के किल्लों की तुलना में पत्तियों में अधिक जैवभार का विभाजन हुआ। किल्लों की तुलना में *टिलरिंग* चरण के अंत में पत्तियों में जैवभार विभाजन उभरने के लगभग 75% से घटकर 20–25% हो गया। बुआई के 75 दिन बाद गन्ने का डंठल कुल जैवभार का लगभग 9–12% था और फसल चक्र के वृहद वृद्धि अवस्था पर लगभग 60–80% तक पहुंच गया। जबकि जैवभार विभाजन पर पादप संख्या के प्रभाव उल्लेखनीय नहीं थे। *पीजीआर* के प्रयोग में विभाजन में अंतर स्पष्ट दिखाई दे रहे थे।
- *एससीटी* के *डिलिग्नीफिकेशन* के लिए उपचार पूर्व प्रक्रिया *लिग्नोसेल्यूलोसिक* कोशिका भित्ति से लिग्निन को प्रभावी रूप से हटाने का कारण बनी, जिसके परिणामस्वरूप *सब्सट्रेट* की बढ़ी हुई *सेल्यूलोज़ हाइड्रोलिसिस* से *एंजाइमैटिक* पहुंच और अधिक बढ़ गई, 10 मिनट के लिए 90 डिग्री सेल्सियस के समय–तापमान संयोजन के साथ गन्ने के रस की *थर्मल ब्लैंचिंग* को *पीपीओ* निष्क्रियता और भौतिक रासायनिक, *माइक्रोबियल* और संवेदी स्कोर के प्रतिधारण के लिए अनुकूलित किया गया।

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- विकसित *केन नोड प्लांटर* के पैमाइश तंत्र को संशोधित किया गया। विभिन्न संयोजनों के दौरान इसके प्रदर्शन के आधार पर पैमाइश प्रणाली के *डिजाइन* को अंतिम रूप दिया गया। यह *मशीन* गहरी नाली खोलने, पहले से भीगी हुई गन्ने की गांठों की पैमाइश करने, खाद देने और बोए गए गन्ने की गांठों पर मिट्टी से ढकने का काम एक ही बार में करती है।
- *ट्रैश मल्चर यूनिट, स्टबल शेविंग यूनिट* और रासायनिक छिड़काव इकाई को समाहित करती हुई *मशीन* का नया *प्रोटोटाइप* गन्ने की दो पंक्तियों को *कवर* करती है। रासायनिक छिड़काव इकाई ने तेजी से सड़ने के लिए *ट्रैश* अपघटन *(डिकपोजर)* लगाया गया और मशीन को संचालित करने के लिए *ट्रैक्टर पीटीओ पावर* का उपयोग किया जाता है। *गियरबॉक्स* के माध्यम से कम *आरपीएम* को बेल्ट और *पुली पॉवर ट्रांसमिशन सिस्टम* द्वारा *मल्चर* और *स्टबल शेवर* को *ट्रैश* करने के लिए प्रेषित किया जाता है। *रियर रोलर* गन्ने की दो पंक्तियों को *कवर* करते हुए पंक्तियों के बीच में पटाई की एक

समान गहराई के नियंत्रण को सुनिश्चित करता है। *प्रोटोटाइप* का परीक्षण *आईआईएसआर* प्रक्षेत्र में किया गया जिसका परिणाम संतोषजनक रहा।

- *सीटीएफ* के लिए प्रक्षेत्र में विभिन्न कृषि कार्यों के लिए मैचिंग उपकरणों के *डिजाइन* विकास का अध्ययन किया गया। विभिन्न मशीनों के अनुरूप ट्रैक्टर ट्रैक की चौड़ाई 150 सें.मी. के बजाय 175 सें. मी. तक समायोजित की गई। *आईआईएसआर* द्वारा 60 सेंटीमीटर की दूरी के लिए द्विपंक्ति *डीप फरो* गन्ना कटाई एवं बुवाई यंत्र विकसित किया गया। यंत्र के पास में गन्ने की बुवाई, उर्वरक और रासायनिक कीटनाशक के प्रयोग, गन्ने के टुकड़ों को मिट्टी से ढकने और ढकी हुई मिट्टी को दबाने के कार्य को पूरा करने में बुवाई यंत्र का कार्य संतोषजनक था। *आईआईएसआर* के प्रक्षेत्र में एक हेक्टेयर में *सीटीएफ* और पारंपरिक गन्ने की खेती का अध्ययन करने के लिए एक परीक्षण किया गया।
- तीन कलिका वाले गन्ने के टुकड़ों को काटने के लिए *सेट कटिंग* मशीन का संस्थीय *(एग्रोनौमिक)* मूल्यांकन संस्थान में किया गया। इस मशीन में 40.6 सेंटीमीटर व्यास के दो गोलाकार *स्टेनलेस स्टील ब्लेड* है। मशीन को संचालित करने के लिए एक अश्वशक्ति (240 वॉल्ट) की विद्युत मोटर का उपयोग किया जाता है। *ब्लेड* को *पावर फ्लैट बेल्ट पुली* और *मोटर* से *डबल ग्रूव्ड वी पुली* के माध्यम से आपूर्ति की जाती है। *ऑपरेटर* द्वारा पारंपरिक *कटिंग ब्लेड* से 20 मिनट में काटे गए सेटों की संख्या 516–715 थी जबकि मशीन से इसी अवधि में 840–1500 *सेट* काटे गए। दो ऑपरेटरों द्वारा *सेट कटिंग* के लिए मशीन की कुल क्षमता 2520–4500 *सेट/* घंटा थी। पुरुष *ऑपरेटर* की तुलना में महिला *ऑपरेटर* की ऊर्जा व्यय दर (8%) और समग्र असुविधा दर (31%) से थोड़ी अधिक थी।
- संस्थान के प्रक्षेत्र में तीन अलग–अलग गन्ने की किस्मों का 225 ग्राम वजन के *आईआईएसआर मैनुअल स्ट्रिपर–कम–डिटॉपर* से पुरुष और महिला *ऑपरेटर* के साथ *एग्रोनौमिक* रूप से मूल्यांकन किया गया। पुरुष और महिला संचालक द्वारा साफ किए गए गन्ने की औसत संख्या 234 से 285 थी, जबकि साफ किए गए गन्ने का औसत वजन 114 से 243 किलोग्राम था। काम करने की हृदय गति और ऊर्जा व्यय दर के संदर्भ में शारीरिक कार्यभार पुरुष और महिला कृषि श्रमिकों दोनों के साथ हल्की श्रेणी में था।
- संस्थान ने दो मशीन गहरी जुताई वाले गन्ना कटाई एवं बुवाई यंत्र और तवेदार पेड़ी प्रबंधन यंत्र को उष्णकटिबंधीय क्षेत्र के लिए उपयुक्त बनाने के लिए संशोधनों के बाद विकसित किया। दोनों मशीनों की आपूर्ति भाकृअनुप–गन्ना प्रजनन संस्थान, कोयम्बटूर को प्रक्षेत्र परीक्षण और प्रदर्शन मूल्यांकन के लिए भेजी गई।
- विभिन्न मशीनों के 102 *प्रोटोटाइप* बनाए गए, जबकि विभिन्न संगठनों को 29 *प्रोटोटाइप* की आपूर्ति की गई।
- गुड़ के लिए *सोलर कलेक्टर यूनिट डिजाइन* की गई। उसमें गर्मी से होने वाली क्षति को न्यूनतम करने के लिए *ग्लास वूल* भरा जाता है। सुखाने वाले कक्ष में गर्म हवा के प्रवेश करने के लिए निकास *वेंट* प्रदान किया जाता है। सुखाने वाले कक्ष में *वेस्ट हीट रिकवरी सिस्टम* और *मैकेनिकल ड्रायर* से गर्म हवा का प्रावधान भी *इनपुट एयर* में जुड़ा हुआ है।
- *आईआईएसआर मॉडल* गुड़ इकाई का मूल्यांकन इसके प्रदर्शन के लिए किया गया। 600 कि.ग्रा. रस से 100 कि.ग्रा. गुड़ के उत्पादन के लिए प्रति बैच खोई की कुल खपत 240 कि.ग्रा. थी। भट्ठी की तापीय क्षमता का अनुमान 28.4% लगाया गया।
- गुड़ के *पाउडर* के छोटे *क्यूब्स* बनाने की मशीन के मूल्यांकन में असमान *मैनुअल* दबाव होने के कारण *क्यूब* के टूटने की समस्या को प्रमुख कारण माना गया। गुड़ पाउडर का *क्यूब* नीचे की *प्लंजर प्लेट* में चिपक कर रह जाता है जिससे *क्यूब* टूट जाता है। समस्या को दूर करने के लिए *बॉटम प्लंजर प्लेट* को बिना किसी *स्टिक* सामग्री के बनाया गया है।
- प्राकृतिक स्रोत के रूप में सोयाबीन का उपयोग कर प्रोटीन युक्त गुड़ के निर्माण के लिए एक *प्रोटोकॉल* विकसित किया गया। तीसरे वर्ष के दौरान, केवल 100 और 150 ग्राम सोयाबीन (400 और 600 ग्राम *सीड कोट* के बिना *पेस्ट*) का उपयोग किया गया

था। 150 ग्राम और 100 ग्राम सोयाबीन गुड़ में प्रोटीन की मात्रा क्रमश: 6.27 और 5.23 प्रतिशत थी।

- 2 ग्राम गुड की कैंडी बनाने के लिए एक निजी निर्माता की मदद से गुड़ उत्पादन के लिए *सिलिकॉन मोल्ड* विकसित किए गए।

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- भारतीय गन्ना अनुसंधान संस्थान, लखनऊ और चुकंदर प्रजनन केंद्र, मुक्तेश्वर में चुकंदर के 139 आनुवंशिक संसाधनों का संरक्षण किया जा रहा है।
- चुकंदर जननद्रव्य एलकेसी 2006 और एलकेसी 2007 की सूखा सहिष्णु के रूप में पहचान की गई।

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- गन्ना के अन्तर्गत 1,00,000 हे. से अधिक क्षेत्र वाले छह जिलों में से केवल दो जिलों (सीतापुर, 2.84% और लखीमपुर खीरी, 1.64%) में में सकारात्मक वृद्धि देखी गई। यह इस बात पर प्रकाश डालता है कि उत्तर प्रदेश में कुल गन्ना क्षेत्र के 47.2% हिस्से वाले छह जिलो ने अपने उत्पादकता स्तरों में काफी उच्च वृद्धि प्रदर्शित की है। राज्य के कुल गन्ना क्षेत्र का लगभग 24.2% हिस्सा सात जिलों में होता है उन जिलों में 50,000 हेक्टेयर से 1,00,000 हेक्टेयर क्षेत्र में गन्ने का उत्पादन होता है। तीन जिलों, पीलीभीत, बरेली और गोंडा ने रकबा और उत्पादकता दोनों स्तरों पर सकारात्मक और उच्च वृद्धि दर को दर्ज किया है। राज्य के नौ जिलों में गन्ना क्षेत्र 25,000 से 50,000 हेक्टेयर तक है और इन जिलों में गन्ना क्षेत्र का 16.1% हिस्सा है। 10 हजार से 25 हजार हेक्टेयर, 5 हजार से 10 हजार हेक्टेयर और 2,000 से 5,000 हेक्टेयर क्षेत्र में गन्ना सघनता समूह के जिले 7, 12 और 10 जिले हैं, जिनका कुल गन्ना 6.3%, 4.2% और 1.3% है।
- गन्ने में अंत:फसल के प्रभाव के अध्ययन से ज्ञात हुआ है कि बसंत ऋतु में लगाए गए गन्ने की तुलना में शरद ऋतु में लगाए गए गन्ने में खर्च किए गए सकल *रिटर्न* का अनुपात अधिक था। मध्य उत्तर प्रदेश में अंत:फसल के कारण चयनित फसल के अनुसार काफी भिन्न (₹ 3,750 से ₹ 67,565) प्रति हेक्टेयर औसत अतिरिक्त लाभ पाया गया। आलू सहित सब्जियों की अंत:फसलीकरण से प्रति हेक्टेयर श्रमिक में उल्लेखनीय वृद्धि हुई है। जैव–नियंत्रण प्रौद्योगिकी के प्रभाव का आकलन करने के लिए, गन्ने में ऊनी माहू के जैव–नियंत्रण के संबंध में विश्लेषण किया गया था। प्रबंधन अभ्यास "केवल जैविक नियंत्रण" 2% किसानों द्वारा किया गया था और 35.5% किसानों द्वारा अपनाई गई "केवल रासायनिक नियंत्रण" प्रथा की तुलना में नुकसान 23.86% बताया गया और औसत नुकसान लगभग 9.84% हुआ।

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- उन्नमिता विकास कार्यक्रम के अंतर्गत बीज उत्पादन हेतु चयनित सभी किस्मों के लिए बीज गन्ने की औसत उपज 110.38 टन/हे. प्राप्त हुई। कुल 5105 टन बीज गन्ना का उत्पादन किया गया, जिससे 76.04% (3882 टन) बीज सामग्री के रूप में अन्य किसानों को बिक्री के माध्यम से वितरित किया गया जिससे उन किसानों के स्वयं के खेतों में बीज गन्ना फसल उगाने के लिए उपयोग किया जा सके। कटा हुआ शेष गन्ना अर्थात 1223 टन (23.96%) किसानों द्वारा पेराई के लिए चीनी मिल/गुड़ इकाई को आपूर्ति किया गया।
- *पीपीपी मोड* के अंतर्गत 8 चयनित गाँवों में गन्ना आधारित हस्तक्षेप प्रारम्भ करने के कारण गन्ने की औसत उपज 67 टन/हेक्टेयर से बढ़कर 82 टन/हेक्टेयर हो गई और गन्ने की खेती से किसानों की शुद्ध आय में 1.9 गुना (वर्ष 2016–17 में ₹ 70,000 प्रति हेक्टेयर से बढ़कर वर्ष 2020–2021 में ₹ 1,32,000 प्रति हेक्टेयर) की वृद्धि हुई।
- बेहतर प्रौद्योगिकी के प्रभाव को प्रदर्शित करने के लिए विभिन्न अग्रिम पंक्ति प्रदर्शनों का आयोजन किया गया। इसी उद्देश्य के लिए इस वर्ष दस प्रक्षेत्र दिवस भी आयोजित किए गए।
- चार किसानों को गन्ना के व्यवसाय के लिए उद्यमी के रूप में विकसित किया गया।

# Executive Summary

## Crop Improvement

- Two sugarcane varieties, *viz.*, CoLk 15201 (early) and CoLk 15207 (mid-late) for North West Zone and one early maturing sugarcane variety, CoLk 15466 for North Central and North Eastern Zones of India were released for commercial cultivation and notified by the CVRC vide The Gazette of India Notification dated Aug. 31, 2022.
- Two sugarcane varieties, *viz.*, CoLk 14201 (early) and CoLk 15206 (mid-late) for North West Zone and one variety CoLk 16466 (early) for North Central and North Eastern Zone of India were identified for release by the Varietal Identification Committee of AICRP on Sugarcane.
- Three early maturing sugarcane clones, *viz.*, CoLk 22201 (LG 17137), CoLk 22202 (LG 17234) and CoLk 22203 (LG 17224) and three mid-late maturing clones, CoLk 22204 (LG 17219), CoLk 22205 (LG 17214) and CoLk 22206 (LG 17213) were accepted for multi-location testing in North West Zone of India during the AICRP(S) Workshop-2022.
- Two early maturing sugarcane clones, *viz.*, LG 909 and LG 910, and two mid-late maturing sugarcane clones, *viz.*, LG 911 and LG 912 were accepted in Zonal Varietal Trial of North Central Zone of India during AICRP (S) Workshop held in October, 2022.
- Two high sugar genetic stocks, LG 15533 and LG 16581 with sucrose per cent in juice in January at 20.0% were submitted for inclusion in NHG at ICAR-SBI, Coimbatore.
- The whole proteome study of *C. falcatum* revealed 18 fungal pathogenesis proteins, out of which 13 proteins (RAS2, STE20, MAPK17, MAPK-HOG1B, MAPKKK-MCK1, MAPK-MST50, MAPKK-sek1, MAPKK-MST7, MAPK8, MAPKK-MKK2, MAPKKK-MST11, MAPK5, and MAPK-MPK-C) were exclusively present in *C. falcatum* (CFS1/CFS2) samples co-cultured with sugarcane stalks.
- Ninety-seven highly conserved and 64 novel miRNAs were identified from sugarcane genotypes CoV 92102 and MS 68/47 contrasting for sucrose content along with two extreme bulks from their $F_1$ population, of which 23 were significantly different for contrasting sucrose content.
- Prediction accuracy for red rot resistance against three pathotypes of *Colletotrichum falcatum* (CF01, CF08 and CF09) was evaluated using Genotyping by sequencing-derived SNP marker profiles of 174 diverse sugarcane genotypes as a training population.
- A genetic linkage map was developed using a selfed population of a popular sugarcane variety CoS 96268 and a QTL linked to red rot resistance (*qREDROT*) was identified, which explained 26% of the total phenotypic variation for the trait. The expression analysis revealed that the plant defense-related gene coding 26S protease regulatory subunit was strongly associated with the red rot resistance.
- *In vitro* cultures of new sugarcane varieties, *viz.*, CoLk 15201, CoLk 15204 and CoLk 15466, CoLk 14201 and CoLk 14204 were established, and multiplied through enhanced axillary shoot proliferation using apical shoot explants.
- A total of 805 tonnes breeder seed of 13 sugarcane varieties was produced at Main Campus and 1740.85 tonnes breeder seed of six sugarcane varieties was produced at different sugar mills of Bihar and RC, Motipur

## Crop Production

- In an autumn initiated sugarcane ratoon intercropping system, the number of millable canes and sugarcane yield were higher in 90 cm and 120 cm row spacing. The highest cane yield in 90 cm row spacing was found in sugarcane + onion (129.54 t/ha) followed by cane yield in 120 cm row spacing in sugarcane + okra (125.49 t/ha) and sugarcane + onion (124.38 t/ha) in 120 cm row spacing of intercropping system.
- The cane yield (85.5 t/ha) of ratoon crop was recorded the highest under *tulsi-Stevia*-sugarcane (spring).
- In autumn sugarcane based integrated farming system, the highest net income of ₹ 4,63,023/ha was observed in sugarcane crop integrated with vegetable crops + horticultural crops + backyard poultry + dairy unit + fisheries + vermicompost + apiculture + mushroom with an additional income of ₹ 2,01,923/ha and B:C ratio of 3.26. In spring planted sugarcane, the combination resulted in net income of ₹ 4,63,079/ha with an additional Income of ₹ 2,06,879/ha and B:C ratio was 3.41.
- Zero tillage with crop residue management (ZTCRM) recorded 15.54 per cent increase in sugarcane equivalent yield (224.49 t/ha) over conventional tillage (194.30 t/ha) with B:C ratio of

2.05. Crop residue management in sugarcane crop recorded increase in cane and ratoon yield of 17% than without crop residue management. ZTCRM recorded the highest increase of soil organic carbon content, infiltration rate, SMBN, SMBC and porosity over conventional tillage.

- Split application of RDF of NPK through drip fertigation was found to maintain the 3rd ratoon cane yield up to 85.62 t/ha over conventional methods of fertilizer & water application (35.87 t/ha). There was about 49% cane yield loss in 3rd ratoon under conventional methods of fertilizer and water application while only 11% cane yield loss was reported under 100 % RDF of NPK applied through drip fertigation. This treatment also decreased the weed infestation by 21.8% and irrigation requirement by 58% over conventional method.
- Significantly higher NMC, cane length, cane girth and cane weight were measured in February initiated ratoon crop followed by March, April and May initiated ratoon crops.
- The yield in NPK by using STCR without IPNS was 69.2 t/ha followed by NPK by using STCR with IPNS (68.5 t/ha). In recommended NPK, the yield was 65.9 t/ha. Further, the application of atrazine 2,000 g/ha applied as pre emergence followed by ametryn 1,500 g/ha along with 2,4-D 725 g/ha used as post emergence during February and March initiated ratoon resulted in the highest yield of sugarcane (108.3 t/ha). The trash mulching produced better results in all the four ratoon initiations.
- Application of microbial consortia under different levels of nutrient management registered higher values of organic and phosphorus content compared to 100% RDF without microbial consortia (C2). On an average, the cane yield level of the second ratoon crop decreased by 13.5% as compared to the first ratoon crop. The microbial consortia in combination with chemical fertilizer improved the growth and the yield levels.
- Developed three targeted yield equations for CoLk 09204 ratoon crop. These equations were used for recommendation of site-specific balance fertilizer application in ratoon crops across all the alluvial soils of subtropical condition. A Mobile App "Fertilizer Calculator" was developed for calculating the exact doses of urea, DAP and MOP on the basis of initial soil test value and the fixed targeted yields.
- Spatial distribution maps of soil pH, electrical conductivity, organic carbon, available NPK, sulphur and micronutrients *viz*., zinc, copper, iron and manganese were developed for research farm of IISR, Lucknow.
- The highest sugarcane yield (73.64 t/ha) was reported in 100% NPK + drenching of Biostimulator derivative @ 5 ml/litre of water + drenching with *Gluconoacetobacter diazotrophicus* + drenching with *Bacillus subtilis* and *Bacillus cereus* and foliar application of $GA_3$ @ 35 ppm at 90, 120 and 150 DAP.
- A slow release, hydrophobic, abrasion resistance coating material for urea was developed. The urea coating from the developed material showed extended period of release than normal coated urea in all types of soils and thus rendered the property of a slow release fertilizer.
- Irrigating sugarcane at IW/CPE ratio 0.8 was found most efficient for water economy and enhancement of water productivity in sugarcane with very less yield penalty. Irrigation in trenches/ furrows was found equally effective in achieving the same yield level as that with flooding hence resulting in considerable saving of irrigation water. Water footprint of spring planted sugarcane in subtropics ranged between 118 and 130 L/kg depending on the irrigation regime and moisture management practices.
- CoPk 05191 (early) and CoLk 11206 (mid-late) varieties were found suitable for drought conditions in sub-tropical India.
- The three species of *Ipomoea* significantly differed in respect of plant height, root length, number of leaves/plant, stem and root dry biomass. *Ipomoea hederifolia* and *I. triloba* had significantly higher plant growth *viz*. stem height, root length, stem, root and leaf dry biomass than *I. nil*, which may exert more competition to sugarcane crop.
- K application through potassic organo-mineral fertilizer (OMF)- an alternative source of K, improved cane yield and quality.

## Crop Protection

- During the 2022 survey for insect pests and diseases, the incidence of red rot was reported as a serious threat for the variety Co 0238. In Datia district of Madhya Pradesh, *Pyrilla perpusilla* was observed in ratoon crops. The incidence of top borer in western UP was found to be quite severe. However, the incidence of other diseases and borer pests at another surveyed area was low.
- In the survey and surveillance of pests and diseases of sugarcane, the command areas of Pravara, Kolpewadi, Sanjeevani, Ashok, Sangmner and Rahuri Cooperative Sugar Mills in Ahmednagar district and sugarcane growing areas of Nashik and Jalgaon districts, Maharashtra were surveyed.

Increased incidences of brown spot, rust, pokkah boeng, and yellow leaf in CoM 0265 and Co 86032 were observed. Infestation of white fly, white grubs, woolly aphids, pyrilla, borer complex, and fall army worm in the command area of sugar mills in North Maharashtra was also observed.

- In Bihar, command areas of HPCL, Sugauli; MSE, Narkatiyaganj; Harinagar Sugar Mills Ltd., Harinagar and IISR RC, Magadh Sugar and Energy Ltd. (Bharat Sugar Mills), Gopalganj, Sasa Musa Sugar Works Ltd., Gopalganj and Vishnu Sugar Mills Ltd., Gopalganj, Bihar were surveyed for the incidence of different diseases.
- The popular variety, Co 0238 had shown 50 to 70% red rot in the surveyed areas. Variety CoP 16437 (10-20%) was found infected with sugarcane wilt in all the areas surveyed. Severe incidence of YLD was observed in the variety CoLk 94184 (5-15%), CoP 16437 (5-10%) and Co 0238 (5-10%).
- Maximum fecundity (139.2) of *Trichogramma chilonis* (top borer strain) was recorded in 15♀ followed by 14♀, 13♀, 12♀ treatments. As female ratio increases, the fecundity also increased. Percentage of adult emergence varied from 89.8 to 120.2 and was maximum in 7♀ and 14♀ treatment. The competition between the developing parasitism for the available amount of food in host appears to the factor that inhibits the normal development of the parasitoid. Reproductive potential of *Trichogrammachilonis* was significantly enhanced in moth (*Corcyra cephalonica*) scales dust treatment.
- The Berger-Parker index showed that abundant species were maximum at grand growth stage of crop under higher initial SOC plots. In case of lower initial SOC, abundant species were more at maturity. Higher diversity (Chao 1 index) was observed at maturity where initial SOC was more than 0.9. But in plots where SOC was less than 0.5, diversity was more during grand growth phase of crop.
- Impact of soil application of chlorpyriphos and chlorantraniliprole at recommended doses revealed that overall population of soil microarthropods were reduced in comparison to their respective controls. However, negative impact of chlorantraniliprole was overcome to some extent by the maturity of crop.
- Maximum numbers of bacterial-feeder nematodes and the abundance of predatory and plant-parasitic nematodes observed to be varied in relation to land use and nutrient management. However, the occurrence of various nematode genera from different trophic groups in soil samples could be related to soil organic carbon content and also influences with the nutrient source in soil.
- Among different anti-protozoan chemicals evaluated against their bio-efficacy against termites reared on artificial diet under laboratory condition, Ornidazole and Tinidazole were found most effective in causing 100% percent mortality of termites within 10 days of treatment.
- Incidence of second and third broods of top borer was significantly higher in CoLk 8102 whereas, in susceptible varieties (CoLk 8102, Co 0238 and CoLk 14201), incidence of fourth brood was more. During July and August, incidence of mealy bug was observed as maximum in CoLk 16202, BO 91 and CoJ 64.
- Mean number of silken discs guarding female pupa of top borer were higher in first, second, third and fourth broods in variety CoLk 13204 (6.80), CoLk 8102 (8.51), CoLk 8102 (5.82) and CoPk 09151 (5.89), respectively. Silken discs in male pupae were 5.67 (CoLk 13204), 7.08 (CoLk 94184), 5.38 (CoLk 13204) and 3.90 (CoLk 13204).
- Percentage parasitisation in 1st brood of top borer varied from 9.7 to 21.1 in five varieties (Co 0238, CoLk 94184, CoLk 8102, CoLk 13204 and CoPk 05191) while, it was reduced in second brood probably due to high temperature and low humidity during April 2022. Highest mortality of top borer larvae was recorded in third brood (11.1-21.1%) and fourth brood (23.3-32.6%) in all the above five varieties.
- *Chilo partellus* was found to be more preferred host for laboratory multiplication of *Cotesia flavipes*.
- Incidences of top borer (IV brood), internode borer and stalk borer were observed as 9.90%, 3.44% and 8.87% in treated plot as compared to 17.15%, 7.80% and 13.42% in untreated plots, respectively in the variety Co 0238. Pink mealy bug incidence was recorded 36.3% in treated as 61.7% in untreated plots in the month of August 2022.
- Studies on the production of infective juveniles (IJs) on different insect hosts showed that maximum number of IJs emerged from Galleria (11286 IJs) followed by early shoot borer (9940 IJs) while the minimum number of IJs was observed in root borer (4948 IJs). The production of IJs on early grub instars of *Holotrichia serrata* increased with the increase in the dose of IJs / grub. *H. indica* IISR BCCH01 strain was observed to infect the adult beetles of *H. serrata* (39% to 69% mortality in 6 to 7 days post EPN infection), however, the development of nematode inside the adult beetles was affected and few IJs emerged from dead beetles.

- Sixty-two genotypes were screened against red rot (CF08 and CF13) and smut. LG 19063 was found resistant against red rot pathotype (CF08 and CF13), A-8 was resistant against CF08. While A-8, A-19, LG 19006, LG 19104, LG 19049, LG 19109 and LG 19101 were MR against CF13. Natural incidence of wilt and yellow leaf disease (YLD) were also recorded. Twenty seven genotypes were found resistant against smut, 49 against wilt and 44 were found resistant against YLD.
- The virulence pattern of all the *C. falcatum* isolates were more or less matched with the existing pathotypes of this zone CF07, CF08, CF09 and CF13, indicating emergence of no new virulent pathotype in this zone.
- Out of 24 ISH genotypes tested, 14 genotypes were rated as MR against both the pathotypes, CF 08 and CF 13 by plug method of inoculation and resistant (R) under nodal method of inoculation.
- Twelve isolates of *Fusarium* sp associated with pokkah boeng of sugarcane isolated from CoM 0265 and Co 86032 cultivars in Maharashtra were identified as *Fusarium sacchari* using translation elongation factor alpha 1 (tefá1) gene sequence and morphological characters. The gene sequence of these isolates was submitted to Gene Bank, NCBI, and cultures were deposited in National Agriculturally Important Microbial Culture Collection at ICAR-NBAIM, Mau, Uttar Pradesh.
- Studies on Artificial Intelligence based detection of disease and insect pests in sugarcane were carried out. A total of 13,919 RGB images of insects, healthy and injured symptoms of insects, pests, diseases and physiological disorders were captured under controlled and real-time conditions under different light conditions. Gathered images were further categorized into 50 different classes to develop the image dataset.
- Twenty-nine genotypes planted during spring 2021 were evaluated for YLD incidence. All of them were infected with YLD exhibiting characteristic yellowing of mid rib symptom. Among these, ten genotypes *viz.*, CoLk 8102, CoLk 14201, CoLk 94184, Co 7701, Co 7717, Co 1148, Co 0238, Co 997, CoLk 11203, CoLk 11206, CoLk 13204 reported to be susceptible to YLD were used for maintenance of the inoculum. A total of 37 symptomatic samples were subjected for DAS-ELISA where all the samples tested negative for sugarcane yellow leaf virus but samples showed positive amplification for presence of phytoplasma with Phytoplasma universal primers under Nested PCR assays. However, SCYLV infection was not confirmed by RT-PCR assays.
- In 2021-2022, 56 sugar beet germplasm were screened under natural conditions for foliar disease incidence. Leaf spot due to *Cercosporabetae*, *Phoma* sp. and *Alternaria* spp, Fusarium yellows and viral disease complex were observed.

## Plant Physiology and Biochemistry

- Root studies and physio-molecular traits in sugarcane under drought, salinity and waterlogging indicated highest increase in root tissue density under salinity while highest increase in root electrolyte leakage was under drought in both tolerant and susceptible varieties. Transcriptomic studies revealed that highest decrease in photosynthetic gene expression was observed under treatment salinity; a total of 9 photosynthetic genes showed more than two-fold decrease in expression under salinity. Whereas, under drought and waterlogging, two photosynthetic genes showed more than two-fold decrease in expression.
- Five potassium transporters genes which were common to drought, salinity and waterlogging showed more than log 2-fold decrease in expression and this resulted in lower leaf tissue concentration under these stresses.
- Root traits and leaf rolling behaviour were also determined and were related to maximum decrease in RWC recorded in CoJ 64 followed by CoLk 14201. Furthermore, under moisture stress, silicic acid exhibited maximum catalase activity which was higher in the non-stressed plants. Peroxidase activity was maximum under non-stressed condition while it was least in stressed plant and peroxidase activity increased significantly with silicic acid in stressed plant over non-stressed.
- Application of PGRs in the crop at various critical growth stages partitioned more biomass into leaves than shoots during 60-120 DAP. Biomass partitioning into leaves decreased from about 75% at 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. While the effects of plant population on biomass partitioning were not remarkable, the differences in partitioning led by PGRs were clear cut.
- Pretreatment process for delignification of SCT caused effective removal of lignin from lignocellulosic cell walls, resulting in enhanced enzymatic accessibility of the substrate and more efficient cellulose hydrolysis, thermal blanching of sugarcane juice with time-temperature combination of 90°C for 10 min was optimized for

PPO inactivation and retention of physicochemical, microbial and sensory scores.

## Agricultural Engineering

- The metering mechanism of the developed cane node planter was modified. The design of metering mechanism was finalized based on its performance during different combinations. Machine performs deep furrow opening, metering of pre-soaked cane nodes, fertilizer application and soil covering over planted cane nodes, simultaneously in a single pass.
- The new prototype machine comprising of trash mulcher unit, stubble shaving unit and chemical spraying unit which cover two rows of sugarcane. The chemical spraying unit applied trash decomposer for its faster decomposition and the tractor PTO power is utilized to operate the machine. The reduced rpm through gearbox is transmutted by belt and pulley power transmission system to trash mulcher and stubble shaver. The rear roller ensures uniform depth control while covering two rows of sugarcane and trash in between the rows. The prototype was field tested at the IISR farm with satisfactory performance.
- Design development of the matching implements for various farm operations in the field for CTF was studied. The tractor track width was adjusted to 175 cm instead of 150 cm to suit the various machines. Two rows IISR deep furrow sugarcane cutter planter for 60 cm spacing was developed. The performance of the planter was satisfactory in accomplishing the unit operations involved in cane planting, application of fertilizer and chemical insecticide, covering of setts with soil and pressing the covered soil; in a single pass of the equipment. An experiment was laid in the IISR farm for one hectare to study the CTF and conventional sugarcane cultivation.
- The ergonomic evaluation of IISR sett cutting machine was carried out for cutting of three budded setts. This machine has two circular stainless-steel blades of diameter 40.6 cm. An electric motor of one horsepower (240 V) is used to operate the machine. Power to the blades is through flat belt pulley and double grooved V pulley from the motor. The number of setts cut by the operator with conventional cutting blade in 20 minute was 516-715, whereas, it was 840-1500 with the machine. The overall capacity of machine for sett cutting by two operators was 2520-4500 sett/h. Female operator had slightly higher energy expenditure rate (8%) and overall discomfort rate (31%) than the male operator.
- The newly developed IISR manual *stripper-cum-detopper* having 225 g weight was ergonomically evaluated with male and female operator at the Institute farm in three different sugarcane varieties. The average number of cane stripped and detopped by male and female operators were 234 to 285 with average weight of cleaned cane 114 to 243 kg. The physiological workload in terms of working heart rate and energy expenditure rate was in the range of light category with both male and female farm workers.
- Two machines of IISR *viz*, deep furrow sugarcane cutter planter and disc type ratoon management device were modified to make it suitable for tropical region. Both machines were supplied to ICAR-SBI, Coimbatore for field testing and performance evaluation.
- One hundred two prototypes of different machines were fabricated, while 29 prototypes were supplied to different organizations.
- A solar collector unit for jaggery has been designed. To reduce heat loss, glass wool is filled. The exit vents are provided to enter the hot air in drying chamber. Provision of hot air from waste heat recovery system and mechanical dryer has also attached in the input air to the drying chamber.
- IISR model jaggery unit was evaluated for its performance. The overall consumption of bagasse per batch was 240 kg for production of 100 kg jaggery from 600 kg juice. The thermal efficiency of the furnace was estimated as 28.4%.
- Evaluation of the machine for development of small powder jaggery cubes highlighted the problems of cube breakage due to non uniform manual pressure application. Jaggery powder cube remained sticky sticks to the bottom plunger plate resulting in cube breakage. To overcome the problem, the bottom plunger plate has been made with no stick material.
- A protocol for manufacturing of protein rich jaggery using soybean as a natural source has been developed. During third year, only 100 and 150 g soybean (400 and 600 g paste without seed coat) was used. Protein content of jaggery with 150 g and 100 g soybean was 6.27 and 5.23 per cent, respectively.
- Silicon moulds for jaggery production were developed with the help of a private manufacturer for making 2g jaggery candy.

## Sugarbeet

- One hundred and forty-nine genetic resources of sugar beet are being maintained at IISR, Lucknow &Sugar beet Out Post, Mukteshwar.

- LKC 2006 and LKC 2007 identified as drought tolerant sugarbeet germplasm.

## Statistics, Economics and ICT

- Analysis of growth behaviour of individual districts in UP revealed that the positive and significant growth in sugarcane area has been observed only in two districts (Sitapur, 2.84% and Lakhimpur Kheri, 1.64%). Six districts in the most intense category (each having more than one lakh ha sugarcane area), accounting for 47.2% of the total sugarcane area in UP State, have exhibited quite high growth in its productivity levels too. The state has seven districts, each growing sugarcane in an area ranging from 50,000 ha to 1,00,000 ha and collectively accounting for about 24.2% of the total sugarcane area in the state. Three districts, *viz.*, Pilibhit, Bareilly and Gonda have experienced positive and quite high growth rates in both acreage and productivity levels. Nine districts in the state are having sugarcane area ranging from 25,000 to 50,000 ha each and these districts account for 16.1% of the sugarcane area. The districts in the group of sugarcane intensiveness from 10,000 to 25,000 ha, 5,000 to 10,000 ha and from 2,000 to 5,000 ha area are 7, 12 and 10 districts accounting for 6.3%, 4.2% and 1.3% of the total sugarcane area, respectively.
- The impact studies on intercropping in sugarcane revealed that the ratio of gross returns to cost incurred were higher for autumn planted sugarcane compared to spring planted sugarcane. The average added benefits per ha due to intercropping were found to be quite varied (₹ 3,750 to ₹ 67,565) as per the crop selected under Central UP conditions. The intercropping of vegetables including potato has led to significant increase in labour absorption per ha.
- For assessing the impact of bio-control technology w.r.t. the bio-control of woolly aphid in sugarcane, the management practice "Biological control only" was found to be practiced by 2% farmers and the loss reported was 23.86% in comparison to the practice "chemical control only" followed by 35.5% farmers and the mean loss reported was around 9.84%.

## Extension and Training

- The average seed cane yield for all the varieties selected for seed production under entrepreneurship development programme was 110.38 t/ha. A total of 5105 tonne seed cane was produced, out of which 76.04% (3882 t) was utilized as seed material through sale to other farmers for use on self farm to raise seedcane crop. The rest of the harvested cane *i.e.* 1223 t (23.96%) was supplied by farmers to sugarmill/ jaggery unit for crushing.
- The average yield of cane increased from 67 t/ha to 82 t/ ha and net income of farmers from cane cultivation increased by 1.9 times (from ₹ 70,000 per ha in the year 2016-17 to ₹ 1,32,000 per ha in the year 2020-2021) due to introduction of cane based interventions in the 8 selected villages under PPP mode.
- Number of frontline demonstrations were conducted to demonstrate the impact of improved technology. Ten field days were also organized.
- Four farmers were developed as entrepreneurs of cane business.

# About the Institute

The Indian Institute of Sugarcane Research (IISR), Lucknow was established in 1952 by the Indian Central Sugarcane Committee for conducting research on fundamental and applied aspects of sugarcane cultivation 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 conveniently situated at about 12 km from CCS Airport, Amausi and 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 and recovery of sugarcane in different agro-ecological zones of the country and to extend appropriate information and technologies to the end users, following issues and strategies have been identified which need to be pursued.

## Issues

- Low levels of cane yield and sugar recovery
- Threats biotic and abiotic constraints
- High cost of cane cultivation
- Decline in 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

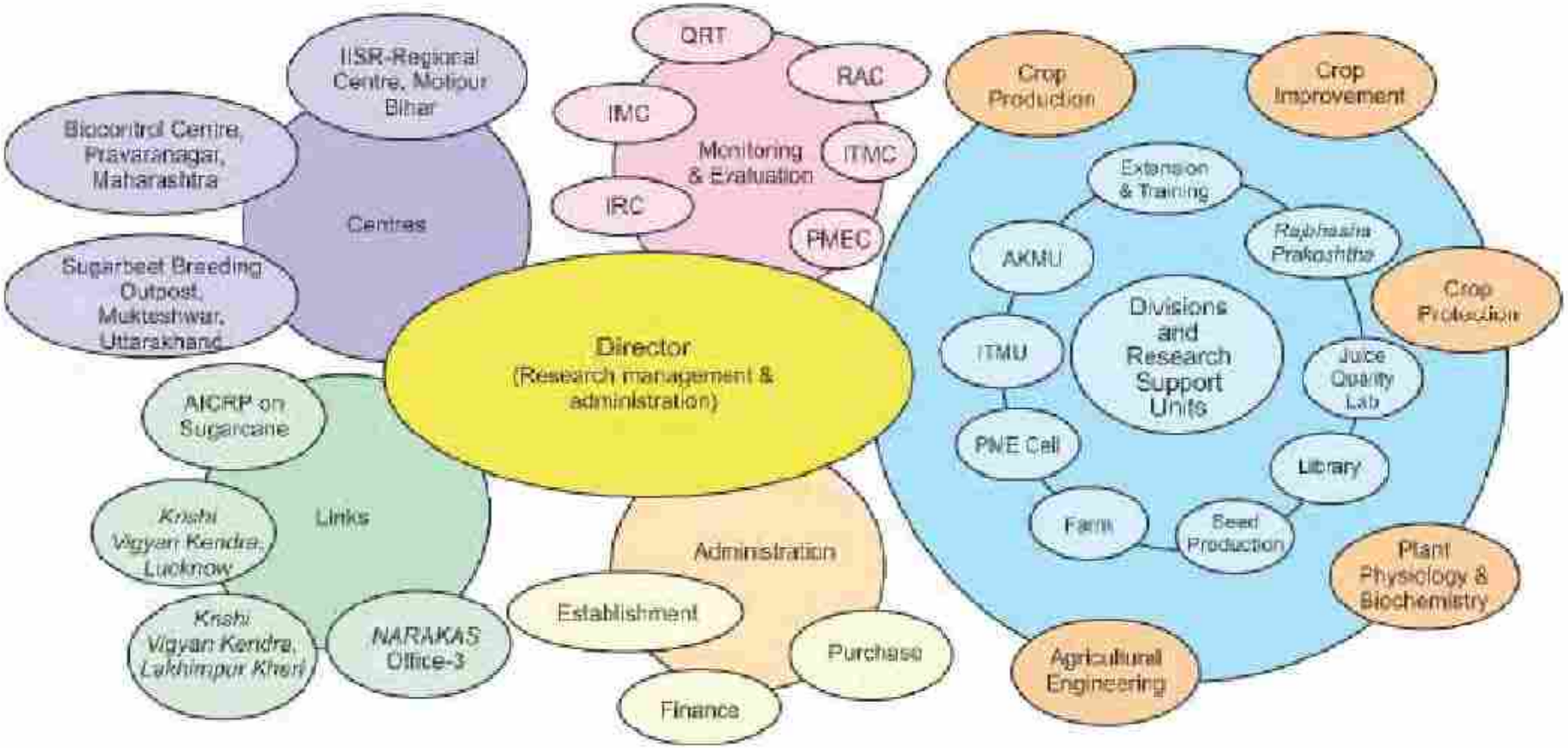
d. Reducing cost of pesticide use in an eco-friendly manner through bio-intensive IPM and IDM

e. Mechanizing sugarcane farming

### *Arresting decline in factor productivity*

a. Soil biological and nutritional dynamism

b. Carbon sequestering through cropping system.




## Organizational Structure

## Financial Statement

### Budget: 2021-22

| Particulars | Plan (₹ in lakh) | |
|---|---|---|
| | Revised Estimate | Expenditure as on March 31, 2022 |
| ICAR-Indian Institute of Sugarcane Research, Lucknow | Salary and Pension: 5529.76<br>Crop Science: 1910.15 | Salary and Pension: 5524.38<br>Crop Science: 1867.39 |
| All India Coordinated Research Project on Sugarcane | Salary and Pension: 690.92<br>Crop Science: 212.75 | Salary and Pension: 690.92<br>Crop Science: 211.74 |

### Budget: 2022-23

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

## Staff Position

(As on December 31, 2022)

| Category | Sanctioned | Filled | Vacant |
|---|---|---|---|
| **Research Management Position** | 1 | 1 | 0 |
| **Scientific** | | | |
| Principal Scientist | 7 | 2 | 5 |
| Senior Scientist | 14 | 12 | 2 |
| Scientist | 52 | 41 | 11 |
| **Total** | **74** | **56** | **18** |
| **Technical** | | | |
| Category-I | 77 | 32 | 45 |
| Category-II | 54 | 29 | 25 |
| Category-III | 3 | 1 | 2 |
| **Total** | **134** | **62** | **72** |
| **Administrative** | 54 | 35 | 19 |
| **Skilled Supporting Staff** | 36 | 5 | 31 |
| **Grand Total** | **298** | **158** | **140** |

CHAPTER 1

# Genetic Improvement of Sugarcane for Higher Cane and Sugar Productivity

## Technology development

### Release and notification of sugarcane varieties

Two sugarcane varieties, CoLk 15201 (early) and CoLk 15207 (mid-late) 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 vide *The Gazette of India* Notification S.O. 4065(E) dated Aug 31, 2022 (Table 1.1, Fig. 1.1, 1.2). Another early maturing sugarcane variety, CoLk 15466 has been released and notified by Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops vide above *Gazette of India* Notification, for commercial cultivation in North Central and North Eastern zones of India (Table 1.1, Fig. 1.3).

### Identification of sugarcane varieties

Two sugarcane varieties, *viz.*, CoLk 14201 (early) and CoLk 15206 (mid-late) were identified by the Varietal Identification Committee of All India Coordinated Research Project on Sugarcane for their release in North West zone of India (Table 1.2, Fig. 1.4, 1.5). Another sugarcane variety CoLk 16466 (Early) was also identified by the Varietal Identification Committee of All India Coordinated Research Project on Sugarcane (AICRP-S) for its release in North Central and North Eastern zone of India (Table 1.2, Fig. 1.6).


**Fig. 1.2. Field view of the plants and buds of CoLk 15207**


**Fig. 1.3. Field view of the plants and buds of CoLk 15466**

**Table 1.1. 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 |


**Fig. 1.1. Field view of the plants and buds of CoLk 15201**

## Sugarcane clones accepted for multi-location testing

Three early maturing sugarcane clones, *viz.*, CoLk 22201 (LG 17137), CoLk 22202 (LG 17234) and CoLk 22203 (LG 17224) and three mid-late maturing clones,

**Table 1.2. 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 0238GC | Early | 91.34 | 11.39 | 18.11 | 13.69 | North West Zone |
| CoLk 15206 (*Ikshu*-14) | LG 95053 GC | Mid-late | 89.81 | 11.64 | 18.42 | 14.32 | North West Zone |
| CoLk 16466 (*Ikshu*-15) | BO 91 × Co 86002 | Early | 85.35 | 10.19 | 17.31 | 13.31 | North Central & North Eastern Zone |

**Fig. 1.4. Field view of the plants and buds of CoLk 14201**


**Fig. 1.5. Field view of the plants and buds of CoLk 15206**

CoLk 22204 (LG 17219), CoLk 22205 (LG 17214) and CoLk 22206 (LG 17213) were accepted for multi-location testing in North West zone of India during the AICRP(S) Workshop-2022 organized at ICAR-IISR, Lucknow (Table 1.3).


**Fig. 1.6. Field view of the plants and buds of CoLk 16466**

## Collection, maintenance, evaluation and documentation of sugarcane germplasm under sub-tropical conditions

A collection of 365 genotypes comprising 185 commercial hybrids, 51 ISH & *Ikshu* ISH lines, 74 LG clones and 30 species level genotypes was maintained. This collection includes *Saccharum officinarum*, *S. barberi*, *S. sinense*, ISH clones, *Ikshu* ISH clones, LG selections, commercial hybrids, somaclonal variants, etc. A 'Varietal Cafeteria' comprising of 20 early and mid-late maturing varieties was planted in March 2022 to provide an opportunity for farmers to select varieties of their choice. DUS character-based characterization of new clones was also conducted.

## Development of sugarcane varieties for sub-tropics

### Hybridization and seedling raising

A total of 29 bi-parental sugarcane crosses were

**Table 1.3. Salient features of the clones accepted for multilocation testing**

| Clone | Parentage | Maturity group | Cane yield (t/ha) | CCS yield (t/ha) | Sucrose % at harvest | Red rot rating |
|---|---|---|---|---|---|---|
| CoLk 22201 (LG 17137) | CoLk 8102 × Co 62198 | Early | 99.29 | 13.01 | 18.61 | MR |
| CoLk 22202 (LG 17234) | LG 08422 × Co 89029 | Early | 96.56 | 12.89 | 18.88 | MR |
| CoLk 22203 (LG 17224) | LG 08422 × Co 89029 | Early | 92.82 | 12.12 | 18.57 | MR |
| CoLk 22204 (LG 17219) | LG 08422 × Co 89029 | Mid-late | 105.67 | 13.63 | 18.71 | MR |
| CoLk 22205 (LG 17214) | LG 08422 × Co 89029 | Mid-late | 104.78 | 13.40 | 18.38 | MR |
| CoLk 22206 (LG 17213) | LG 08422 × Co 89029 | Mid-late | 95.79 | 12.65 | 18.78 | MR |

made during the crossing season 2022, of which 24 crosses were attempted at National Hybridization Garden, ICAR-SBI, Coimbatore and 05 at National Distant Hybridization Facility (NDHF), ICAR-SBI RC, Agali. In addition, fluff of 50 GCs was also requested from the ICAR-SBI, Coimbatore. Fluff of these crosses will be sown in the glass / poly house to raise seedlings. Approximately, 12,220 seedlings derived from 13 biparental crosses, 02 PCs, and 15 GCs (from the crossing season 2020) were raised and transplanted in the field conditions for evaluation.

## Selection in seedling ($C_0$) population

Based on the HR Brix and other growth parameters, 498 clones selected from the seedling populations were planted as $C_1$ clones along with standard varieties for further evaluation.

## Evaluation of advanced clonal generations

A total of 110 sugarcane clones selected from $C_1$ population were promoted to the $C_2$ generation and about 60 promising clones selected from $C_2$ generation were promoted to the $C_3$ generation for further evaluation. The most promising ones were evaluated in replicated trials for yield and quality parameters and red rot testing and the eight best performing clones, *viz.*, LG 17222, LG 18145, LG 18410, LG 18907, LG 19014, LG 19021, LG 19077, and LG 19120 were included in the Station Trial (2022-23) for evaluation.

## Station Trial (2021-22)

Ten elite sugarcane genotypes, *viz.*, LG 14440, LG 14467, LG 14474, LG 15256, LG 17137, LG 17213, LG 17214, LG 17219, LG 17224 and LG 17234 along with six standard varieties (Co 0238, Co 05009, CoJ 64, CoS 767, CoPant 97222, Co 05011) were evaluated in Station Trial (2021-22) for their growth, yield and quality parameters (Table 1.4). The genotype LG 17214 recorded the highest (104.78 t/ha) cane yield which was significantly superior to the best standard followed by LG 17219 (103.67 t/ha) and LG 17137 (99.29 t/ha). Similarly, LG 17219 recorded the highest CCS yield (13.63 t/ha) followed by the LG 17214 (13.40 t/ha) and LG 17137 (13.13 t/ha) at 360 days. The highest sucrose per cent at 360 days was recorded in LG 17224 (19.16%) followed by LG 17213 (18.78%) and LG 17234 (18.77%). However, at 300 days, the highest sucrose percent was recorded in LG 17234 (18.88%) followed by LG 17137 (18.61%) and LG 17224 (18.57%). Among the standards, Co 0238 was found to be the best for all the parameters at both 300 and 360 days.

**Table 1.4. Performance of elite sugarcane genotypes under Station Trial (2021-22)**

| Genotype | Cane yield (t/ha) | CCS yield at 360 days (t/ha) | Sucrose % at 360 days | Sucrose % at 300 days |
|---|---|---|---|---|
| LG 14440 | 63.42 | 7.89 | 18.07 | 17.20 |
| LG 14467 | 85.92 | 10.88 | 18.18 | 17.70 |
| LG 14474 | 62.54 | 7.85 | 18.05 | 17.51 |
| LG 15256 | 78.70 | 10.25 | 18.67 | 17.95 |
| LG 17137 | 99.29 | 13.13 | 18.75 | 18.61 |
| LG 17213 | 95.79 | 12.65 | 18.78 | 18.17 |
| LG 17214 | 104.78 | 13.40 | 18.38 | 17.87 |
| LG 17219 | 103.67 | 13.63 | 18.71 | 17.18 |
| LG 17224 | 92.82 | 12.55 | 19.16 | 18.57 |
| LG 17234 | 96.56 | 12.64 | 18.77 | 18.88 |
| CoJ 64 | 69.47 | 9.21 | 18.88 | 18.05 |
| Co 0238 | 82.91 | 10.76 | 18.74 | 18.50 |
| Co 05009 | 61.74 | 7.80 | 18.23 | 17.59 |
| CoS 767 | 74.14 | 8.96 | 17.48 | 17.06 |
| CoPant 97222 | 80.09 | 10.23 | 18.37 | 18.23 |
| Co 05011 | 73.20 | 9.32 | 18.25 | 17.89 |
| CD (0.05) | 7.42 | 0.92 | 0.47 | 0.87 |
| CV % | 5.38 | 5.14 | 1.52 | 2.91 |

## Evaluation of early sugarcane clones for North West zone

### Initial Varietal Trial (Early)

A trial comprising of eight test sugarcane genotypes, *viz.*, CoS 17232, CoPb 18181, CoPb 18182, CoLk 18201, CoLk 18202, CoPb 18211, CoPb 18212 and CoPant 18221 and three standards (CoJ 64, Co 0238, Co 05009) was conducted and observations were recorded on various yield and quality parameters. The genotype, CoS 17232 recorded the highest cane yield (88.95 t/ha) closely followed by CoLk 18202 (88.36 t/ha). Further, the genotype CoS 17232 also recorded the highest CCS yield (11.37 t/ha) followed by CoLk 18202 (10.88 t/ha). The highest sucrose content at harvest was recorded in CoPb 18212 (18.73%) followed by CoS 17232 (18.53%). Among the standards, Co 0238 was found to be the best for both yield and quality parameters and recorded the highest cane yield (88.94 t/ha) and CCS yield (11.21 t/ha).

### Advanced Varietal Trial II Plant (Early)

Six sugarcane clones, *viz.*, CoLk 14201, Co 15025, Co 16029, CoLk 16201, CoLk 16202 and CoPb 16181 along with three standards (CoJ 64, Co 0238, Co 05009) were evaluated for yield and quality parameters. Among the tested genotypes, CoLk 16202 recorded the highest cane yield (108.37 t/ha) and CCS yield (13.99 t/ha). The genotype Co 16202 showed the highest sucrose per cent at harvest (18.64%) followed by CoLk 14201 (18.39%). Among the standards, Co 0238 was the best check for cane yield (88.21 t/ha) and CCS yield (11.34 t/ha).

### Advanced Varietal Trial Ratoon (Early)

Six sugarcane clones, *viz.*, CoLk 14201, Co 15025, Co 16029, CoLk 16201, CoLk 16202 and CoPb 16181 along with three standards, CoJ 64, Co 0238 and Co 05009 were evaluated for ratoonability. The genotype, CoLk 16202 recorded the highest cane yield (84.19 t/ha) and CCS yield (10.22 t/ha). Among the standard varieties, Co 0238 was the best for cane yield (76.42t/ha) and CoJ 64 for CCS yield (9.31 t/ha).

### Seed Multiplication (Early)

The seed of ten sugarcane genotypes, *viz*, Co 19016, CoLk 19201, CoLk 19202, CoLk 19203, CoPant 19221, CoPb 19181, CoPb 19211, CoPb 19212, CoS 19231 and CoH 19261 is being multiplied for next year's IVT trial.

## Evaluation of mid-late sugarcane clones for North West zone

### Initial Varietal Trial (Mid-late)

Eleven sugarcane clones, *viz.*, Co 18021, Co 18022, CoLk 18203, CoLk 18204, CoPb 18213, CoPb 18214, CoPant 18222, CoS 18231, CoS 18232, CoS 18233 and CoS 18234 along with three standards, CoS 767, CoPant 97222 and Co 05011 were evaluated for yield and quality parameters. The genotype, CoLk 18203 recorded the highest cane yield (110.58 t/ha) followed by CoPant 18222 (107.88 t/ha) and CoS 18231 (96.65 t/ha). The genotype, CoLk 18203 showed the highest CCS yield (14.48 t/ha) followed by CoPant 18222 (13.81 t/ha) and CoS 18231 (12.66 t/ha). Among the test genotypes, Co 18204 recorded the highest sucrose percent at harvest (19.12%) followed by CoS 18231 (18.82%). Among the standard varieties, CoPant 97222 recorded the highest CCS yield (11.69 t/ha) followed by CoS 767 and Co 05011.

### Advanced Varietal Trial I 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 (104.26 t/ha) which was significantly superior to the best check. The genotype, CoH 17262 exhibited the highest sucrose % at harvest (18.84%) followed by CoH 17261 (18.63%) and CoLk 17204 (18.54%). Among the standard varieties, CoPant 97222 was found to be the best for cane yield (86.06 t/ha) and CCS yield (11.62 t/ha).

### Advanced Varietal Trial II Plant (Mid-late)

Five sugarcane genotypes, *viz.*, Co 16030, CoLk 16203, CoLk 16204, CoS 16232 and CoS 16233 along with three standards CoS 767, CoPant 97222 and Co 05011 were evaluated for yield and quality parameters. CoLk 16204 recorded the highest cane yield (105.22 t/ha) which was significantly superior to the best check. Similarly, the genotype CoLk 16204 exhibited the highest sucrose per cent at harvest (19.43%) followed by CoS 16233 (18.91%) and Co 16030 (18.83%). Among the standard varieties, CoPant 97222 was found to be the best for cane yield (82.47 t/ha) and CCS yield (11.17 t/ha).

### Advanced Varietal Trial Ratoon (Mid-late)

Five genotypes, *viz.*, Co 16030, CoLk 16203, CoLk 16204, CoS 16232, and CoS 16233 along with three standard varieties, CoS 767, CoPant 97222 and Co 05011 were evaluated for ratooning ability. The genotype, CoLk 16204 recorded the highest cane yield (80.77 t/ha) and CCS yield (10.27 t/ha). Among the standard varieties, CoPant 97222 was found to be the best for cane yield (74.37 t/ha) and CCS yield (9.27 t/ha).

### Seed multiplication (Mid-late)

The seed of twelve genotypes, *viz.*, Co 19017, Co 19018, CoH 19262, CoLk 19204, CoPant 19222, CoPb 19182, CoPb 19213, CoPb 19214, CoS 19232, CoS 19233, CoS 19234 and CoS 19235 is being multiplied for next year's IVT trial.

## Development of sugarcane clones/varieties for North Central Zone

IISR RC, Motipur has intensified all aspects of sugarcane cultivation for North Central Zone (NCZ) by making crosses every year at ICAR-SBI, Coimbatore to develop sugarcane varieties for the North Central Zone, evaluation of elite material for waterlogging tolerance & red rot resistance, and dissemination of IISR technologies for sugarcane productivity enhancement in NCZ. In this context, 47 different cross combinations (BP, GC & PC) were attempted this year. Fluff supplied by ICAR-SBI, Combatore was sown and healthy/good seedlings of these crosses have been raised in 2021-22. All these crosses are in the $C_1$ stage and segregating populations of the subsequent generation are being evaluated. Juice analyses and morphological observations in segregating populations were performed/recorded for further assessment and selection. Further, a preliminary varietal trial with 18 progenies of bi-parental, self, and general crosses of sugarcane including five checks has been established for evaluation of yield, juice quality and resistance to red rot disease. Based on the data of previous year trial, four clones *viz*, LG 909 [LG 05828 (GC)] and LG 910 (BO 91 × Co 62198) in early group and LG 911 (CoP

**Table 1.5. Performance of elite sugarcane genotypes accepted for Zonal Varietal Trial (ZVT) of North Central Zone**

| Clone | Parentage | Maturity Group | Cane yield (t/ha) | CCS Yield (t/ha) | Sucrose (%) | Red Rot rating |
|---|---|---|---|---|---|---|
| LG 909 | LG 05828 (GC) | Early | 94.58 | 11.27 | 11.91 | MR |
| LG 910 | BO 91 × Co 62198 | Early | 92.62 | 10.98 | 11.86 | MR |
| LG 911 | CoP 06436 × Co 62198 | Mid-late | 92.17 | 10.70 | 17.56 | MR |
| LG 912 | CoLk 7901 (GC) | Mid-late | 96.49 | 11.06 | 17.49 | MR |

06436 × Co 62198) and LG 912 [CoLk 7901 (GC)] in mid-late maturing group were accepted for Zonal Varietal Trial (ZVT) for NCZ during AICRP (S) Workshop (Table 1.5).

## Defining ideotypes in sugarcane for moisture deficit conditions

This project was started with the collection of sugarcane genotypes (varieties, clones and IGH/ISH) for screening them under moisture deficit conditions. During this year, ratoon of 24 genotypes including clones developed at IISR RC, Motipur and four checks (CoP 06436, CoSe 95422, CoP 9301, CoLk 94184) were evaluated for yield and sucrose content under moisture deficit conditions. Soil moisture content at 90 DAP was low in the upper soil layer (0-15 cm) compared to the lower soil layer (15-30 cm). Soil moisture content in the upper soil layer was higher than the lower soil layer at 180 and 270 DAP. Sugarcane clones showed significant variation for chlorophyll content in the drought stress period (90 DAP) and recovery period (180 DAP). All the tested clones had higher sucrose content in comparison to checks under irrigated conditions. Clones of LG 951 and LG 952 showed superiority against check for sucrose content under drought conditions. A similar pattern was observed for sucrose, Brix, commercial cane sugar and purity (%) under both the conditions. Internode length, number of internodes, number of leaves, cane height, leaf weight, sheath weight, number of tillers and number of millable canes were also recorded. The stalk diameter varied in different clones; the highest stalk diameter (2.62 cm) was recorded in LG 953 followed by LG 954 (2.60 cm), and LG 07601 (2.15 cm) under drought conditions and LG 953 (2.72 cm) followed by LG 954 (2.67 cm), and LG 07601 (2.21 cm) under irrigated conditions. Cane height was the highest (236 cm) in LG 955 followed by LG 957 (205 cm) against CoP 06436 (191 cm) under drought conditions. Single cane weight was the highest (0.76 kg) in LG 955 followed by LG 07601 (0.74 kg) and LG 952 (0.70 kg) against CoP 06436 (0.62 kg) in drought conditions, while, LG 958, LG 956, CoLk 8102, LG 07601 and LG 953 had the highest single cane weight of 0.79, 0.77, 0.77, 0.73, 0.61 kg, respectively, against CoP 06436 (0.60 kg) in irrigated conditions. This showed that LG 951, LG 952, LG 955 and LG 07601 have drought tolerance characteristics and can be used for further research.

## 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. 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 2022 showed five genotypes from different advanced clonal stage having sucrose per cent in juice of >20% (Table 1.6), all having a purity of ~90%. These clones had satisfactory morphological attributes and are being evaluated further for their suitability as early maturing varietal candidates. Twenty-nine clones out of the approximately 200 clones exhibited >19% sucrose in juice in the month of January and February 2022. The 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 crossing and selection, gave a good number of progenies with sucrose % in juice values of 19-20%. Two promising sugarcane clones LG 15670 and LG 16487 (sucrose per cent in juice >18% in January and good morphological attributes) are being evaluated in the divisional station trial for economically important traits. Both the genotypes are the progenies of the high sugar genotypes developed in the earlier cycles of recurrent selection. Two high sugar genetic stocks, LG 15533 and LG 16581 with sucrose per cent in juice values 20.0% in January, were submitted for inclusion in NHG at ICAR-SBI, Coimbatore (Table 1.7).

The high sugar genotypes advanced to the next clonal stage showed good germination and initial vigour along with other attributes. Juice analysis was initiated in the different clonal stages from the month of October-November 2022. Out of the 150 promising clones studied in November, 10 clones exhibited >16% sucrose in juice in the month of November 2022. The evaluation will be continued in the subsequent months for selecting the early/mid-late maturing promising genotypes.

A portion of the fluff from 2020 crossings that were sown in the mist chamber in November 2021 showed

satisfactory germination in the different crosses. The general collections from the high sugar clones LG 14564, LG 09487, LG 08422, LG 01118 and LG 07590 and the bi-parental crosses involving LG 08422, LG 09487, LG 14564 and LG 09475 gave good germination. Hand refractometer Brix readings recorded during November 2022 in these progenies indicated that 10% of the seedlings had a mean HR Brix value of >20 (°Bx). Approximately, 20 crosses involving the high sugar genotypes and improved high sugars sugarcane varieties were effected during the crossing season 2022-23. This also included a few crosses involving *S. officinarum* clones at Distant Hybridization Facility, ICAR-SBI RC, Agali, Kerala. The fluff from the crosses of the crossing season 2021 were sown in the mist chamber. The crosses involving the species clones showed poor germination.

A preliminary estimate of the sucrose per cent in juice values of the high sugar clones indicated that, as compared to the sucrose content of the genotypes developed in the first crossing and selection cycles, the newly developed genotypes showed an improvement in the mean sucrose per cent in juice values by 8-10% (Table 1.6).

**Table 1.6. Promising sugarcane clones with high sugar accumulation potential**

| Genotype | Parentage | Mean sucrose % in juice (Jan.-Feb. 2022) |
|---|---|---|
| LG 15676 | LG 07408 GC | 20.75 |
| LG 15533 | LG 07408 GC | 20.52 |
| LG 16527 | LG 08422 × LG 07482 | 20.72 |
| LG 16547 | LG 08422 × LG 07482 | 20.33 |
| LG 16487 | LG 05460 GC | 20.07 |

**Table 1.7. High sugar genetic stocks submitted to NHG**

| Genotype | Parentage | Features |
|---|---|---|
| LG 15533 | LG 07406 GC | High sugar content. Mean sucrose in juice >20% in January |
| LG 16581 | LG 08422 × LG 07482 | High sugar content. Mean sucrose in juice >20% in January |

## Mapping of loci linked to sugar content in sugarcane

The project aims to map the loci linked to sugar content related traits in sugarcane. Segregating populations from bi-parental crosses and selfs were maintained in the field and phenotyped. A comparison of the selfed population and bi-parental crosses with same female parent (CoLk 7901 self, CoLk 7901 × ISH 176 and CoLk 7901 × HR-83-65) indicated a higher potential of the bi-parental crosses to give rise to progenies with better sucrose content but the range of values for sucrose content was more in the selfed population. Out of a subset of 220 clones phenotyped from a selfed population of CoLk 7901, approximately, 60% of the clones exhibited mean Pol% juice values in the range of 14-17% at peak sucrose accumulation. 7% of the genotypes were of low sugar content with mean Pol% juice values of 9-14%. Twenty per cent genotypes had a mean pol% juice value >18% at 12 months, with eight genotypes exhibiting pol% juice values ranging from 19% to 21%.

Genotyping studies were continued for the segregating population using microsatellite markers and sugar gene specific markers. A very limited number of primers were used for genotyping during the period of reporting out of which, 65% of the primer pairs studied exhibited polymorphism among the genotypes. Out of the total markers used, 10 primer pairs gave rise to distinct bands in different genotypes. The genotyping studies will be completed with more number of newly developed as well as already reported markers.

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

This project was taken up to unravel the profile of conserved and novel miRNA in response to red rot disease and the role of small RNA in red rot resistance. Small RNA libraries from stalks of sugarcane cultivars BO 91 and CoJ 64 inoculated with *C. falcatum* along with control were sequenced using the Illumina NextSeq 500. Cleaned and filtered reads greater than 18nt in length (17842325, 24861131, 19116774 and 18902784 in BO 91 and CoJ 64 control and red rot inoculated samples respectively) were aligned to the fungal genome *Colletotrichum falcatum*. Aligned reads were discarded and 16054692, 15322712, 15742052 and 16193356 unaligned (non-fungal) reads from above samples were mapped to *Sorghum bicolor* reference genome to classify tRNA, snRNA, snoRNA etc. Unmapped reads between the range of 18-30 nt were used for identification of novel and known miRNA genes, and differential expression analysis and comparison amongst the samples (Fig 1.7). Scores greater than 4 for mature novel miRNAs were reported to be present in the analyses, leading to the presence of 79 novel miRNAs from the total mined set of

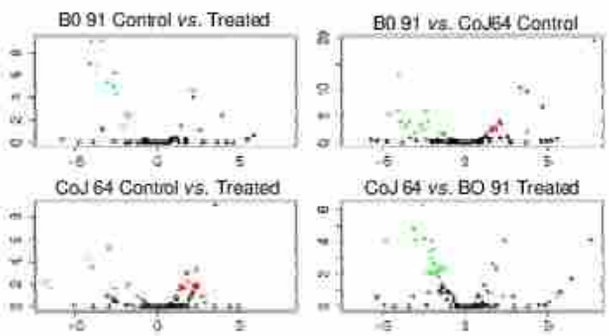



**Fig. 1.7 Volcano plot of Known miRNA genes in control *vs.* red rot inoculated samples of sugarcane cultivars BO 91 and CoJ 64**

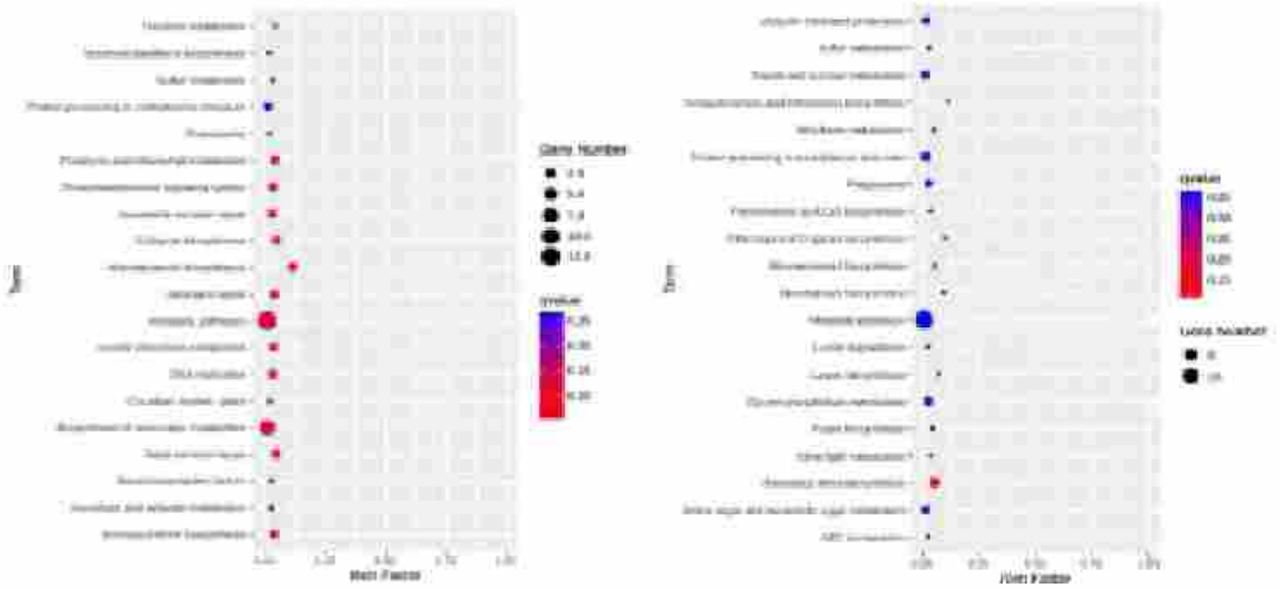


**Fig. 1.8 Scatter plot of KEGG pathway analysis of upregulated novel miRNA genes in BO91 *vs.* CoJ64 control and red rot inoculated samples**

206. A total of 143 up & 60 down regulated miRNA genes were identified in CoJ 64 control *vs.* red rot inoculated samples, 36 up & 66 down regulated in BO 91 control *vs.* red rot inoculated samples, 132 up & 145 down regulated in BO 91 *vs.* CoJ 64 control samples, and 67 up & 187 down regulated in CoJ 64 *vs.* BO 91 red rot inoculated samples. Differentially expressed miRNA were taken as an input for prediction of targets. Enriched Gene Ontology (GO) term of differentially expressed transcripts and its hierarchy was visualized by Directed Acyclic Graph (DAG). KEGG Pathway enrichment analysis was done to understand the biology of differentially expressed genes and proteins (Fig 1.8). Further validation of miRNA gene expression levels using Q-RTPCR is underway.

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

The whole proteome study of *C. falcatum* revealed as many as 18 fungal pathogenesis proteins. Out of 18, 13 fungal pathogenesis proteins (RAS2, STE20, MAPK17, MAPK-HOG1B, MAPKKK-MCK1, MAPK-MST50, MAPKK-sek1, MAPKK-MST7, MAPK8, MAPKK-MKK2, MAPKKK-MST11, MAPK5, and MAPK-MPK-C) were exclusively present in *C. falcatum* (CFS1/CFS2) samples co-cultured with sugarcane stalks. On the other hand, 5 fungal pathogenesis proteins (STE23, STE20, MST20, MAPKKK-nsy1 and MAPKKK5) were present in both control *C. falcatum* (CFS) & *C. falcatum* samples cultured with sugarcane stalks (CFS1/CFS2). However,

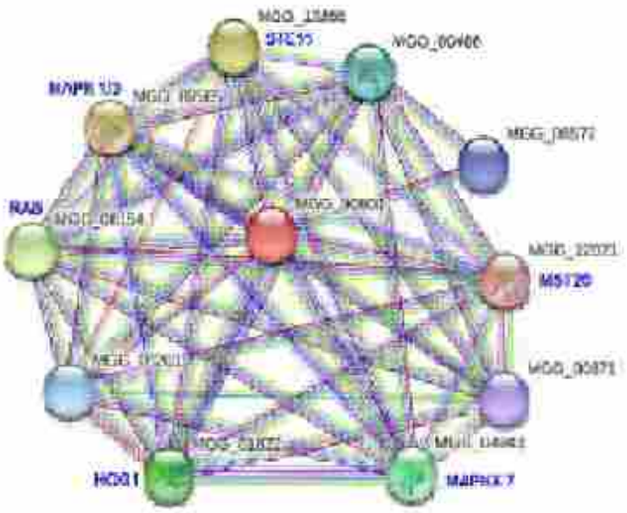



**Fig. 1.9. String association network of STE7/MST7 with the proteins involved in MAPK signal cascade in *C. falcatum*.**

STE 23, STE20 (Q7RZD3), and MAPKKK-nsy1 proteins were significantly more abundant in CFS1/CFS2, compared to CFC. MAPKs, as described above, are the key signal transduction components of pathogenic fungi required for host cell invasion.

String based protein-protein association network revealed strong association between STE7/MKK2 and STE11/MST11 (Fig. 1.9). Moreover, STE7/MKK2 and STE11/MST11 also established interaction with several other proteins implicated in MAPK signal pathway in fungi like MAPK1/3, RAS like proteins, MAPK- HOG1, MAPK7, and serine/threonine protein kinase MST20.

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

The experiment involving the study of transcriptomic profile of sugarcane and *C. falcatum* was initiated. Literature has been reviewed and the sugarcane planting has been done in open field as well as in glass house to collect the samples for transcriptome analysis.

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

Micropropagation technique of plant tissue culture is useful for rapid multiplication of new varieties with superior traits and production of virus-free genetically uniform seed cane. Virus indexed mother stock cultures of sugarcane variety CoLk 14201 were supplied to tissue culture production units in U.P. *In vitro* cultures of new sugarcane varieties, *viz.*, CoLk 15201, CoLk 15204 and CoLk 15466 CoLk 14201 and CoLk 14204 were established, and multiplied through enhanced axillary shoot proliferation using apical shoot explants. Shoot initiation was achieved on MS 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. The *in vitro* multiplied sugarcane varieties CoLk 09204, CoLk 11203, CoLk 11206, CoLk 12207 and CoLk 12209 that were transferred to field last year were harvested and utilized as seed cane.

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

The new phase (2021-2026) of the Accredited Test Laboratory (ATL) for genetic fidelity and virus indexing of tissue culture raised plants under NCS-TCP is presently being operated at IISR, Lucknow with the financial support from Department of Biotechnology (DBT), New Delhi. The aim of ATL is to support the DBT recognized tissue culture production facilities (TCPF) for testing of mother stock and TC plants so as to ensure availability of genetically uniform and virus-free planting materials to the farmers. During the year 2022, a total of 20,488 samples were tested, out of which 9,247 samples comprising 90 samples of sugarcane, 5,930 samples of banana and 3,227 samples of potato from TCPF were tested for mother stock virus indexing. Of the total samples, 11,241 samples comprising of 200 samples of sugarcane, 8,490 samples of banana and 2,551 samples of potato were tested for batch culture (virus indexing and genetic fidelity testing, which equals to quality certification of >10 million tissue culture plantlets, for which test reports and certificate of quality were issued as per DBT Guidelines. Among the batch testing, 200 samples of sugarcane were found positive for presence of Phytoplasma, 60 samples of sugarcane were found positive for presence of sugarcane streak mosaic viru, and 10 samples of sugarcane mother cultures were found positive for presence of sugarcane mosaic. The testing included virus indexing of sugarcane for sugarcane mosaic virus (SCMV), sugarcane yellow leaf virus (SYLV), sugarcane bacilliform virus (SCBV), and phytoplasma, and banana samples for banana bract mosaic virus (BBrMv), cucumber mosaic virus (CMV), banana bunchy top virus (BBTV), and banana streak virus (BSV)].

## Identification of conserved and novel microRNAs regulating sucrose accumulation in sugarcane

MicroRNAs (miRNAs), which are a class of small non-coding RNAs play a very important role in post-transcriptional regulation of genes. Very little has been reported on the miRNA-mediated regulation of sucrose accumulation in sugarcane. Two sugarcane genotypes contrasting for sucrose content (CoV 92102 and MS 68/47) along with two extreme bulks from their $F_1$ population were used to identify differentially expressed miRNAs which might play a regulatory role in sucrose accumulation. The RNAseq of the two parental lines generated 40-50 million paired-end reads per sample. The four small RNA libraries generated 10-15 million raw reads. A major proportion of the small RNAs were 21-24 nucleotides long (Fig. 1.10); 25.5% of the small RNA sequences from the high sucrose parent (CoV 92102) were 21 nucleotides in length, while, it was only 12.08% in the low sucrose parent (MS 68/47). A total of

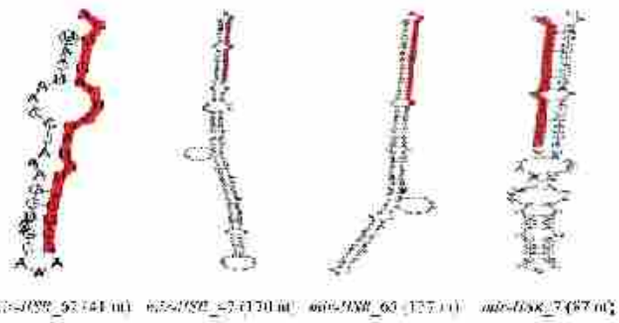


**Fig. 1.10. Predicted secondary structures along with the length of putative differential miRNA hairpin loops identified in this study. The secondary structures of miRNAs were predicted using software packages miREvo and mirdeep2. The red highlighted sequences denote mature miRNA.**

97 highly conserved and 64 novel miRNAs were identified, of them, 23 were significantly different for contrasting sucrose content. The target genes of the identified miRNAs were predicted and some of them were validated using transcriptome library-based gene expression levels and q-RT PCR. A KEGG pathway analysis of all the targets revealed that between the parents, maximum number of differentially enriched genes were observed in carbon metabolism, endocytosis and RNA degradation. Significant differential regulation was observed in the target genes comprising of transcription factors (PCF8, GRFs, ARF, *etc.*), RAV6, calcium dependent protein kinase, HSC20, diacylglycerol kinase, squamosa promoter binding protein, *etc.*, which have been reported to be involved in carbohydrate metabolism, vegetative to mature phase transition, stress response, ion transport, growth and developmental pathways in sugarcane. This study identifies the regulatory miRNAs involved in sucrose accumulation and adds to the small RNA inventory of sugarcane.

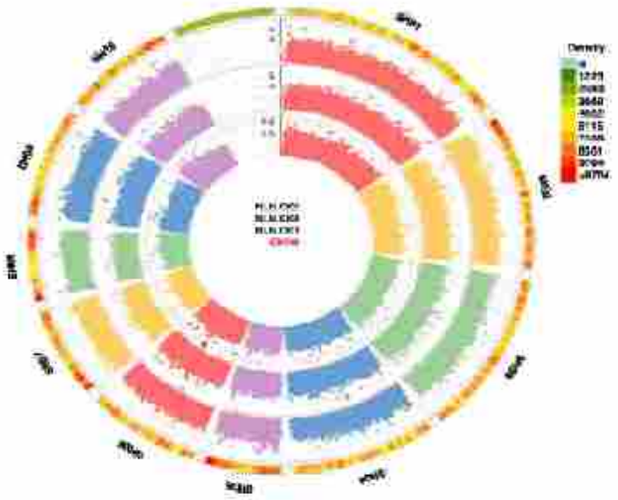


**Fig. 1.11. Circular Manhattan plot showing significant markers for resistance to the three pathotypes of *Colletotrichum falcatum* Went (CF01, CF08, CF09) used in study**

## Genomic selection based accelerated breeding in sugarcane (*Saccharum* species complex) with special reference to sugar content

Genomic selection has earned significant attention of plant breeders owing to its ability to fine-tune and increase the rate of genetic gain per breeding cycle. Genomic selection was applied for evaluation of prediction accuracy for red rot resistance against three races of *Colletotrichum falcatum* (CF01, CF08 and CF09) using Genotyping by sequencing-derived SNP marker profiles of 174 diverse sugarcane genotypes as a training population (Fig. 1.11). Detection of SNPs was carried out using genotyping by sequencing (partially methylation sensitive penta-cutter *ApeK1*) (Table 1.8). LD-kNNi imputation was carried out in order to account for missing data. Genomic prediction was performed using genomic best linear unbiased prediction, (gBLUP) and Settlement of MLM Under Progressively Exclusive Relationship gBLUP (SUPER gBLUP) in the training population. Further studies on the prediction accuracy of ML-based algorithms are being carried out. This study was also able to identify SNPs linked with resistance to each of the three races of red rot in sugarcane through GWAS (Table 1.8).

**Table 1.8. Highly significant SNP markers located on reference genome assembly of sugarcane (Garsmeur *et al.* 2018) associated with resistance to the three pathotypes of *Colletotrichum falcatum* Went. (CF01, CF08, CF09) used in study**

| Pathotype | SNP | p-value |
|---|---|---|
| CF01 | SSH01_5056553 | 0.000100104 |
| CF01 | SSH01_5056561 | 0.000100104 |
| CF01 | SSH01_53509146 | 0.000100157 |
| CF01 | SSH03_18382924 | 0.000100594 |
| CF01 | SSH10_14987976 | 0.000100856 |
| CF08 | SSH01_36306251 | 0.000100112 |
| CF08 | SSH01_64909276 | 0.000100151 |
| CF08 | SSH01_61558506 | 0.000100399 |
| CF08 | SSH05_22489765 | 0.000100663 |
| CF09 | SSH10_17660820 | 0.000100488 |
| CF09 | SSH08_20669177 | 0.000100948 |
| CF09 | SSH06_4238157 | 0.000100975 |

## QTL mapping and identification of candidate genes linked to red rot resistance in sugarcane

A genetic linkage map was developed using a selfed population of a popular sugarcane variety CoS 96268. A QTL linked to red rot resistance (*qREDROT*) was identified, which explained 26% of the total phenotypic variation for the trait (Fig. 1.12). A genotype-phenotype network analysis was performed to account for epistatic interactions and identify all the key markers involved in resistance to red rot. The differential expression of the genes located in the genomic region between the two flanking markers of the *qREDROT* as well as in the near vicinity of the markers identified through the genotype-phenotype network analysis, in a set of contrasting genotypes for red rot infection further confirmed the mapping results. The expression analysis further revealed that the plant defense-related gene coding 26S protease regulatory subunit is strongly associated with the red rot resistance.

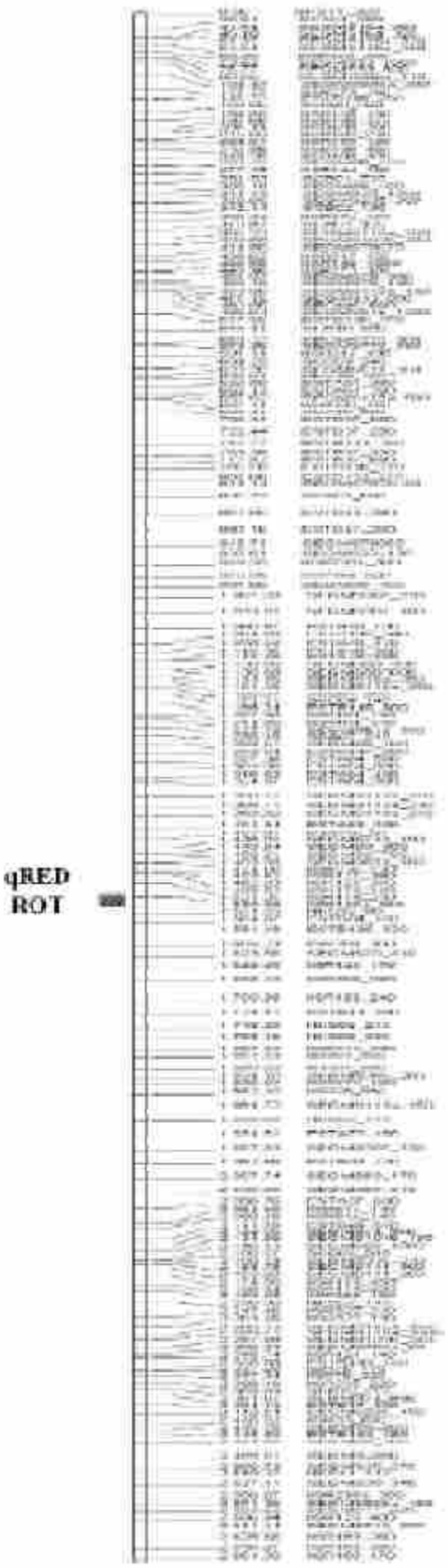



**Fig. 1.12. Details of QTL analysis on LG 4 and one QTL, *qREDROT* located at 1545 cM, and flanked by markers IISR139a_260 (1539.98 cM) and KS32_80 (1551.59 cM)**

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

This year, a total of 180 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 organization working on sugarcane. DUS characters were recorded on 150 varieties in reference collection as per the DUS testing guidelines.

## Seed production in agricultural crops (ICAR Seed Project)

During the year 2022, approx. 8,050 quintals of seed cane was produced (Table 1.9). CoLk 14201 is very much in demand and 16,36,175 single bud seed was supplied to more than 20 districts of U.P. Apart from this, 101.28 quintal seed was supplied as whole cane till December 2022. This variety is gaining popularity among sugar mills, farmers and farmers engaged in jaggery making. Twelve hectare area was planted with newly released varieties for seed cane production during spring and autumn seasons of 2022. New varieties *viz.*, CoLk 15201, CoLk 15207 and CoLk 15466 were included in the seed production. Under seed cane awareness, seed of newly released varieties *viz*, CoLk 11206, CoLk 11203, CoLk 12207, CoLk 12209, CoLk 14201 and CoLk 14204 were distributed to farmers and several sugar industries from Uttar Pradesh and Bihar. Field visits of the farmers and other stakeholders to popularize recently released and notified varieties were organized at the Institute.

**Table. 1.9. Sugarcane Seed Production (Estimated) at ICAR-IISR, Lucknow during 2022**

| Variety | Group | Quantity (q) |
|---|---|---|
| CoLk 14201 | Early | 2750 |
| CoLk 12207 | Early | 500 |
| CoLk 11203 | Early | 600 |
| CoLk 9709 | Early | 500 |
| CoLk 94184 | Early | 300 |
| CoLk 15201 | Early | 200 |
| CoLk 15466 | Early | 300 |
| CoLk 15207 | Early | 300 |
| Co 05011 | Mid-late | 100 |
| CoLk 09204 | Mid-late | 500 |
| CoLk 11206 | Mid-late | 800 |
| CoLk 14204 | Mid-late | 700 |
| CoLk 12209 | Mid-late | 500 |
| **Total** | | **8050** |

## Bihar Sugarcane Breeder Seed Production Programme

Under Bihar Sugarcane Breeder Seed Production

Programme funded by Sugarcane Industries Department, Government of Bihar, IISR Regional Centre, Motipur is producing breeder seed of sugarcane varieties with different sugar mills of Bihar. This year, 17,408.55 q breeder seed of six varieties was produced at seven centres including IISR RC, Motipur which was distributed to different agencies of Bihar for foundation seed production. During 2022-23, breeder seed is being produced at four centres, *viz.*, IISR RC, Motipur, New Swadesi Sugar Mills, Narkatiaganj; Harinagar Sugar Mills, Harinagar and Tirupati Sugars Limited, Bagahain in 35 ha area. Further, a sum of ₹ 7,74,283.00 was generated as revenue from breeder seed during 2022-23 at IISR Regional Centre, Motipur.

## Breeder Seed Production Programme at Farmers field under NFSM

The Breeder Seed Production was carried out at farmers field in Bihar from 2016-17 to 2019-20 (7 ha each year) and 2020-2021 (3 ha). In 2021-22, the three-tier system for Seed Production Programme was adopted at Chakia and East Champaran (Bihar) by six farmers covering an area of 3 ha under National Food Security Mission (NFSM).

CHAPTER 2

# Natural Resource Management

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

A field experiment was planted with the 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 in sub-tropical India. The experiment comprising 12 treatment combinations was laid out in RBD with three replications under three wide row spacings (90, 120, 150 cm) and three intercrops (maize/ cowpea, garlic/ okra, and fenugreek/ onion in the plant/ ratoon cropping system) with sugarcane variety Co 0238. During the reported period, the ratoon crop was harvested, yield attributes were recorded and subsequent treatments were imposed in the field. In the autumn sugarcane ratoon crop, the number of millable cane (NMC) and sugarcane yield were higher in 90 cm and 120 cm row spacing (NMC: 61.33 thousand/ ha; cane yield: 105.30 t/ ha and 62.14 thousand/ ha, 103.17 t/ ha, respectively) in the sugarcane sole crop as compared to 150 cm row spacing (69.11 thousand/ ha, 118.66 t/ ha), however, they were non-significant. Sugarcane + onion (129.54 t/ ha) had the highest cane yield at 90 cm row spacing among the sugarcane ratoon intercropping systems, followed by sugarcane + okra (125.49 t/ ha) and sugarcane + onion (124.38 t/ ha). Similarly, these treatments recorded the highest growth characteristics as well as various yield-attributing characters. The single cane weight was in the range of 1.50 to 1.86 kg with cane length of 203 to 285 cm and an average cane diameter of 2.32 to 3.04 cm. The internode number ranged from 18.5 to 30 and the length of the internodes was in the range of 11.3 to 16.3 cm.

Thus, the autumn sugarcane-based intercropping system under wide row spacing with high-value intercrops holds more promise than sole sugarcane.

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

A field experiment was initiated in the month of June 2019 with the objective to identify the most remunerative sugarcane-based cropping system in sub-tropical India. During the reported period, the ratoon crop were harvested, yield attributes were recorded and subsequent treatments were executed in the field. The highest cane yield (85.5 t/ ha) of sugarcane ratoon crop was recorded under the Tulsi-*Stevia*-Sugarcane (spring) – Sugarcane Ratoon-Mint cropping sequence, compared to ratoon cane yield (68.8 t/ ha) under the Rice-Wheat-Sugarcane (spring) – Sugarcane Ratoon-Wheat cropping sequence.

## Developing sugarcane-based integrated farming system model for small farm holders for sub-tropical India

A sugarcane-based integrated farming system with the objective to develop integrated farming system models for small farm holders was executed. Sugarcane alone provided ₹ 2,61,100/ ha in autumn planted sugarcane based integrated farming system. Sugarcane + vegetables (garlic, fenugreek, coriander, tomato, cauliflower, spinach, carrot, fababean, and onion) fetched a net income of ₹ 3,24,400/ ha. Sugarcane + vegetables (garlic, fenugreek, coriander, tomato, cauliflower, spinach, carrot, fababean, onion) + horticultural crop (banana) + backyard poultry (Asheel, Nirbheek, Kadaknath) fetched a net income of ₹ 3,60,100/ ha. while sugarcane + vegetables (garlic, fenugreek, coriander, tomato, cauliflower, spinach, carrot, fababean, and onion) + horticultural crop (*Karonda* boundary plantation) + backyard poultry (breed Asheel, Nirbheek, Kadaknath) + fisheries (Rohu, Catla, Nain) + vermicompost (*Eucinia fotida*) + apiculture + mushroom + dairy unit (breed, Sahiwal) + dairy fetched a net income of ₹ 4,63,023/ ha, fetched additional income of ₹ 2,01,923/ ha and B:C Ratio was 3.26.

Similarly, Spring-planted sugarcane based integrated farming system, sugarcane alone gave ₹ 2,56,200/ ha. Sugarcane + vegetables (bottle gourd, sponge gourd, tomato, brinjal, pumpkin, onion,) fetched a net income of ₹ 3,25,000/ ha. Sugarcane + vegetables (bottle gourd, sponge gourd, tomato, brinjal, pumpkin, onion) + horticultural crop (banana) + backyard poultry (breeds: Asheel, Nirbheek, Kadaknath, Quail) netted ₹ 3,57,399/ ha. Sugarcane + vegetables (bottle gourd, sponge gourd, tomato, brinjal, pumpkin, onion) + horticultural crop (banana) + backyard poultry (breed- Asheel, Nirbheek, Kadaknath, Quail) + fisheries (Rohu, Catla, Nain) + vermicompost (*Eucinia fotida*) + apiculture + mushroom + dairy unit (breed- Sahiwal) fetched net income of ₹ 4,63,079/ ha, fetched additional income of ₹ 2,06,879/ ha and B:C Ratio was 3.41.

## Studies on effect of tillage and management practices on rice-wheat-sugarcane-ratoon-wheat in conservation agriculture (CA) system

A field experiment to assess the effect of conservation agriculture practices on the productivity and profitability of sugarcane-based production system and on soil quality parameters was initiated in June 2017 (first year) with the sowing of rice crop followed by wheat-sugarcane-ratoon-wheat. In main plots, four treatments *viz.* conventional tillage without crop residue; conventional tillage with crop residue incorporation; zero tillage without crop residue; zero tillage with crop residue retention and in subplots, two treatments *viz.* with and without brown manure; and in sub-sub plots, three treatments *viz.* recommended dose nitrogen of the crop (RDN); 75% of RDN and 125% of RDN. The results highlight that the crop residue management – retention and incorporation of previous crop (CRM) treatment in sugarcane crops increased cane and ratoon yields by 17% over that of without crop residue management. Zero tillage with crop residue management (ZTCRM) recorded 15.54% enhancement in sugarcane equivalent (sugarcane-based production system) yield (224.49 t/ha) over conventional tillage (194.30 t/ha) with a maximum benefit-cost ratio (2.05). ZTCRM recorded the highest increase in soil organic carbon content, infiltration rate, SMBN, SMBC, and porosity over conventional tillage. The use of brown manure improved soil quality by increasing organic carbon in the soil and reducing weed infestation. Reduction of input cost was achieved by adopting this technique. Zero-tillage saved seed rates in rice and wheat and reduced weed control due to low weed infestation in all the crops. Recycling of crop residues and brown manure improved soil health. Saving of 44 tractor hours resulted in environmental benefits.

## Synchronizing nutrient supply with crop demand under drip fertigation for up scaling nutrient use efficiency in sugarcane (plant) - ratoon system

The third ratoon crop was initiated and the treatment 100% RDF of NPK application through drip (T4) outperformed the conventional treatments in terms of tiller count at 120 and 180 DAI of the ratoon crop (26.43 and 42.66%, respectively). On a further increase of 10% RDF of NPK (T7) over T4, a non-significant increase in the number of shoots was reported. A similar trend was also reported in the case of tiller count at different stages. The 3rd ratoon cane yield (85.62 t/ha) was 139% higher in 100% RDF of NPK application *via* drip (T4) than the conventional (35.87 t/ha) method (T1). Irrespective of the treatments, there was a decrease in the cane yield in the 3rd ratoon crop over the plant crop yield (2018 planting) but the minimum decrease *i.e.* 5.8 & 11.2% was observed in T7 & T4 treatments, respectively, while the T1 & T6 gave higher yield decline to the extent of 49% & 23.12%, respectively. The cut of 25 or 50% in RDF of NPK delivered by drip-fertigation resulted in significantly higher ratoon cane yield over 100% RDF of NPK applied conventionally. In T4 treatment, 85% RDF of N & P & 26% RDF of K was given till 110 DAI (20 splits) & 74% RDF of K was delivered between 110 and 190 days stage (22 splits) and it was found to be the overall best treatment with respect to ratoon growth and yield. There was very less reduction in 3rd ratoon cane yield under drip fertigated crop (5.81 to 34.6%) over conventional methods of water and fertilizer application (49%) (Table 2.1). No significant differences were observed among treatments on juice quality parameters (brix and sucrose %). Among the split applications of different fertilizers, the effect of N was more pronounced in the growth and yield of sugarcane than in P&K splitting. Weed density was less under drip fertigation than conventional methods. T4 treatment resulted in a 21.8% lower weed dry weight than the conventional method. One replication was kept

**Table 2.1. Effect of different treatments on yield attributes and yield of sugarcane ratoon crop (3rd ratoon)**

| Treatment | Treatment | Tillers at 120 DAI/ha (000) | Tillers at 180 DAI/ha (000) | NMC (000/ha) | Yield (t/ha) | % change in yield of 3rd ratoon over plant crop |
|---|---|---|---|---|---|---|
| T1 | Conventional | 105.75 | 77.30 | 45.99 | 35.87 | - 49.00 |
| T2 | N through drip+PK basal | 108.63 | 84.85 | 61.16 | 55.66 | - 34.60 |
| T3 | NP drip+ K basal | 118.90 | 92.54 | 67.54 | 64.16 | - 24.31 |
| T4 | 100% NPK drip | 133.70 | 110.28 | 88.28 | 85.62 | - 11.21 |
| T5 | 75%NPK drip | 129.65 | 106.29 | 80.44 | 66.78 | - 12.55 |
| T6 | 50% NPK drip | 128.70 | 99.30 | 71.73 | 52.72 | - 23.12 |
| T7 | 100% NPK through drip* | 139.73 | 117.65 | 93.28 | 90.35 | - 5.81 |
| | CD (P= 0.05) | 12.57 | 9.23 | 7.73 | 8.01 | |

*10% additional NPK was applied

to study the weed infestation (weedy up to 90 DAI), which revealed that grasses became dominant over broad-leaved weeds overtime. Among grasses, *Cynodon dactylon* was more prevalent. Water requirement was 57.99% less under drip fertigation (463.92 mm) over conventional methods (800 mm).

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

**Effect of planting dates on single cane parameters and cane yield of ratoon crop:** The longest cane (2.14m) was measured in the February planted crop, followed by March (2.03 m), April (1.94m) and May (1.83 m). It was significantly longer than the March, April and May planted crops. March planted crop had higher cane heights than April and May planted. The thickest cane (22.14 mm) was also found in February planting, which was statistically superior to April and May planting but similar to March planting. The thinnest cane (20.28 mm) was obtained from May planted crop. Similar trends were also observed in cane weight, with the heaviest cane (0.87 kg) recorded in February planting and the lightest cane (0.64 kg) from May planting. In fertilizer application treatments, the longest cane (1.99 m) was obtained from both the applications, *i.e.*, NPK through soil test crop response (STCR) with an integrated plant nutrient system (IPNS) and NPK through soil test crop response (STCR) without an integrated plant nutrient system (IPNS). The thickest cane (1.99 m) was recorded in NPK by using STCR with IPNS, which was significantly higher than the recommended NPK fertilizer application. A slightly higher cane weight was recorded in NPK through STCR without IPNS (0.78 kg), followed by NPK through STCR with IPNS. Similar trends were also observed in case of NMC. However, planting dates have a significant effect on the number of millable canes and its yield of cane crops. February planted cane had the highest number of NMC (148796), followed by March, April, and May planted cane. The cane planted in February were significantly higher than the cane planted in March, April, and May, whereas March planting was statistically superior to April and May planting, which was comparable.

The highest cane yield was obtained in the February plant crop (87.8 t/ha) which was statistically higher than the March (82.3 t/ha), April (52.2 t/ha), and May (49.2 t/ha) crop (Table 2.2). The higher cane yield in February planted crop is due to higher length, girth, the weight of single cane, and higher NMC. Regarding fertilizer application, the highest yield (69.2 t/ha) was obtained in NPK through using STCR without IPNS followed by NPK through using STCR with IPNS (68.5 t/ha). The least yield (65.9 t/ha) was recorded in recommended NPK. The fertilizer treatments did not differ significantly.

**Effect of integrated weed management and planting dates on cane yield of ratoon crops:** The treatment T4 (108.3 t/ha), which included Atrazine 2,000 g/ha applied as a pre-emergence herbicide, Ametryn 1,500 g/ha applied as a post-emergence herbicide, and 2,4-D @ 725 g/ha applied as a post-emergence herbicide during February and March-initiated ratoon was found to be the most effective in the present weed control study. The yield of ratoon initiated in March (96.9 t/ha), April (81.7 t/ha), and May (66.1 t/ha) was higher in the T4 treatment than in the other treatments. The lowest yield was found in T1 (91.6 t/ha) treatment. The combining of pre-emergence and post-emergence weedicide application yielded better results than either pre-emergence or post-emergence herbicide application alone. Hand weeding alone also did not yield significant results. The trash mulching in addition to herbicide application produced better results in all four months of ratoon initiation (Table 2.3).

**Table 2.2. Effect of planting dates on single cane growth parameters and cane yield of ratoon crop**

| Main Plot (Planting date) | Length (m) | Girth (mm) | Weight (kg) | NMC (ha) | Yield (t/ha) |
|---|---|---|---|---|---|
| February | 2.14 | 22.14 | 0.87 | 148796.3 | 87.8 |
| March | 2.03 | 21.82 | 0.82 | 133703.7 | 82.3 |
| April | 1.94 | 20.89 | 0.69 | 111296.3 | 52.2 |
| May | 1.83 | 20.28 | 0.64 | 107777.8 | 49.2 |
| SEm ± | 0.01 | 0.33 | 0.02 | 3579.9 | 3.7 |
| CD (P=0.05) | 0.05 | 1.16 | 0.06 | 12629.0 | 13.2 |
| **Sub Plot** | | | | | |
| Recommended NPK | 1.98 | 20.71 | 0.74 | 124861.1 | 65.9 |
| NPK through using STCR Without IPNS | 1.99 | 21.24 | 0.78 | 128680.6 | 69.2 |
| NPK through using STCR With IPNS | 1.99 | 21.89 | 0.74 | 122638.9 | 68.5 |
| SEm ± | 0.03 | 0.27 | 0.03 | 3996.8 | 2.7 |
| CD (P= 0.05) | NS | 0.80 | NS | NS | NS |

**Table 2.3. Effect of planting dates on single cane parameters and cane yield of ratoon crop**

| Sr no. | Treatment | Yield (t/ha) | | | |
|---|---|---|---|---|---|
| | | February | March | April | May |
| 1 | T1 Control | 91.6 | 78.3 | 65.6 | 59.7 |
| 2 | T2 Flumioxazin 50 100 g/ha (Pre) *fb* trash mulching | 100.2 | 89.4 | 70.6 | 63.0 |
| 3 | T3 Flumioxazin 100 g/ha *fb* 2,4-D 725 g/ha + Halosulfuron 67.5 g/ha (Post) | 102.8 | 93.0 | 73.0 | 65.0 |
| 4 | T4 Atrazine 2,000g/ha (Pre) *fb* Ametryn 1,500 g/ha + 2,4-D 725 g/ha (Post) | 108.3 | 96.9 | 81.7 | 66.1 |
| 5 | T5 Ametryn 1,500 g/ha (Pre) *fb* SL 160 60 g/ha (Post) | 100.0 | 89.2 | 77.2 | 63.6 |
| 6 | T6 Trash mulching alone @ 10 t/ha | 96.0 | 85.0 | 70.8 | 59.4 |
| 7 | T7 Metribuzine 750 g/ha (Pre) *fb* Trash mulching | 100.8 | 85.8 | 78.6 | 61.1 |
| 8 | T8 Trash mulching (10 t/ha) *fb* 2,4-D 725 g/ha + Ametryn 1,500 g/ha (Post) | 101.4 | 88.6 | 78.9 | 66.4 |
| 9 | T9 Trash mulching *fb* 2,4-D 725 g/ha + halosulfuron 67.5 g/ha (Post) | 101.7 | 87.2 | 68.6 | 65.6 |
| 10 | T10 Hand weeding (at 30, 60 and 90 days after ratoon initiation) | 100.8 | 84.4 | 67.2 | 65.6 |

*fb* = followed by

## Improving soil health and sugarcane ratoon productivity through the application of microbial consortia

A field experiment was initiated during 2019-20 to assess the effectiveness of various microbial cultures in increasing ratoon cane productivity and the effect of microbial cultures on soil quality parameters in multi-ratooning systems. The experiment comprising of 14 treatments in combination with three nutrient management levels (RDF 75% (N1), RDF 50% (N2) and organic FYM @ 15 t/ha (N3) and four levels of microbial consortia (M1: Microbial culture of N + P + K + Zn + S + Fe; M2: Microbial culture of N + P + K + Zn + S; M3: Microbial culture of N + P + K + Zn; M4: Microbial culture of N + P + K) along with one absolute control (0 kg/ha) and one 100% RDF (only chemical fertilizers) was laid out in RBD with three replications in plant crop (cv. CoLk 09204). The second ratoon crop was initiated on February 1, 2021, and treatments were allocated as per the experiment's protocol. Nutrient management levels significantly affected the second ratoon cane yield. RDF at 75% (N1) recorded the highest cane yield (82 t/ha) and sugar yield (9.49 t/ha) significantly compared to 50% RDF (N2) and FYM application @ 15 t/ha (N3). The difference between 50% RDF (N2) and FYM application (N3) was found non-significant. The 75% RDF combined with microbial consortia superseded the cane yield and sugar yield compared to 100% RDF. Microbial consortia M1 (79.6 t/ha) and M2 (79.3 t/ha) being at par produced higher cane yield but were significantly different from M3 (74.9 t/ha) and M4 (72.9 t/ha). Nutrient management and microbial consortia did not show an interaction effect. RDF at 100% (C2) significantly increased the yield by 22.2% over absolute control C1 (59.1 t/ha). Microbial consortia did not significantly affect growth and quality parameters, being at par among all cultures. However, M1 and M2 showed higher values compared to M3 and M4, which are on par with each other. The higher mean values of soil total bacteria count, soil respiration, SMBC, and soil enzymatic activity of dehydrogenase and amylase were recorded at all the growth stages with FYM application @ 15 t/ha (N3), closely followed by 75% RDF and 50% RDF in combination with microbial consortium treatments. Application of microbial consortia under different levels of nutrient management registered higher levels of organic and phosphorus content compared to 100% RDF without microbial consortia (C2). On an average, the cane yield level of the second ratoon crop decreased by 13.5% as compared to the first ratoon crop. The microbial consortium in combination with chemical fertilizer improved growth and yield.

## Soil test and resource based integrated plant nutrient supply system for sustainable sugarcane production

### Development of targeted yield equations

In order to create targeted yield equations for spring-planted sugarcane (variety CoLk 94184) that can be used to suggest balanced fertilization in alluvial soil under sub-tropical conditions, an experiment was started in 2022. Results showed that low fertility gradient treatments (ST-I) recorded the lowest tillering (at 150 and 180 DAP), shoot counts, and NMC (Table 2.4), while high fertility gradient treatments recorded the highest levels of these traits (ST-III). Germination was high in low fertility gradient treatments (ST-I).

### Verification of universal targeted yield equations

During February 2022, an experiment was carried out using CoLk 94184 to validate the universal targeted yield equations (FN = 5.86T 1.51SN 0.44ON, $FP_2O_5$ = 1.04T 2.44SP 0.32OP, and $FK_2O$ = 2.66T 0.74SK 0.26OK) developed during 2020-2021 for spring-planted alluvial soils of sub-tropical conditions. All the

**Table 2.4. Effect of different fertility gradient on germination, growth and yield attributes**

| Treatment | Germination (%) | Tillering at 150 DAP (000/ha) | Tillering at 180 DAP (000/ha) | Shoot counts ($10^3$/ha) | NMC ($10^3$/ha) |
|---|---|---|---|---|---|
| ST-I (0:0:0:: kg N, $P_2O_5$: $K_2O$/ha) | 37.9 | 96.0 | 112.6 | 104.6 | 97.6 |
| ST-II (150:60:60:: kg N, $P_2O_5$: $K_2O$/ha | 36.7 | 134.4 | 139.7 | 124.2 | 116.8 |
| ST-III (300:120:120:: kg N, $P_2O_5$: $K_2O$/ha | 36.2 | 142.4 | 144.6 | 131.7 | 118.6 |

treatments recorded significantly higher growth and yield attributes than the control. Balanced fertilizer application based on soil test values improved growth and yield attributes over RDF to achieve a targeted yield of 100 and 120 t/ha with and without FYM. The highest counts of tillers, shoots, NMC, leaf area index and chlorophyll contents were recorded in targeted yield (T4 and T5) treatments than in RDF (T3). The use of FYM in conjunction with balanced mineral fertilizers to achieve the desired yields of 100 and 120 t/ha (T7 and T8) resulted in improved growth and yield characteristics (Table 2.5). However, balanced fertilization had no significant effect on germination.

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

A project was initiated on developing scientific aids for site-specific nutrient management through variable mapping of soil properties in sugarcane growing soils at ICAR-IISR, Lucknow. In this study, geostatistical analysis was performed using data on various soil properties by following the ordinary Kriging method. The best-fit semivariogram models were selected to develop ICAR-IISR research farm spatial distribution maps for various soil properties. The results of the analysis revealed the pentaspherical semivariogram model to be the best-fit for the development of a spatial distribution map for soil pH. The k-bessel semivariogram model was found to be the best for electrical conductivity, and J-bessel for soil organic carbon and iron. The best-fit for the spatial mapping of available nitrogen was found to be an exponential semivariogram model. A rational-quadratic semivariogram model was found to be the best for available phosphorus and copper mapping. Similarly, circular, hole effect, and Gaussian semivariogram models were found best-fit for the development of spatial distribution maps of available sulfur, zinc, and manganese, respectively. The above models, which were found to be the best-fit for the spatial mapping of soil properties at the ICAR-IISR research farm, showed weak to strong spatial dependence. Based on the best-fit semivariogram models, spatial distribution maps of soil pH, electrical conductivity, organic carbon, available NPK, sulphur and micronutrients (zinc, copper, iron, and manganese) were developed for the research farm of ICAR-IISR at Lucknow.

Kharika research farm of ICAR-IISR, Lucknow was geo-referenced for site specific nutrient management through variable mapping of soil properties.

For grid-based soil sampling, the entire Kharika research farm was sub-divided into 50 x50 meter grids. The central point of each grid was considered the soil sample collection point. Following this method, total 212 soil samples were collected. Out of the total soil samples collected, 106 soil samples were from surface (0-15 cm soil depth) layer of soil and equal number were from sub-surface (15-30 cm soil depth) layer of the soil. The grid-based, soil samples collected were processed and analysed for various physico-chemical soil properties. Results of the soil analysis revealed that overall, the soils of the Kharika farm were neutral in soil

**Table 2.5. Effect of different treatments on growth and yield attributes of spring planted plant crop (2022-23)**

| Treatment | Germination (%) | Tillering at 150 DAP (₹000/ha) | Shoot counts ($10^3$/ha) | LAI at 180 DAP | Chlorophyll content at 180 DAP (mg/g fresh weight) | | | NMC ($10^3$/ha) |
|---|---|---|---|---|---|---|---|---|
| | | | | | a | b | total | |
| $T_1$- Control | 34.4 | 128.9 | 108.6 | 3.78 | 2.69 | 1.22 | 3.92 | 101.0 |
| $T_2$- FYM @ 10 t/ha | 37.9 | 136.9 | 114.5 | 4.01 | 2.75 | 1.28 | 4.04 | 106.5 |
| $T_3$- RDF | 35.3 | 143.4 | 118.1 | 4.09 | 2.84 | 1.32 | 4.17 | 109.8 |
| $T_4$- TY 100 t/ha | 36.9 | 147.3 | 127.3 | 4.34 | 2.96 | 1.40 | 4.36 | 118.4 |
| $T_5$- TY 120 t/ha | 37.8 | 156.4 | 129.5 | 4.55 | 3.02 | 1.59 | 4.61 | 120.4 |
| $T_6$- RDF + FYM | 36.6 | 151.3 | 123.0 | 4.24 | 2.88 | 1.40 | 4.29 | 114.3 |
| $T_7$- TY 100 t/ha + FYM | 35.1 | 159.9 | 130.9 | 4.45 | 2.99 | 1.51 | 4.49 | 121.8 |
| $T_8$- TY 120 t/ha + FYM | 36.8 | 164.0 | 137.6 | 4.64 | 3.06 | 1.87 | 4.93 | 128.0 |
| SEm ± | 1.31 | 6.67 | 2.96 | 0.13 | 0.07 | 0.10 | 0.12 | 2.70 |
| CD (P=0.05) | NS | 20.5 | 9.08 | 0.40 | 0.21 | 0.31 | 0.36 | 8.25 |

reaction and normal in salinity (electrical conductivity < 0.5 dS/m). A wide variation was found in soil organic carbon content, ranging from low to very high. The status of available nitrogen ranged from low to medium. However, the available phosphorus varied from low to very high. The available potassium content in soil varied from medium to very high. A widespread sulphur nutrient deficiency was found in the soils of the Khanka research farm. The DTPA extractable micronutrients *viz.*, zinc, copper, iron and manganese were found adequate in research farm soils. However, few soil samples exhibited iron nutrient deficiency. The soil analysis data of sub-surface soil showed lower nutrient availability as compared to the surface soil. However, soil pH was found higher in sub-surface soil as compared to the surface soil.

## Effect of silicon nutrition on growth, yield, juice and soil quality of sugarcane in subtropics

A field experiment was carried out with the objective to assess the available silicon in sugarcane-growing soils and to find out the suitable source and optimum dose of silicon for enhancing sugarcane productivity. The experiment consisted of 10 treatments *viz.*, T1 - Control (No silicon application), T2 - Silicon @ 200 kg/ha through bagasse ash, T3 - Silicon @ 400 kg/ha through bagasse ash, T4 - Silicon @ 600 kg/ha through bagasse ash, T5 - Silicon @ 800 kg/ha through bagasse ash, T6 - Silicon @ 200 kg/ha through diatomaceous earth, T7 - Silicon @ 400 kg/ha through diatomaceous earth, T8 - Silicon @ 600 kg/ha through diatomaceous earth, T9 - Silicon @ 800 kg/ha through diatomaceous earth and T10 - 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. On February 25, 2021, the experimental crop (second plant crop) of the variety CoLk 09204 was planted with a row-to-row spacing of 75 cm. At the proper soil moisture, the treated three-bud setts were used to plant the crop. The experimental findings showed that tillering, NMC, cane length and cane yield indicated significant variations among the treatments (Table 2.6). Though numerically highest values of the above parameters were noted under the effect of silicon application @ 800 kg/ha, the difference was found to be significant only up to the level of 400 kg/ha of silicon application. Tiller formation and the number of millable canes (NMC) increased significantly, up to 400 kg/ha of silicon application and control compared to 200 kg/ha of silicon application and control. More or less, a similar pattern was observed in cane length under different treatments. The cane yield increased significantly with increasing levels of silicon up to 400 kg/ha but was at par with the yield levels recorded under higher levels of silicon application. The foliar spray of 2.5% potassium silicate at 60, 90 and 120 DAP showed a significant variation in cane yield to control. Among different sources of silicon, diatomaceous earth exhibited numerically better performance compared to bagasse ash and significantly superior to the foliar spray of potassium silicate and control.

During the year (2021–22), the performance of the first ratoon crop as influenced by various treatments was assessed. The ratoon was initiated in March 2021. Application of silicon up to the level of 400 kg/ha resulted in a significant improvement in the yield-attributing characteristics and yield of the ratoon sugarcane crop (Table 2.7). Application of silicon through diatomaceous earth exhibited a better response on sugarcane compared to other sources of silicon tested in the study. It was also discovered that the ratoon sugarcane crop produced more than the plant crop.

**Table 2.6. Number of tillers, NMC, cane length and cane yield as influenced by source and dose of silicon (2nd plant crop)**

| Treatment | Tiller no. (000/ha) | NMC (000/ha) | Cane length (cm) | Yield (t/ha) |
|---|---|---|---|---|
| Control (No silicon application) | 90.36 | 87.04 | 245.69 | 81.12 |
| Silicon @ 200 kg/ha through bagasse ash | 98.06 | 94.01 | 253.10 | 87.71 |
| Silicon @ 400 kg/ha through bagasse ash | 105.61 | 99.26 | 259.02 | 92.81 |
| Silicon @ 600 kg/ha through bagasse ash | 107.39 | 100.38 | 261.68 | 94.56 |
| Silicon @ 800 kg/ha through bagasse ash | 108.60 | 100.75 | 264.30 | 96.12 |
| Silicon @ 200 kg/ha through diatomaceous earth | 98.52 | 94.89 | 255.20 | 88.62 |
| Silicon @ 400 kg/ha through diatomaceous earth | 106.61 | 99.95 | 260.61 | 94.16 |
| Silicon @ 600 kg/ha through diatomaceous earth | 108.23 | 100.54 | 263.18 | 95.81 |
| Silicon @ 800 kg/ha through diatomaceous earth | 112.30 | 101.36 | 267.17 | 96.81 |
| Foliar spray of 2.5 % Potassium silicate at 60, 90 and 120 DAP | 96.91 | 95.73 | 257.11 | 89.51 |
| SEm ± | 2.40 | 1.67 | 3.68 | 1.67 |
| CD (P=0.05) | 7.27 | 4.98 | 11.01 | 5.01 |

**Table 2.7. Number of tillers, NMC, cane length and cane yield as influenced by source and dose of silicon (1st ratoon crop)**

| Treatment | Tiller no. (000/ha) | NMC (000/ha) | Cane length (cm) | Yield (t/ha) |
|---|---|---|---|---|
| Control (No silicon application) | 164.18 | 84.90 | 218.57 | 68.17 |
| Silicon @ 200 kg/ha through bagasse ash | 177.36 | 92.26 | 230.11 | 74.36 |
| Silicon @ 400 kg/ha through bagasse ash | 199.61 | 98.64 | 241.31 | 79.60 |
| Silicon @ 600 kg/ha through bagasse ash | 209.79 | 100.15 | 247.08 | 81.12 |
| Silicon @ 800 kg/ha through bagasse ash | 219.38 | 100.88 | 250.13 | 82.12 |
| Silicon @ 200 kg/ha through diatomaceous earth | 182.28 | 93.37 | 231.17 | 75.30 |
| Silicon @ 400 kg/ha through diatomaceous earth | 204.17 | 99.90 | 244.12 | 80.82 |
| Silicon @ 600 kg/ha through diatomaceous earth | 216.12 | 100.30 | 249.70 | 81.45 |
| Silicon @ 800 kg/ha through diatomaceous earth | 227.98 | 101.23 | 252.13 | 82.60 |
| Foliar spray of 2.5 % Potassium silicate at 60, 90 and 120 DAP | 182.60 | 93.93 | 232.03 | 75.80 |
| SEm ± | 4.30 | 2.04 | 4.95 | 1.71 |
| CD (P=0.05) | 12.88 | 6.12 | 14.83 | 5.12 |

## Management of bioresources for enhancing sugarcane productivity and soil health

The present study was undertaken to work out the efficacy of oligochitosan (Bio stimulator) and other bioresources and their integration into sugarcane productivity and soil health. The experiment was conducted with 12 different treatment combinations *viz.*, T1: 100% N:P:K (Control), T2: 75% N:P:K (Control), T3: T1 + Use of Bio stimulator derivative-drenching @ 2.5 ml/l of water *, T4: T3 + drenching (*Gluconacetobacter diazotrophicus*), T5: T4 + drenching (*Bacillus subtilis*), T6: T5 + drenching (*Bacillus cereus*), T7: T6 + foliar application of $GA_3$ @ 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 (*Gluconacetobacter diazotrophicus*), T10: T9 + drenching of (*Bacillus subtilis*), T11: T10 + drenching of (*Bacillus cereus*), T12: T11 + foliar application of $GA_3$ @ 35 ppm at 90, 120 and 150 DAP. The design of the experiment was RBD with three replications. At nutshell, treatment T7 (100% N.P.K. + use (drenching) of Bio stimulator derivative @ 2.5 ml/l of water + drenching with *Gluconoacetobacter diazotrophicus* + drenching with *Bacillus subtilis* and *Bacillus cereus* and foliar application of $GA_3$ @ 35 ppm at 90,120 and 150 DAP) was found the best treatment for cane yield (73.64 t/ha) and significantly influenced 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 also followed similar trends. The initial soil analysis was also done for chemical and biological properties of soil and values for 0-15 cm depth and results were as follows: Organic Carbon- 0.59%, pH-7.73, ECe-0.12/m, N-254.01 kg/ha, $P_2O_5$-29.12 kg/ha, $K_2O$-202.16 kg/ha. However, at 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 were bacteria-$8.8\times10^5$, actinomyces-$3.74\times10^4$, fungi-$9.31\times10^4$.

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

The jute grafted silica rings were synthesized by hydrolysis of silane in the presence of jute fibre as the template, which resulted in the intermediate having a tubular silica coating on the fiber. Thus, synthesized silica-coated jute fibre was ball milled to get the uniform jute grafted silica ring. Following the synthesis of the jute grafted silica ring, their suitability for coating was studied using protein as the binder. The importance of flexibility and hydrophobicity has been highlighted here. Young's moduli of the material were measured for flexibility quantification (Fig. 2.1). The jute-stuffed silica ring with the protein gave higher Young's moduli, compared to jute and protein; silica and protein; jute and silica. These preliminary findings suggest that the composite coating will provide a stable and strong shield for transport, storage, and controlled release. Since Young's moduli of the urea coated with silica and protein are not satisfactory, further studies were limited to urea coated with jute grafted silica ring and protein. Aside from stability, the coating material should also provide hydrophobicity to the urea pellet, as a quick release is a major issue that leads to poor N-use efficiency in urea. The hydrophobicity of the coating was measured using the contact angle measurement. The coating material shows the contact angle to raise from 106° in the raw jute fibre to 114° in the jute grafted silica ring to 144° in the final composite (Fig. 2.1). To understand the reason behind the increase in the contact angle, the surface roughness of the film was measured with the AFM. This showed a steady decrease in roughness from the raw jute to the jute grafted silica and the final coating of jute-grafted silica + protein, hence, the increase in the smoothness may be the reason for the increase in the hydrophobicity. Another reason for the increase in the hydrophobicity might be the protein assembly, especially when they form β-sheets, the protein is known to have more hydrophobicity.

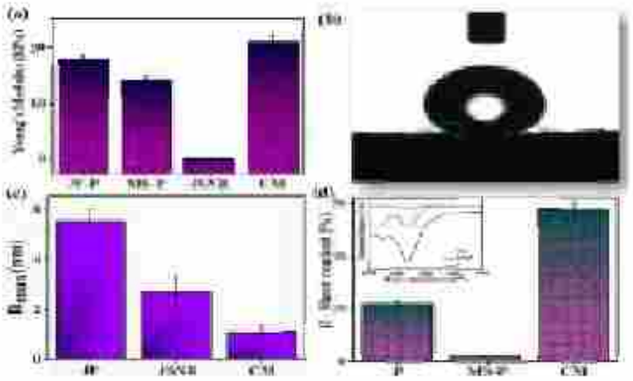


**Fig. 2.1 Graph showing the young's modulus of jute fiber with protein (JF-P), silica with protein (MS-P), jute grafted silica nano-ring (JSNR), and coating material (CM), (b) image showing the water contact angle of coating composite, graphs showing (c) roughness ($R_{max}$) of jute fiber (JF), jute grafted silica nano-ring (JSNR) and coating material (CM), (d) $^2$-sheet content of protein (P), silica with protein (MS-P) and coating material (CM).**

The SEM morphology of the sample with and without coating was captured (Fig. 2.2). The surface of the urea pellet without the nanocomposite coating is rough and porous, whereas the surface of the urea pellet with the nanocomposite coating is smooth. Further, the cross-section of the coated pellet with different coating material percentages shows a significant change in the size of the coating thickness. Thus, the coating thickness in CU14, CU9, and CU4 has been observed to be 326, 292, and 215 µm, respectively, which clearly shows that the thickness is proportional to the coating amount used.

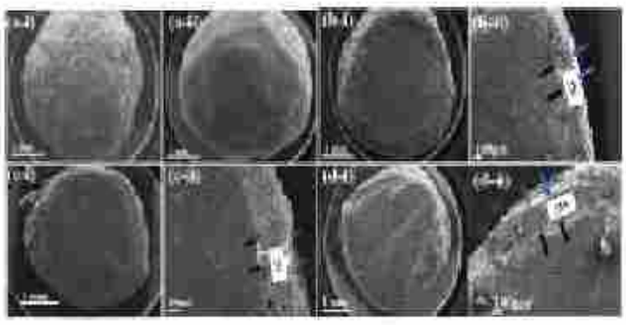


**Fig. 2.2. SEM images showing the surface morphology of uncoated and coated urea pellets (a-i, ii), respectively, SEM images (b-i, b-ii), (c-i, c-ii) and (d-i, d-ii) showing cross-section morphology and coating thickness of CU14, CU9, and CU4, respectively.**

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

A field experiment was carried out with the objective to develop feasible technology to improve the sugarcane ratoon productivity, profitability and sustainability in multiple ratooning systems, with the application of sugarcane bagasse ash (SBA), sulphitation press mud cake (SPMC), brown manure, and potassium silicate. The experiment consisted of 10 treatments in the main plot (nutritional management) with five treatments *viz.* N1: recommended practices of ratoon management, N2: N1 +300 kg $Si$/ha through SBA, N3: N2 +500 kg SPMC, N4: N3 + foliar spray of 2.5 % potassium silicate at 0, 30 and 60 days of ratoon initiation and N5 : N4+ brown manuring of *Sesbania* at ratooning. In sub-plot, two treatments as dates of sugarcane ratoon initiation *viz.* D1: 15 December & D2: 15 February. The experiment was initiated with ratoon initiation on December 2021 and February 2022. Treatments were given as per schedule. The first ratoon was harvested as per D1 on 15$^{th}$ December 2022 and the rest ratoon will be harvested as per D2 treatment on 15$^{th}$ February 2023. Second year experiment was initiated on October 2022 as per schedule.

## 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, the performance of the first spring-planted sugarcane crop as influenced by various treatments was assessed. The crop was planted with the help of a sugarcane trench planter on Febraury 12, 2021 after laser levelling the experimental field and pre-sowing irrigation and was harvested in February 2022. The experimental field was made-up of 7m x 6m plots planted with four paired rows of sugarcane in a 150:30 configuration, and the trenches formed remained intact for applying irrigation treatments until monsoon season arrived. Earthing up during the rainy season resulted in trench formation in the inter-row spaces that were used for post-monsoon irrigation treatments. The crop was given general irrigation at 30 DAP, and thereafter an irrigation schedule was adopted as per the technical programme. The experiment consisted of maintaining irrigation regimes (03) based on IW/CPE ratios 1.0, 0.8, and 0.6 with an 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. The quantity of water applied to every plot for each irrigation was measured with the help of a water meter. Irrigation

**Table 2.8. Effect of different irrigation regimes and moisture management practices on sugarcane growth and yield**

| Treatment | Tiller no. (000/ha) | | NMC (000/ha) | Cane length (cm) | Single cane wt (kg) | Cane yield (t/ha) |
|---|---|---|---|---|---|---|
| | 135 DAP | 225 DAP | | | | |
| **Irrigation regime** | | | | | | |
| I1: 1.0 | 197.73 | 115.89 | 115.15 | 203.02 | 0.83 | 86.23 |
| I2 0.8 | 192.93 | 120.06 | 108.02 | 201.57 | 0.83 | 87.25 |
| I3 0.6 | 197.62 | 120.56 | 101.33 | 189.23 | 0.76 | 80.02 |
| CD ($P=0.05$) | NS | NS | 5.23 | 7.32 | 0.04 | 3.30 |
| **Moisture management** | | | | | | |
| Flooding without mulch | 183.09 | 114.88 | 104.67 | 203.77 | 0.791 | 86.70 |
| Flooding with mulch | 207.11 | 124.49 | 108.62 | 205.28 | 0.851 | 88.11 |
| Trench irrigation without mulch | 192.61 | 119.81 | 113.73 | 193.44 | 0.789 | 84.57 |
| Trench irrigation with mulch | 199.54 | 116.82 | 106.58 | 208.51 | 0.887 | 87.17 |
| Alternate trench without mulch | 191.21 | 120.28 | 108.75 | 187.06 | 0.782 | 78.34 |
| Alternate trench with mulch | 203.02 | 116.74 | 106.66 | 189.57 | 0.778 | 82.12 |
| C D (P= 0.05) | 11.23 | 06.54 | 4.65 | 11.23 | 0.025 | 2.60 |

regimes were laid to main plots and moisture management practices were allotted to sub-plots. A strip plot design with three replications was adopted. The crop was harvested in February 2022 and the ratoon crop was initiated with similar treatments and an observation schedule. Data collected and analysed throughout the year show that irrigating sugarcane at an IW/CPE ratio of 0.8 was the most efficient for the water economy and increases water productivity in sugarcane with little yield penalty (Table 2.8). Irrigation in trenches or furrows was found to be as effective as flooding in producing a comparable yield while saving a significant amount of irrigation water. The highest water productivity was obtained with alternate trench irrigation at subsequent irrigations, however, with a yield penalty (Table 2.9). Mulching was the most effective when irrigation was applied in trenches or alternate trenches. The water footprint of spring-planted sugarcane in sub-tropics was in the range of 118–130 L/kg depending on the irrigation regime and moisture management practices. The blue water footprint of sugarcane was around 10% of the total water footprint in sub-tropics.

## Evaluation of sugarcane varieties for drought tolerance

This experiment was conducted under the AICRP on Sugarcane at ICAR-IISR, Lucknow Research Farm, with the objective of identifying drought tolerant varieties suitable for specific agro-climatic conditions. The experiments were initiated during the spring season in three years 2019-20, 2020-21, and 2021-22. The experiment comprising 12 treatment combinations was laid out in a strip plot design with three replications. Three early maturing varieties, *viz.*: CoPk 05191, CoLk 94184, and CoLk 9709, and three mid-late maturing varieties, *viz.*, CoLk 09204, CoLk 11206, and CoS 08279 (total 6 varieties), and two irrigation scheduling as strip treatments, *viz.*, irrigation scheduling at IW/C.P.E. ratios of 1.0 (IS 1) and 0.3 (IS 0.30). Each irrigation time, the crop was irrigated 7.5 cm deep. Irrigation treatment was started 50 days after the planting of sugarcane. Among the six varieties of sugarcane, CoPk 05191 produced the highest NMC, cane girth, sugarcane yield, juice extraction percentage, and CCS t/ha, which may be due to the production of higher root dry weight, LAI and

**Table 2.9. Effect of irrigation regimes and moisture management practices on water productivity of spring planted sugarcane in sub-tropics**

| Treatment | IW (mm) | Rain (mm) | Total (mm) | WP Irrigation water (L/kg) | WP Total (L/kg) |
|---|---|---|---|---|---|
| **Irrigation regime** | | | | | |
| I1 | 631 | 1088.8 | 1719.8 | 72.7 | 198.15 |
| I2 | 591.2 | 1088.8 | 1680 | 67.75 | 192.55 |
| I3 | 449.3 | 1088.8 | 1538.13 | 56.14 | 192.21 |
| **Moisture management** | | | | | |
| M1 | 693.66 | 1088 | 1781.66 | 79.00 | 205.58 |
| M2 | 686.33 | 1088 | 1774.33 | 79.13 | 201.46 |
| M3 | 557 | 1088 | 1645.00 | 65.36 | 194.60 |
| M4 | 540.33 | 1088 | 1628.33 | 61.98 | 186.84 |
| M5 | 439.66 | 1088 | 1527.66 | 56.12 | 195.10 |
| M6 | 426 | 1088 | 1514.00 | 51.87 | 184.46 |

average cane weight. The minimum reduction in sugarcane yield was to the tune of 10.76-13.96% with treatment IS 0.30 over treatment IS 1.0 with variety CoPk 05191, followed by variety CoLk 11206, which was at par with CoLk 94184 (15.19-16.8%).

## Biology and management of binding weed *Ipomoea* spp. in sugarcane

A pot experiment on the growth behaviour of *Ipomoea* spp. comprising of *Ipomoea hederifolia, I. triloba* and *I. nil* was conducted during the summer season of 2021-22. Results revealed that all the species of *Ipomoea* undertaken in the study significantly differed with respect to plant height, root length, number of leaves/plant, stem and root dry biomass *etc. Ipomoea hederifolia* and *I. triloba* had significantly higher plant height and root length than *I. nil*. However, significantly higher stem, root, and leaf dry biomass were recorded with *I. triloba* over the other two prevalent species of morning glory. The highest number of leaves/plants was recorded with *I. hederifolia*. Among different species of prevalent morning glory, *I. nil* had lesser growth with respect to plant height, root length, number of leaves/plant, stem and root dry biomass, indicating weaker competitor species with sugarcane crops. The findings of this study showed that two species of morning-glory *I. hederifolia* and *I. triloba* may exert more competition with sugarcane crop, hence necessating their management well in time to avoid yield losses.

## ICAR-ISR Lucknow and ICAR-CAZRI, Jodhpur (Rajasthan) Collaborative Project

### Efficacy and evaluation of potassic organo mineral fertilizer (OMF) in sugarcane crop

A field trial to assess the potassic organo-mineral fertilizer (OMF) in sugarcane crop was initiated during the spring of 2020 as a collaborative project with ICAR-CAZRI, Jodhpur. The OMF contains 10% K using feldspar, developed by ICAR-CAZRI, Jodhpur. The release of potassium from it is gradual and slow over the crop growth period of the sugarcane crop. The treatments were imposed on the first ratoon crop, initiated in spring 2021 and harvested in January 2022. The experiment comprised ten treatments in a randomized block design with three replications in different combinations of MOP, OMF, and FYM with 50 and 75% recommended levels of potash. Potassium through muriate of potash (MOP) registered higher cane diameter (2.27 cm), NMC (116.5 thousand/ha), and single cane weight (0.975 kg), resulting in significantly highest cane yield (92.7 t/ha), closely followed by OMF (99.7 t/ha) at 100% of recommended K. Significantly, cane yield increased with increasing levels of potassium, being at par with 75 and 100% of K levels (Table 2.10). K through MOP recorded higher cane and sugar yields, being at par with OMF at 50, 75, and 100% of the recommended level of potassium. MOP increased the cane yield compared to OMF at different levels of K. The

**Table 2.10. Effect of irrigation treatments on sugarcane yield**

| Treatment | Yield (t/ha) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Plant crop | 4th ratoon | 5th ratoon | 6th ratoon | 7th ratoon | 8th ratoon | 9th ratoon | Average |
| T1 Planting at 75 cm row to row distance with Surface irrigation & recommended fertilizers application in soil | 65.29 | 45.07 | 55.58 | 30.98 | 35.25 | 45.99 | 36.30 | 41.53 |
| T2 Planting at 75 cm row to row and at alternate row drip irrigation-fertigation | 74.37 | 73.00 | 82.32 | 56.66 | 62.99 | 67.25 | 47.00 | 64.87 |
| T3 Paired row planting under 40×110 ×40 cm with drip irrigation-fertigation. | 81.62 | 64.49 | 77.01 | 60.98 | 61.68 | 69.78 | 39.43 | 62.23 |
| T4 Paired row planting under 45×135 × 45 cm with drip irrigation-fertigation. | 71.68 | 64.98 | 66.71 | 61.30 | 62.36 | 68.16 | 47.36 | 61.82 |
| T5 Paired row planting under 60×120 ×60 cm with drip irrigation-fertigation | 82.40 | 78.94 | 68.06 | 63.50 | 61.06 | 69.51 | 43.99 | 64.18 |
| T6 Paired row planting under 40×110 × 40 cm with Sub-surface drip irrigation-fertigation | 80.48 | 70.71 | 79.46 | 61.57 | 61.79 | 65.13 | 45.44 | 64.02 |
| T7 Surface drip in Ring- pit planting method (105×75cm) with drip irrigation-fertigation | 88.78 | 85.91 | 89.72 | 65.08 | 66.39 | 71.63 | 46.62 | 70.89 |
| T8 Planting at 90 cm row to row distance with Surface irrigation & recommended fertilizers application in soil | 67.09 | 44.24 | 44.54 | 37.49 | 32.57 | 42.43 | 35.06 | 39.39 |
| Average for drip irrigated crop | 79.89 | 73.01 | 77.21 | 61.52 | 62.72 | 68.58 | 44.97 | 64.67 |
| Average for surface irrigated crop | 66.19 | 44.66 | 50.06 | 34.24 | 33.91 | 44.21 | 35.68 | 40.46 |
| SE± | 1.44 | 2.72 | 0.74 | 1.55 | 1.40 | 1.20 | 1.47 | |
| CD, 0.05 | 2.53 | 4.80 | 1.30 | 2.72 | 2.46 | 2.12 | 2.58 | |

lowest cane yield and attributes were noticed in absolute control (69.8 t/ha). When compared to only N and P application, potassium application, either through MOP or OMF, improved cane and sugar yield. The results revealed that K application through potassic organo-mineral fertilizer (OMF) improved cane yield and quality and appeared to be an alternative source of K without any detrimental effect on yield.

## Sustaining sugarcane yield under multiple ratooning through drip irrigation

The experment was initiated from the 4th ratoon. Ninth ratoon crop has been harvested in the first week of February, 2022. The crop was drip irrigated daily and fertigation was done weekly. Recommended dose of fertilizer i.e 200 kg N, 60 kg $P_2O_5$ and 60 kg K was applied through fertigation in 20 equal doses. Irrigation water was kept equal to pan evaporation. Drip irrigation treatments were provided with irrigation water equal to 0.6 times the pan evaporation, assuming 60% surface area of field as wet. Surface treatments were irrigated at IW/CPE ratio equal to 1 and depth of irrigation water was kept at 80 mm. The highest sugarcane yield (47.36 t/ha) was recorded in drip irrigated crop when planting was done in paired row planting at 45×135×45 cm (Table 2.10). The lowest sugarcane yield (35.06 t/ha) was recorded in surface irrigated crop planted at 90 cm spacing. The highest irrigation water use efficiency (1020.6 kg/ha-cm) was recorded in drip irrigated crop, planted in paired row 6 at 45×135×45 cm (Table 2.11). The lowest irrigation water use efficiency (438.3 kg/ha-cm) was recorded in surface irrigated crop planted at 90 cm spacing. Yield decline in sugarcane ratoon crop (average of 4th to 9th ratoons) with respect to the plant crop was 38.9% in surface irrigated crop whereas it was only 19.1% in drip irrigated crop. Average irrigation water use efficiency with respect to plant crop was 20% less in surface irrigated crop, whereas it was 5.6% higher in drip irrigated crop. Clump mortality was 25.3% in surface irrigated crop, whereas it was 15.6% in drip irrigated crop.

## Temporal estimation of drought in sugarcane growing region by using drought indices

In the study, the drought characteristics of the sugarcane-growing regions in the Bahraich district in Uttar Pradesh were analyzed. The study used a variety of meteorological data, including maximum and minimum temperatures, sunlight hours, relative humidity, rainfall, and evapotranspiration from 1990 to 2020. The study also employed the standardised precipitation index (SPI) and reconnaissance drought index (RDI) as the two meteorological drought indices (Fig. 2.3 & 2.4). The results showed the overall increase in the drought severity, area, and frequency during the study period in the Bahraich district, mainly due to an increase in evapotranspiration due to climate change. The SPI index has rainfall as one input data, while the RDI index has two input data, potential evapotranspiration, and rainfall, for identifying drought

**Table 2.11. Effect of irrigation treatments on irrigation water use efficiency**

| Treatment | IWUE (kg/ha-cm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Plant crop | 4th ratoon | 5th ratoon | 6th ratoon | 7th ratoon | 8th ratoon | 9th ratoon | Average |
| T1 Planting at 75 cm row to row distance with Surface irrigation & recommended fertilizers application in soil | 583.0 | 512.1 | 615.8 | 276.6 | 338.9 | 718.6 | 453.8 | 486.0 |
| T2 Planting at 75 cm row to row and at alternate row drip irrigation-fertigation | 1106.7 | 1360.9 | 1496.7 | 758.5 | 1014.3 | 1935.7 | 1013.0 | 1263.2 |
| T3 Paired row planting under 40×110 ×40 cm with drip irrigation-fertigation. | 1214.6 | 1202.3 | 1347.2 | 816.4 | 993.2 | 1961.9 | 849.8 | 1195.1 |
| T4 Paired row planting under 45×135 × 45 cm with drip irrigation-fertigation. | 1066.6 | 1211.4 | 1213.0 | 820.6 | 1004.5 | 2061.8 | 1020.6 | 1222.0 |
| T5 Paired row planting under 60×120 ×60 cm with drip irrigation-fertigation | 1226.1 | 1471.8 | 1236.1 | 850.1 | 983.2 | 2001.0 | 948.1 | 1248.4 |
| T6 Paired row planting under 40×110 ×40 cm with Sub-surface drip irrigation-fertigation | 1197.7 | 1318.3 | 1444.7 | 824.3 | 995.0 | 1874.7 | 979.2 | 1239.4 |
| T7 Surface drip in Ring- pit planting method (105×75cm) with drip irrigation-fertigation | 1321.2 | 1601.6 | 1631.3 | 871.2 | 1069.1 | 2008.6 | 1004.8 | 1364.4 |
| T8 Planting at 90 cm row to row distance with Surface irrigation & recommended fertilizers application in soil | 599.0 | 502.7 | 506.1 | 334.8 | 313.2 | 663.0 | 438.3 | 459.7 |
| Average for drip irrigated crop | 1188.8 | 1361.0 | 1394.8 | 823.5 | 1009.9 | 1974.0 | 969.3 | 1255.4 |
| Average for surface irrigated crop | 591.0 | 507.4 | 561.0 | 305.7 | 326.1 | 690.8 | 446.1 | 472.8 |
| SE± | 17.80 | 46.20 | 11.74 | 18.57 | 20.42 | 30.66 | 29.20 | |
| CD, 0.05 | 31.40 | 81.35 | 20.67 | 32.69 | 35.96 | 53.99 | 51.40 | |

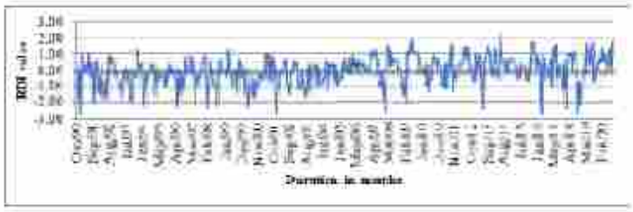


**Fig. 2.3. RDI value verses months**

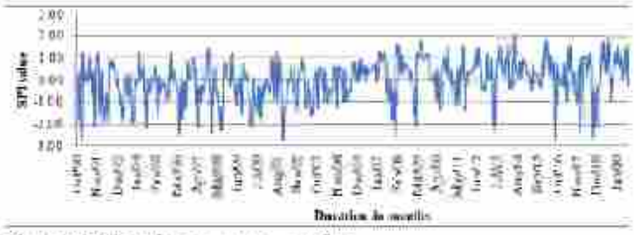


**Fig. 2.4 SPI value verses months**

incidents. The SPI index identified a total of 93 drought months in the study region, with 55 severe to extremely dry months. Extremely dry drought years were 1990, 1996, 2001, 2008, 2013, 2016, and 2018. In the case of the RDI index, 68 drought months were observed, with extremely dry drought years observed in the 1990, 1994, 1996, 2001, 2008, 2013, 2016 and 2018. The study shows an increasing trend in the potential evapotranspiration and the number of drought months, which severely impact the growth and productivity of sugarcane.

CHAPTER 3

# Management of Insect Pests and Diseases

## Survey and surveillance of major diseases and insect pests of sugarcane in sub-tropical India

Surveys for insect pests and diseases were carried out from February 2022 till November 2022. In February 2022 in the command areas of DCM Sugar, Rupapur (Hardoi), incidence of top borer (V brood 5-7%), stalk borer, (<5%) and mealy bug (traces) was observed at certain locations in the sugarcane variety Co 0238.

The variety Co 0238 was found to be infected with red rot in 70 to 80% areas surveyed, in the command areas of HPCL, Sugauli MSE, Narkatiyaganj, Harinagar Sugar Mills Ltd., Hannagar and IISR RC, Motipur, in March 2022. Incidences of pokkah boeng (up to 30%) and smut (2-10%) were observed in the variety Co 0238 in most of the locations. The variety CoP 16437 was found to be infected with sugarcane wilt in all the areas surveyed. Incidences of red rot, smut, yellow leaf disease (YLD) and GSD were noticed with the variety CoSe 01423 to the tune of 2-10%. Incidence of smut in the variety CoP 9301 was found to the tune of 1-5% Sporadic incidences of pokkah boeng, GSD, YLD and leaf scald were also observed in other varieties in the most of the locations surveyed.

In April 2022, Datia and Narsinghpur (MP) were visited. Incidence of top borer increasing in the area was believed to be spread by seed material transported from UP. Farmers were suggested to opt for IPM practices for top borer and other borers too. Overall, insect incidence was low. Incidence of *Pyrilla perpusilla* was observed in ratoon crops. In all the villages of Datia, old cane varieties like Co 1148, Co 1158, Co 1169 *etc.*, were under cultivation in more than 90% of the area and in some pockets the varieties and Co 0238 and Co 0118 were affected with red rot and pests. The command areas of two sugar mills, Mekalsuta Sugar Mill, Barwani and Maa Rawe Sugars Pvt. Ltd., Dhar were surveyed in the last week of May 2022. The ratoon crops were infected with smut. The incidence of smut (50-90%) was reported in ratoon crop of CoVSI 8005 with one field was heavily infested with white fly (>90%) in Mekalsuta Sugar Mill, Barwani. Incidence of early shoot borer (1-4%), top borer and root borer (traces) and mealy bug (1-2%) was observed in both the sugar mill areas.

In June 2022, Balrampur Chini Mills Ltd, Unit-Haidergarh, Barabanki, UP and its command area were surveyed. Co 0238 is the major sugarcane variety in the area and having more than 60% of the total cane acreage. Even though the variety has succumbed to the disease, the overall incidence of red rot during early stage *i.e.*, tillering phase was low. The variety CoS 08272 also got infected with red rot in Budhwal area. The incidence of other sugarcane diseases namely smut was noticed 1-2% in the variety Co 0238 and CoS 08272. Pokkah boeng was found associated with the variety Co 0238 in the range of 1-5%. Sugarcane grassy shoot disease (GSD) was noticed (1-2%) in two varieties (CoLk 94184 and Co 0238), sugarcane mosaic was found in traces irrespective of the variety. Insect pests were well managed in the command area. Sporadic incidences of mealy bugs, aphid, top borer and root borer were observed.

In September 2022, the sugarcane growing command areas of Magadh Sugar and Energy Ltd., Sasa Musa Sugar Works Ltd, and Vishnu Sugar Mills Ltd. Gopalganj in Bihar; Avadh Sugar and Energy Ltd. Hata, Kushinagar; United Providence Sugar Co. Ltd, Seorahi, and Triveni Energy and Industries Ltd, Ramkola, Kushinagar district in UP, were surveyed for the sampling and incidence of different diseases and insect-pests. Four varieties, namely Co 0238, CoP 9301, CoP 16437 and CoSe 1423 were found to be infected with the different diseases. Almost all the fields of Co 0238 were found infected with red rot, up to 40-60%. Variety CoP 16437 was found infected with sugarcane wilt in all the surveyed areas. The incidence of pokkah boeng was noticed in several varieties and it was up to 40% in the variety Co 0238 at the most of the locations. Incidence of red rot, smut, YLD and GSD were noticed in the varieties CoSe 1423 and BO 154 to the tune of 2 to 5%. Sugarcane smut was observed in the variety Co 0238 to the tune of 2-10%, whereas with the variety CoP 9301, it was 1-5%. Sporadic YLD and leaf scald were also observed in few locations surveyed like Gopalganj.

Severe incidence of sugarcane woolly aphid was observed at Padegaon, Pune, Pravaranagar, Navsari, Powarkheda, Kawardha, Basmathnagar and Rudrur in November 2022, in the varieties Co 86032, CoC 671 (VSI Pune) and Co 19017, CoT 19366 (Basmathnagar). Severe incidence of root borer, white fly and mite was also recorded in Co 19005 (Rudrur), Co 17001, CoVSI 16121, Co 86032, Co 17001 (Kawardha) and CoN 19071 (Navsari), respectively. Incidence of internode borer was 0.5% on core basis. While, incidence of smut was about 10%. Ratoon stunting disease (RSD) was also seen at some places.

Survey and surveillance of sugarcane diseases were carried out at the ICAR-IISR research farm to know about the prevalence of diseases. Brown spot disease was recorded up to 20% on the species clone *Khakai*. Minor diseases like black stripe, red stripe, ring spot, eye spot and red leaf spot were observed in trace amounts. Diseases like wilt (Co 7717-up to 15%), smut (CoLk 11203, CoLk 11204, Co 0238-up to 20%) and pokkahboeng (CoLk8102, Co 7717, Co0238-up to 30%) were recorded. Viral diseases like YLD, SCMV and SCBV were seen on most of the varieties planted at the research farm.

Surveys were conducted in the command areas of Pravara, Kolpewadi, Sanjeevani, Ashok, Sangmner and Rahuri Cooperative Sugar Mills of the district Ahmednagar and sugarcane growing area of the districts Nashik and Jalgaon, Maharashtra for the seasonal prevalence of diseases and pests in the sugarcane fields. The incidence of diseases *viz*., brown spot, rust and pokkahboeng were observed in the range of 80-97%, 40-80% and 21-30%, respectively in the surveyed sugarcane fields. The incidence of yellow leaf disease (YLD) was monitored from 20-35% in CoM 0265 and VSI 8005 varieties and a minor incidence of sugarcane leaf scorch (10-20%) was also reported in both the varieties (Fig. 3.1).

**Fig. 3.1. 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 subepidermal uredinia.**

Among the insect pest infestations, the white grub infestation was sporadic in the range of 40% to 80%, the infestations of woolly aphid, pyrilla, internode and early shoot borer were reported to be in the range of 20% to 40% and minor infestations of top borer and root borer were also reported in the surveyed sugarcane fields. White fly infestation was 70-95% in the sugarcane-grown area of Jalgaon, Dhule and Nashik District in July, however, this level of infestation was observed in December in the sugar mills command area of Ahmednagar (Fig. 3.2). White grub beetle emergence started with the onset of pre-monsoon shower and the highest beetle emergence (500-1800 beetles/day) was observed between June-July 2022. *Holotrichia serrata* was the dominant species recorded from the command area of PDVVPSSK, Ltd, Pravaranagar (Fig. 3.2).

**Fig. 3.2. Incidence of pests a white fly nymph and pupae at the lower leaf surface; b- Woolly aphid adult and nymphal stages on lower leaf surface; c- Pyrilleggs and nymphal stages; d-internode borer, exit hole with excreta and cane damage; e- Top borer damaged top with larvae top drying symptoms; f- Root borer cane damage and larvae**

**Fig. 3.3. White grub adult emergence, collection and damage a- Adult beetle feeding on neem leaves; b &c- beetle collection during emergence studies; d- cane damage, e- Pupal stage, f- Grubs**

Mycoparasitic fungi incidence of 50-80% was observed on brown rust fungi that occurred in CoM 0265 and Co 86032. The predator of sugarcane pyrilla *Epiricania melanoleuca* was observed in the range of 2-3 cocoon per leaf during July – December. The woolly aphid predator *Micromus igoratus* was observed in the range of 9-10 per leaf where high densities of nymphs were present. The infestation of predators was observed on nymphal and pupal stages of white fly and laboratory study indicated the highest emergence in pupal stage as compared to nymph (Fig. 3.4).

Entomopathogenic fungi (EPF) infection was recorded in the white fly particularly in the months of June-August and in months of October-December in the districts Jalgaon, Dhule, Nashik and Ahmednagar. The mummified larvae of lily borer and fall armyworm were observed during survey and EPF was isolated and pure cultures were maintained at BCC, Pravaranagar (Fig. 3.5).

**Fig. 3.4. Predators reported during survey and surveillance a-*Micromus igorotus* feeding on adult and nymph of woolly aphid, b- parasitoids emerged from nymph and pupae of white fly; c- *Epiricania melanoleuca* cocoon and eggs; d- predator feeding on nymph and pupae of white fly**

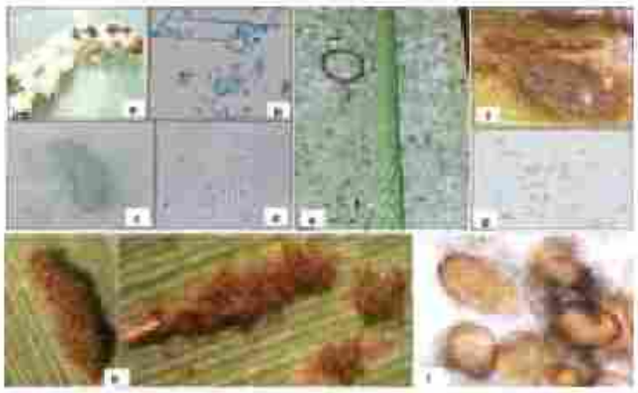


**Fig. 3.5. Entomopathogenic fungi reported during survey and surveillance a- lily borer mummified larvae b- microphotograph of isolated pure culture; c- Fall army worm mummified larva; d- microphotograph of isolated pure culture; e- EPF on white fly nymph and pupae; f- microphotograph of nymph infested with EPF; g- microphotograph of isolated culture; h- parasitized pustules of rust; d- parasitized urediospore**

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

### Response of parasitoid ratio on quality attributes of *Trichogramma chilonis* (top borer strain)

Individual *T. chilonis* male and female of top borer strain (collected on egg mass of top borer) were kept singly in glass vials (70 x 30 mm). The female was fed on streaks of honey – water solution (1:1 v/v). Trichocard was cut into small pieces (40 x 10 mm) and 150 eggs of *C. cephalonica* were glued on each Trichocard and about 75 eggs on subsequent days till death. Each individual trichocard was provided with 1-15 females of *T. chilonis* in glass tubes (20 x 4 cm) separately and allowed to parasitise for 24 hrs. The Trichocards were removed and kept separately for emergence. The experiment was conducted at 28±2°C & 65±5% RH in a BOD incubator.

Developmental period of the sugarcane adapted top borer strain of *Trichogramma chilonis* varied from 8.6 to 12.0 days. The female ratio (7) delayed the development period (12 days) while 15♀ ratio supported faster development (8.6 days). The development period in other sex ratios were at par. Maximum fecundity (139.2) was recorded in 15♀ ratios followed by 14♀, 13♀, 12♀. Percentage of adult emergence from different female ratios varied from 89.8 to 120.2 and was maximum in 7♀ and 14♀. The competition between the developing parasites for the available amount of food in host appears to the factor that inhibits the normal development of the parasitoids. The female progeny emergence was maximum (77.2%) with 2♀ ratios followed by 6♀, 7♀, 11♀, 13♀, 15♀ ratios (69.7 - 73.3%). As parasitoid ratios increase, the ratios of females decrease.

### Kairomonal effect on *Trichogramma chilonis* Ishii

Scales of *Corcyra cephalonica* (laboratory host of *Trichogramma*) were collected from freshly emerged laboratory reared moths by immobilizing at 0-2°C. Fifty fresh UV treated *Corcyra cephalonica* eggs were glued on small trichocards. Scales of *Corcyra* were sprinkled on trichocards, while control strips had no scales. These trichocards were provided to freshly emerged mated female of *T. chilonis* for parasitisation. The experiment was conducted in the laboratory at 28 ± 2° C and 65 ± 5% RH with five replications. Though the development period was more in eggs with *Corcyra* scales (Fig. 3.6), the fecundity rate was higher than that in control. Adult emergence varied from 96.3 to 104.1%. The scales-treated trichocards showed that *Corcyra* eggs were super-parasitised. Female emergence was maximum (78.75%) in treated cards than untreated cards (68.71%). Female biased sex ratio was minimum (2.21:1) in untreated than


**Fig. 3.6. Kairomonal effect of *Corcyra* scales on reproductive potential of *T. chilonis***

in treated cards (3.74:1). Comparison of data clearly demonstrates that reproductive potential was significantly enhanced due to moths' scales treatment of the trichocards compared to control.

## Natural incidence of insect-pests on sugarcane

### Top borer, *Scirpophaga excerptalis*

Incidence of second brood was significantly highest (27.5%) in CoLk 8102 followed by CoLk 11203 (26.4%), CoLk 94184 (24.9%), CoLk 11206 (22.5%), CoLk 16203 (22.7%), Co 0238 (18.4%), CoLk 16203 (22.7%), with the least susceptible ones being *Khakai*, CoJ 64, CoS 767, Co 7717, CoC 671, Co 1148, CoLk 13204, CoS 8436, BO 91, CoLk 16201, CoLk 16204, CoLk 16202, CoLk 14201 and Co 05011 (Fig. 3.7). Second brood incidence was higher than third and fourth broods during 2022.

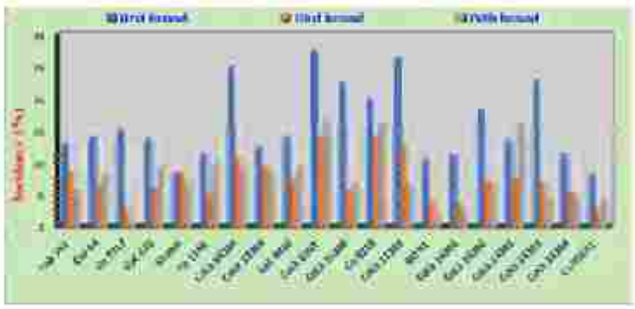


**Fig. 3.7. Incidence of top borer broods in different varieties**

Maximum incidence of third brood (14%) was observed in CoLk 8102 and Co 0238 followed by CoLk 11203 (12.6%) and CoLk 94184 (10.8%), with the incidence ranging from 3.1 to 9.3% in CoS 767, CoJ 64, Co 7717, CoC 671, *Khakai*, Co 1148, CoLk 13204, CoS 8436, CoLk 11206, BO 91, CoLk 16201, CoLk 16202, CoLk 14201, CoLk 16203, CoLk 16204 and Co 05011. Most of the top borer attacked tillers didn't form harvestable canes.

Minimum incidence of fourth brood was recorded in CoS 767, CoJ 64, Co 7717, CoC 671, *Khakai*, Co 1148, CoLk 94184, CoLk 13204, CoS 8436, CoLk 11206, CoLk 11203, BO 91, CoLk 16201, CoLk 16202, CoLk 16203, Co 16204 and Co 05011 (0.7-10.4%). Incidence in susceptible varieties CoLk 8102, Co 0238, and CoLk 14201 was 16-17%. Fourth brood (overlapping generation) occurred in the middle of August and continued till early September.

### Stalk borer, *Chilo auricilius* Dudgeon and Internode borer, *Chilo sacchariphagus indicus* (Kapur)

Incidence of stalk borer in standing cane (in August) varied from 2.2 to 6.8% in 20 varieties. Activity of stalk borer increased considerably during the monsoon from August onwards and overall crop damage was accentuated. By end of monsoon period, stalk borer larvae infested the water shoots. Incidence of internode borer ranged from 0.4 to 4.3% in different varieties in standing cane in August. The varieties with soft rind generally have a higher incidence of internode borer than those with hard rind.

### Mealy bug

The incidence of pink mealy bug, *Saccharicoccus sacchari* (Cockerell) was observed in standing cane in the month of July and August (Fig. 3.8). During July, maximum incidence was observed in CoLk 16202 (36.6%) followed by CoLk 11206, CoLk 8102, CoLk 94184, Co 1148, CoS 8436, Co 0238 CoLk 16201, CoLk 16204 and Co 05011 (28.1-33.9). However, during August incidence increased with maximum in BO 91 and CoJ 64 (61.9%) followed by CoC 671 (59.9%). In the rest of the varieties, it varied from 39.7-57.9% (Fig. 3.9).

**Fig. 3.8. Pink mealy bug infested crop**

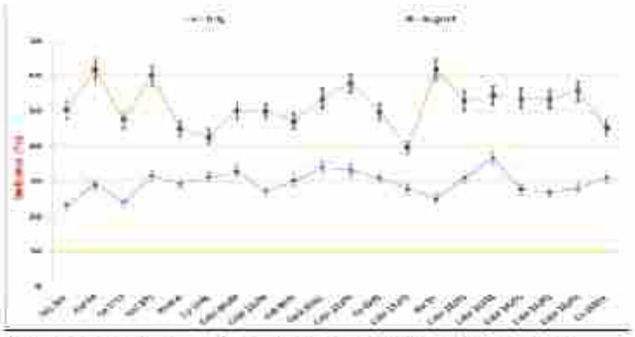


**Fig. 3.9. Incidence of mealy bug in different varieties**

### Silken disc in the female and male pupa of sugarcane top borer

A prophylactic protection of silken discs is produced by the larva, that also maintains the required humidity around the pupa in pupal chamber by preventing the moisture. The observations in three early maturing varieties (Co 0238, CoLk 94184 and CoPk 09151) and two mid-late varieties (CoLk 8102 and CoLk 13204) showed that the mean number of silken discs guarding the female pupa was higher in first, second, third and fourth broods in the varieties CoLk 13204 (6.80), CoLk 8102 (8.51), CoLk 8102 (5.82) and CoPk

09151(5.89), respectively (Fig. 3.10). The male pupa was surrounded by 5.67 (CoLk 13204), 7.08 (CoLk 94184), 5.38 (CoLk 13204) and 3.90 (CoLk 13204) silken discs, respectively (Fig. 3.11). The female pupa showed a greater number of silken discs than male pupa (Fig. 3.12). The silken discs were more in anterior end than posterior end of female and male pupa (Fig. 3.13). The number of discs was found to vary widely and was greatly influenced by the cane variety, broods and growth stage of the cane.

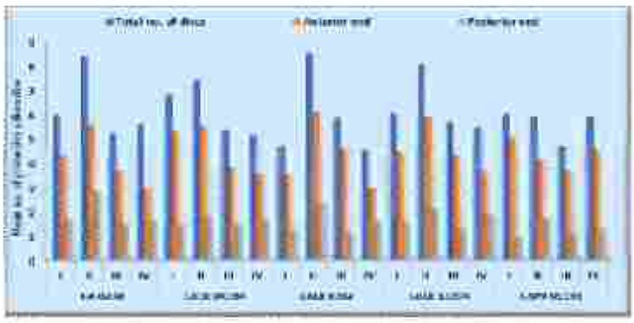


**Fig. 3.10. Silken disc in female pupa of sugarcane top borer**

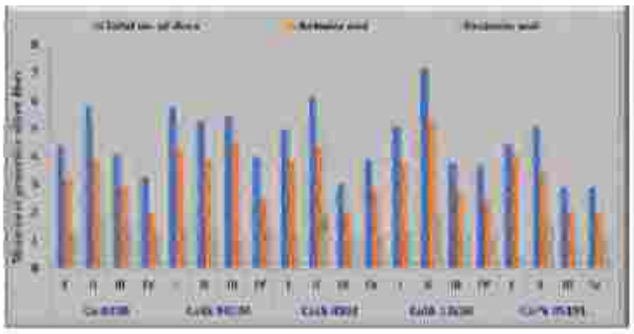


**Fig. 3.11. Silken disc in male pupa of sugarcane top borer**


**Fig. 3.12 Male and female pupa with silken disc**

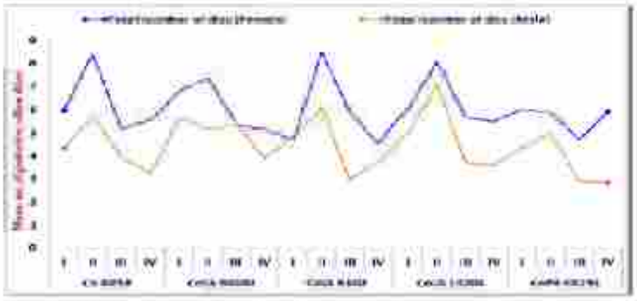


**Fig. 3.13. Silken disc in the female and male pupa of sugarcane top borer**

## Field parasitization of different broods of top borer larvae

Natural field parasitization of larvae of top borer (first to fourth broods) by three parasitoids *i.e., Isotima javensis, Rhaconotus scirpophagae* and *Stenobracon nicevillae* (Fig. 3.14) was observed in three early varieties (Co 0238, CoLk 94184 and CoPk 05191) and two mid late varieties (CoLk 8102 and CoLk 13204) to the extent of 12.8%, 9.7%, 20.0%, 5.6% and 21.1% in Co 0238, CoLk 94184, CoLk 8102, CoLk 13204 and CoPk 05191, respectively, on the first brood of top borer. *I. javensis* parasitized 1st brood only in CoLk 94184, CoLk 8102, CoLk 13204 and CoPk 05191 whereas in Co 0238, both *Isotima* and *Rhaconotus* parasitied the 1st brood (Fig. 3.15).

In the second brood, maximum parasitization was observed in CoLk 8102 (12.9%) followed by Co 0238 (9.3%), CoLk 13204 (8.9%), CoPk 05191(7.4%) and CoLk 94184 (5.8%). In the second brood, the activity of parasitoids was reduced due to high temperature and low humidity. *I. javensis* was the dominant parasitoid contributing maximum mortality of larvae in the third and the fourth broods. Mortality of larvae of top borer by three parasitoids was high in the third (11.1-21.1%) and fourth broods (23.3-32.6%) in all the five varieties.

**Fig. 3.14. Parasitoides of top borers**

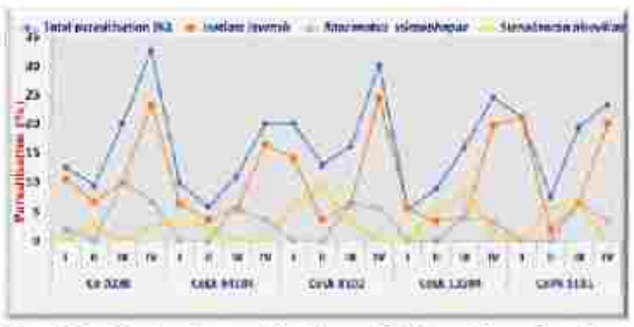


**Fig. 3.15. Natural parasitisation of different broods of top borer larva**

## Behavior of stalk borer damage in water/late shoots

Weekly observations were made during December-January on late/water shoots from six varieties *i.e.*, CoLk 94184, CoLk 8102, CoLk 13204, CoLk 11203, CoLk 11206 and Co 0238 (Fig. 3.16).

**Fig. 3.16. Water/late shoots infested with stalk borer**

Maximum percentage of node damage by stalk borer was found in CoLk 94184 (33.2%) and it varied from 13.6 to 25.3% in CoLk 8102, Co 0238, CoLk 13204, CoLk 11203 and CoLk 11206 (Fig. 3.17), with 1-2 larvae per infested shoot. In the susceptible genotype *i.e.*, CoLk 94184, 3-4 caterpillars were encountered in a single water shoot but each larva forms its own feeding tunnel. The tunnels made by the larvae extend from 2 to 4 internodes of late shoots.

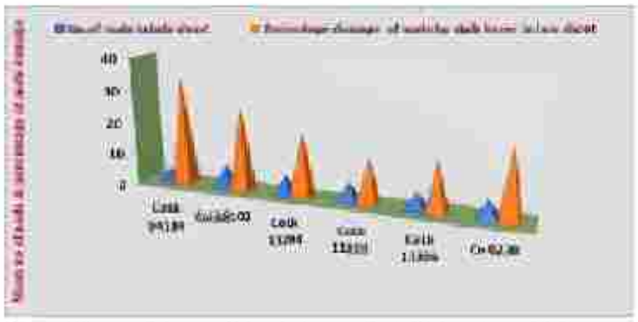


**Fig. 3.17. Incidence of mealy bug in different varieties**

## Developing arthropods-based soil health indicators for sub-tropical sugarcane ecosystem

A set of experiments were laid under two initial SOC levels (<0.5 &>0.9) to evaluate impact of different nutrient sources and agrochemicals on beneficial soil fauna and flora in sugarcane agro-ecosystem.

Berger-Parker index, synthetically describes the species abundance distribution (SAD) of disturbed communities and indicates the fraction of total sampled individuals that is contributed by the most abundant species. The Chao1 index is a qualitatively measure of alpha diversity which, besides species richness, takes into account the ratio of singletons to doubletons giving more weight to rare species. This study assessed the bio-indicator potential of the Berger-Parker index and Chao1 index by comparing their variations among different nutrients and pesticides applied in sugarcane cultivation under two different initial soil organic carbon levels and at different crop growth stages *viz.*, tillering, grand growth phase and at harvest.

The Berger-Parker index showed that abundant species are maximum at grand growth stage of the crop, changes among treatments at different crop growth stages under different higher initial SOC and in case of lower initial SOC, abundant species are more at maturity (Fig. 3.18). Higher Chao 1 index was observed at maturity where initial SOC was more than 0.9. But in plots where SOC was less than 0.5, diversity was more during grand growth phase of crop (Fig. 3.18). So, it may be concluded as abundance and diversity of fauna were related with SOC as well as crop growth stages.

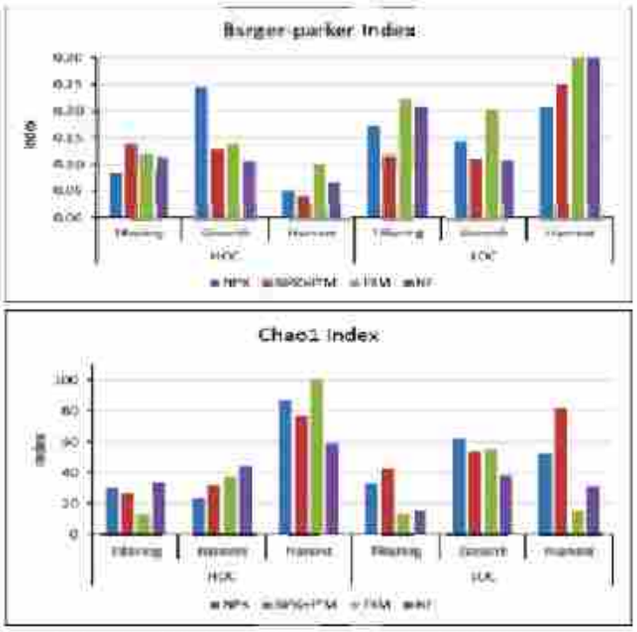



**Fig. 3.18. Diversity of soil microarthropods under different sources of nutrition at different crop stages (HOC = Initial higher soil organic carbon, LOC = Initial lower soil organic carbon)**

Impact of soil application of chlorpyriphos and chlorantraniliprole at recommended doses revealed that overall population of soil microarthropods was reduced in comparison to their respective controls (Table 3.1). However, negative impact of chlorantraniliprole was overcome by the maturity of crop.

Nematode diversity and community structure in the soil samples (from low &high SOC plots at tillering) with their respective treatments were studied. Cobb's sieving and decantation technique were used to isolate nematodes from soil. The nematodes were observed under the microscope and based on distinct body morphology (buccal capsule, mouth armature), these

**Table 3.1 Impact of Insecticide on abundance (%) of soil micro arthropods over the respective controls**

| Initial SOC level | Crop Stage | NPK | NPK+FYM | FYM | No fertilizer |
|---|---|---|---|---|---|
| | | Chlorpyriphos | | | |
| SOC (>0.9) | Tillering | 60 | -45 | 47 | 39 |
| | Growth | 31 | -12 | -18 | -46 |
| | Harvest | -69 | -77 | -5 | -80 |
| SOC (<0.5) | Tillering | -37 | -30 | -92 | 83 |
| | Growth | -16 | -38 | -64 | -54 |
| | Harvest | -62 | -56 | -83 | -9 |
| | | Chlorantraniliprole | | | |
| SOC (>0.9) | Tillering | -52 | -19 | 46 | 39 |
| | Growth | 61 | 14 | -25 | -55 |
| | Harvest | -83 | -80 | -73 | -62 |
| SOC (<0.5) | Tillering | -20 | -21 | -36 | 42 |
| | Growth | -47 | -74 | 5 | 21 |
| | Harvest | -36 | -31 | -36 | -60 |

were grouped into predatory, omnivores, bacterial feeders, fungal feeders, plant-parasitic and free-living *etc.*

In high SOC soil samples, the predatory and plant-parasitic groups of nematodes occurred the most. The predatory nematodes *viz.*, *Seinura* sp., *Mononchus* sp., *Discolaimus* sp., *Actinolaimus* sp. *Dorylaimus* sp. and *Ironus* sp. were noticed with varying degrees of abundance. The frequency of occurrence of these nematodes ranged from 75-100%. Among them, the most dominant nematode species were *Dorylaimus* sp. (24%) followed by *Discolaimus* sp. (20.1%) and *Mononchus* sp. (19.7%). The bacterial-feeding nematodes were observed as the most dominant group among all other groups. The nematode species *Cephalobus* sp., *Rhabditids* sp. and *Aphelenchus* sp. were present in the highest number in the soil samples. The plant-parasitic nematodes *viz.*, *Pratylenchid* sp., *Criconema* sp., *Hemicriconema* sp., *Logidorus* sp. and *Helicotylenchus* sp. were observed with the *Logidorus* sp. and *Helicotylenchus* sp. being the most abundant (Table 3.2).

Among the low SOC soil samples, the bacterial-feeding nematodes have been observed to be the most dominant group of nematodes followed by the predatory and plant-parasitic group of nematodes. Among the predatory group, *Dorylaimus* sp. and *Mononchus* sp. have been seen mostly. The Rhabditids nematodes were most dominant followed by *Cephalobus* sp. among the bacterial-feeding nematodes. The plant-parasitic nematodes occurred in fewer numbers as compared to high SOC soil samples with varying degrees of frequency. *Criconema* sp., *Hemicycliophora* sp., and *Tylenchorhynchus* sp. were found to be most abundant (Table 3.3).

It is, therefore, concluded that the maximum numbers of bacterial-feeder nematodes and the abundance of predatory and plant-parasitic nematodes varied in relation to land use and nutrient management, however, the occurrence of various nematode genera from different trophic groups in soil samples could be

**Table 3.2 Abundance of soil nematodes in high SOC soils samples**

| Sl No. | Nematode species | Mean | Absolute density (%) | Absolute frequency (%) | Relative density (%) | Relative frequency (%) | PV |
|---|---|---|---|---|---|---|---|
| A | Predatory Nematodes | | | | | | |
| 1. | *Seinura* sp. | 6.3 | 2.5 | 93.7 | 9.7 | 16.8 | 24.4 |
| 2. | *Mononchus* sp. | 12.8 | 5.1 | 100 | 19.7 | 17.9 | 51.2 |
| 3. | *Discolaimus* sp. | 13.0 | 5.2 | 100 | 20.1 | 17.9 | 52.2 |
| 4. | *Actinolaimus* sp. | 11.1 | 4.4 | 87.5 | 17.1 | 15.7 | 41.6 |
| 5. | *Dorylaimus* sp. | 15.5 | 6.2 | 100 | 24.0 | 17.9 | 62.2 |
| 6. | *Ironus* sp. | 9.1 | 5.9 | 75 | 9.1 | 13.4 | 20.5 |
| B | Bacterial feeding nematodes | | | | | | |
| 7. | *Cephalobus* sp. | 10.8 | 4.3 | 81.2 | 32.4 | 30.9 | 39.2 |
| 8. | *Rhabditids* sp. | 11.4 | 4.5 | 81.2 | 34.1 | 30.9 | 41.2 |
| 9. | *Aphelenchus* sp. | 11.1 | 4.4 | 100 | 33.3 | 38.0 | 44.7 |
| C | Plant-parasitic nematodes | | | | | | |
| 10. | *Pratylenchid* sp. | 9.5 | 3.8 | 75 | 15.0 | 16.9 | 32.9 |
| 11. | *Criconema* sp. | 13.3 | 5.3 | 93.7 | 21.1 | 21.1 | 51.5 |
| 12. | *Hemicriconema* sp. | 9.8 | 3.9 | 87.5 | 15.5 | 19.7 | 36.7 |
| 13. | *Longidorus* sp. | 13 | 5.2 | 100 | 20.6 | 22.5 | 52.0 |
| 14. | *Helicotylenchus* sp. | 17.4 | 6.9 | 87.5 | 27.6 | 19.7 | 65.2 |

**Table 3.3 Abundance of soil nematodes in low SOC soil samples**

| Sl No. | Nematode species | Mean | Absolute density (%) | Absolute frequency (%) | Relative density (%) | Relative frequency (%) | PV |
|---|---|---|---|---|---|---|---|
| A | Predatory Nematodes | | | | | | |
| 1. | *Seinura* sp. | 4.6 | 1.8 | 93.7 | 18.7 | 27.7 | 18.1 |
| 2. | *Mononchus* sp. | 6.7 | 2.7 | 68.7 | 27.0 | 20.3 | 22.3 |
| 3. | *Actinolaimus* sp. | 5.3 | 2.1 | 93.7 | 21.2 | 27.7 | 20.5 |
| 4. | *Dorylaimus* sp. | 8.2 | 3.3 | 81.2 | 33.0 | 24.0 | 29.7 |
| B | Bacterial feeding nematodes | | | | | | |
| 5. | *Cephalobus* sp. | 10.3 | 4.1 | 93.7 | 32.9 | 33.3 | 40.1 |
| 6. | *Rhabditids* sp. | 13.3 | 5.3 | 100 | 42.4 | 35.5 | 53.5 |
| 7. | *Aphelenchus* sp. | 7.7 | 3.1 | 87.5 | 24.6 | 31.1 | 28.9 |
| C | Plant-parasitic nematodes | | | | | | |
| 8. | *Prahylenchid* sp. | 8.1 | 3.2 | 87.5 | 15.5 | 19.7 | 30.3 |
| 9. | *Criconema* sp. | 17.8 | 7.1 | 100 | 34.1 | 22.5 | 71.5 |
| 10. | *Hemicriconema* sp. | 9.6 | 3.8 | 93.7 | 18.4 | 21.1 | 37.3 |
| 11. | *Hemicycliophora* sp. | 7.2 | 2.9 | 81.2 | 13.9 | 21.4 | 26.2 |
| 12. | *Tylenchorhynchus* ssp. | 9.4 | 3.7 | 81.2 | 17.9 | 18.3 | 33.9 |

related to soil organic carbon content and also varies with the nutrient source in soil.

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

Different anti-protozoan chemicals *viz.*, Metronidazole; Albendozole; Ornidazole; Tinidazole; Nitazoxanide were evaluated for their bio-efficacy against termites reared on artificial diet under laboratory condition. Amongst these, 100 per cent mortality of termites was recorded within 10 days in Albendozole and Tinidazole treatments, while it was 11, 13 and 15 days in case of Ornidazole, Metronidazole and Nitazoxanide, respectively. Termites could survive up to 29 days in untreated control (Fig. 3.19). Single factor ANOVA revealed that Albendozole, Tinidazole and Nitazoxanide treatments were significantly effective over control ($F_{5,48}$ = 3.03, p= 0.02).

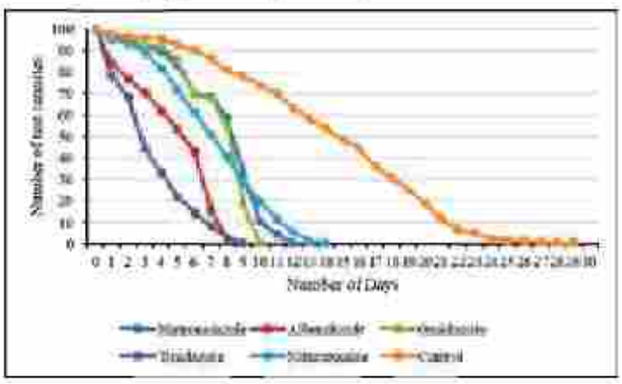



**Fig. 3.19 Mortality of termites under different anti-protozoan chemicals *in vitro* condition**

## Isolation, identification and synthesis of sex pheromones lures for the management of major borers of sugarcane

Top borer and stalk borer pupa were collected from field. Male and female pupae were kept separately in wide mouth glass tubes at ambient temperature. On emergence of moths, one hundred (100) virgin female moths were released into the THF Cutter apparatus, inlet was covered with tissue paper and outlet was connected to sintered gas dissolving bottle containing 150 ml Methanol AR grade. Air from THF with female scent to sintered bottle sucked with the help of vacuum pump. The electric pump was on and off for 15 minutes alternatively for 10 times to get maximum scent dissolved in solvent. The solvent with scent was stored in reagent glass bottles at 5 °C in refrigerator. Another method for the extraction of sex scent was used as described by Collins and Potts, (1932). The abdomen tips from 7th segments were clipped off in to solvent (Methanol AR Grade) and shacked well on rotary shaker for 150 minutes and stored at 5 °C in refrigerator.

Laboratory experiment was conducted to find out efficacy of extracted female semiochemical towards male moth attraction. There were four treatments (semiochemical extracts of top borer and stalk borer obtained by two methods) and each treatment was replicated five times. For each replication one Whatman filter paper, dipped in extract concentrates and dried at room temperature was used for experimentation. Such dried filter paper was stuck with glue on the upper inner surface of the plastic jar, (20×20 cm). In each jar 10 male moths were released in the bottom of jar. Visual observations were made at 15, 30, 45, 60 minutes and 24 hours after release of moths.

Immediately after release of moths, male moths showed no attraction. However, attraction of moths was noticed 15 minutes after release. Maximum attraction was observed at forty five minutes after release (32% in extract A and 30% in extract B) in the case of top borer. In the case of stalk borer, it was maximum (30% and 18% in A and B extract) at 45 minutes after release. Cumulative percent attraction of male moths 24 hrs after release was 84 and 68 per cent of top borer moths in extract A and B while it was 88 and 58 percent in the case of stalk borer (Table 3.4).

**Table 3.4. Percent attraction of male moths of top borer and stalk borer of sugarcane towards female semiochemical extracts**

| Treatments | Percent attraction of male moths | | | | | |
|---|---|---|---|---|---|---|
| | 15 minutes after release | 30 minutes after release | 45 minutes after release | 60 minutes after release | 24 hours after release | Cumulative attraction (%) |
| **Top Borer** | | | | | | |
| Extraction A | 8 | 14 | 32 | 12 | 18 | 84 |
| Extraction B | 6 | 8 | 26 | 14 | 14 | 68 |
| **Stalk borer** | | | | | | |
| Extraction A | 10 | 12 | 30 | 10 | 26 | 88 |
| Extraction B | 6 | 8 | 18 | 8 | 18 | 58 |

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

Four genotypes *viz.*, CoS 17231, CoS 17232, CoPb 18181, CoLk 18202 along with three standard checks (CoJ 64, Co 0238, Co 05009) were evaluated against top, stalk, internode borers and pink mealy bug in AVT (Early)-I Plant trial. All the genotypes showed the least susceptible (LS) reaction against top borer (IV brood), stalk borer, internode borer and highly susceptible (HS) to pink mealy bug.

In AVT (Mid-late)-I Plant trial, six genotypes *i.e.*, CoS 18231, CoPb 18213, CoPb 18214, Co 18022, CoS 18232, CoS 18233 and three standard checks (Co 05011, CoPant 97222, CoS 767) showed LS reaction for top borer (IV brood), stalk borer, internode borer and HS reaction to pink mealy bug.

Nine genotypes *viz.*, Co 17018, CoS 17235, CoLk 17204, CoPb 17215, CoPant 17233, CoS 17236, CoH 17261, CoH 17262, CoS 17234 along with three standard checks (CoPant 97222, Co 05011, CoS 767) in AVT (Mid-late)-II plant were found LS to top borer (IV brood), stalk borer and internode borer. For mealy bug, all the genotypes were highly susceptible except CoLk 17204 and Co 05011 which were moderately susceptible.

In AVT (Mid-late)-ratoon trial, nine genotypes *viz.*, Co 17018, CoS 17235, CoLk 17204, CoPb 17215, CoPant 17233 CoS 17234, CoS 17236, CoH 17261, CoH 17262 and three standard checks (Co 05011, CoPant 97222, CoS 767) showed LS reaction for top borer (IV brood), stalk borer, internode borer and HS reaction to pink mealy bug except Co 17018, CoPb 17215, CoPant 17233, CoS 17236 which were moderately susceptible.

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

The gregarious larval parasitoid, *Cotesia flavipes* was reared on larvae of stalk borer, *Chilo auricilus*, maize stem borer, *Chilo partellus* and pink borer, *Sesamia inferens*. Freshly emerged mated females from respective cocoons of stalk, maize stem borer and pink borer were kept singly in each plastic jar. The fourth instar larvae of stalk, maize stem borer and pink borer were provided to mated females for parasitisation. The parasitised larvae were transferred individually in glass vials along with semi dried sugarcane leaf sheath for stalk and maize stem borers larvae and dried paddy leaves for larvae of pink borer for further development, with replacement of the leaves and sheath with fresh ones after every three days. The number of cocoons produced, progeny and female emergence larvae were 23.0%, 15.2%, 13.4%, respectively from *C. partellus*, 22.2%, 18.95% 15.28% from *C. auricilus*, and 58.6%, 55.0%, 51.8% from *S. inferens*. It is found that *C. partellus* is the more preferred host for laboratory multiplication of *C. flavipes*.

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

The incidence of top borer (IV brood), internode borer and stalk borer were 9.90%, 3.44% and 8.87% in treated plots as compared to 17.15%, 7.80% and 13.42% in the untreated plots, respectively in the variety Co 0238. The pink mealy bug incidence was 36.3% in treated plot as against 61.7% in untreated plot in the month of August 2022.

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

Initial screening of *Paenibacillus* sp. isolates (BpM, BpRjBpPr, LL1, LL2, LL3, LS1, and LS2) and isolates of *Bacillus thuringiensis* namely Btg1 and Btg 2 were conducted for pathogenicity against third instar grub $F_1$ population of *Holotrichia serrata* reared under *in vitro* conditions (Fig. 3.20). Healthy grubs were allowed to feed on sprouted cowpea seeds inoculated with spore talc formulation ($2 \times 10^8$ spores/gm) for 24 hrs. These grubs were later shifted to an insect breeding box containing soil cocopeat mixture with sprouted seed and incubated at 28°C for 12/12 hrs light and dark cycle.

**Fig. 3.20 Disease caused by LL1 (a), LL2 (b), and LS1 (c) and microphotograph of spores observed in infected grub haemolymph**

The mortality was observed on 24, 27, 30, and 72 days after feeding (DAF) in LL2, LS1, LL1 and LS4 treated grubs, respectively. However, the grub treated with LL1 isolate with $2\times10^{12}$ spores/gram showed disease symptoms on the 9th DAF and mortality on the 13 DAF. In *Bacillus thuringiensis* treated grubs, mortality was observed on 43 and 74 DAF in Btg1 and Btg 2 isolates respectively (Fig. 3.21).

**Fig. 3.21 Disease caused by *Bacillus thuringiensis* isolates from *Corcyra (b)* and *Galleria* (c) and a- microphotograph of spores observed in infected grub haemolymph**

## Utilization of entomopathogenic nematodes against white grubs infesting sugarcane

### *Isolation and pathogenicity of Entomopathogenic bacteria (EPBs) associated with EPN*

Entomopathogenic bacteria associated with EPN were isolated from dead *Galleria* larvae, which were exposed to the *H. indica* IISRBCCH01. Mortality was observed within 24 hrs after re-infection of bacterial cells in healthy *Galleria*. The Koch postulate was proved by re-isolation and infection in healthy *Galleria* larvae.

## Production of infective juveniles (IJs) of EPN on different insect hosts

To study the trend of IJ production on different insect hosts, the larvae of *Galleria mellonella, Chilo infuscatellus, Scirpophaga nivella, Corcyra cephalonica*, and *Polyochade pressella* was infected with *H. indica*. The larval mortality was observed in *C. infuscatellus* (58 hrs), *S. nivella* (58 hrs), *P. depressella* (60 hrs), *G. mellonella* (40 hrs) and *C. cephalonica* (35 hrs) post-nematode infection (Fig. 3.22). EPN-killed larvae were kept in white trap separately and the emergence of infective juveniles was counted daily for the next 6 to 7 days. It was observed that the maximum number of IJs emerged from *Galleria* (11286 IJs) followed by *Chilo infuscatellus* (9940 IJs), while the minimum number of IJs was counted in *Polyocha depressella* (4948 IJs). The production of IJs on early grub instars of *H. serrata* was also studied at different doses and it was observed that an increase in the dose of IJs per grub led to an increase in the production of IJs per grub. The maximum IJs were counted at a dose of 800 IJs per grub (6751 IJs).

## Infectivity and pathogenicity of EPN against adult beetles of *H. serrata*

The adult beetles of *Holotrichia serrata* were exposed to *H. indica* @ 500, 1000 and 10000 IJs per beetle. EPNs induces mortality in the beetle after 36 to 72 hours (39% to 63% mortality) post-infection. To study the EPN development inside the beetles, the dead beetles were dissected in Ringer's solution at different duration (3, 7, 9 and 15 days) of post-EPN infection. A few first-generation hermaphrodite stages of nematodes were observed after 3 days of nematode penetration. The body of the hermaphrodite female was seen to be filled with juveniles. Second-generation females were seen after 7 days of post-infection but with abnormal body morphology and devoid of juveniles or most females

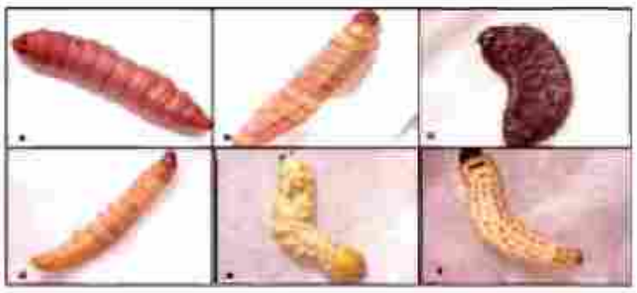


**Fig. 3.22 Production of infective juveniles (IJs) of EPN on different insect hosts a- *G. mellonella*; b- *S. nivella*; c- *H. serrata*; d- *C. cephalonica*; e-*P. depressella*; f- *C. infuscatellus***

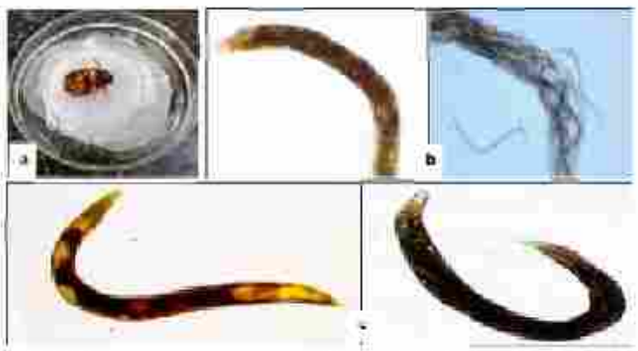


**Fig. 3.23 Infectivity and pathogenicity of EPN against adult beetles of *H. serrata* a-dead adult beetle on white trap; b-First-generation hermaphrodite female after 3 days of post-EPN infection and the juveniles inside the body of first-generation female; c- second-generation females after 7 days of post-EPN infection**

were aborted. A few IJs emerged from the dead beetles even after 15 days of post-EPN infection thereby concluding the nematode development inside the beetle might be disturbed (Fig. 3.23).

## Evaluation/screening of sugarcane germplasm/genotypes against red rot, smut, wilt and YLD

During 2022-23, 62 germplasm/genotypes were screened against red rot (CF08 and CF13) and smut and the disease incidence was recorded. Natural incidence of wilt and yellow leaf disease (YLD) was also recorded (Table 3.4). The plug method of inoculation was used for the red rot screening.

**Table 3.5. Reaction of genotypes against red rot pathotypes (CF08 and CF13), wilt, smut and YLD**

| Reaction | Genotype |
|---|---|
| Red rot pathotype (CF08 and CF13) | |
| R | LG 19063, (1) |
| MR | A-2, A-3, A-5, A-7, A-10, A-11, A-16, A-21, A-24, A-28, A-30, LG 19136, LG 19015, LG 19171, LG 19003, LG 19123, LG 19025, LG 19039, LG 19036, LG 19033, LG 19158, LG 19066, LG 19037(25) |
| MS | A-4, A-14 & LG19100(3) |
| SMUT | |
| R | A-6, A-7, A-13, A-14, A-15, A-19, A-21, A-23, A-24, A-29, A-31, A-32, LG 19006, LG 19100, LG 19043, LG 19171, LG 19005, LG 19063, LG 19109, LG 19123, LG 19025, LG 19039, LG 19136, LG 19066, LG 19087, LG 19142, LG 19037(27) |
| MR | A-8, A-17, A-18, A-26, A-27, A-30, LG 19015, LG 19003, LG 19101(9) |
| MS | A-1, A-3, A-4, A-9, A-16, A-20, A-22, A-25, A-28, LG 19165, LG 19033(11) |
| S | A-2, A-5, A-10, A-12, LG 19097, LG 19104, LG 19049, LG 19096, LG 1919103, LG 19158, LG 19107(11) |
| HS | A-11, LG 19136, LG 19105, LG 19158(4) |
| WILT | |
| R | A-2, A-3, A-4, A-5, A-7, A-8, A-11, A-12, A-13, A-14, A-15, A-16, A-18, A-19, A-21, A-22, A-23, A-24, A-26, A-27, A-28, A-29, A-30, A-31, A-32, LG 19006, LG 19100, LG 19097, LG 19136, LG 19105, LG 19104, LG 19049, LG 19096, LG 19171, LG 19005, LG 19063, LG 19109, LG 19103, LG 19025, LG 19039, LG 19033, LG 19158, LG 19017, LG 19107, LG 19066, LG 19087, LG 19142, LG 19037, LG 19101(49) |
| S | A-1, A-6, A-9, A-10, A-17, A-20, A-25, LG 19043, LG 19015, LG 19003, LG 19123, LG 19165, LG 19036(13) |
| YLD | |
| R | A-1, A-4, A-5, A-6, A-7, A-8, A-9, A-11, A-12, A-14, A-15, A-16, A-18, A-19, A-21, A-22, A-23, A-24, A-26, A-27, A-29, A-31, A-32, LG 19006, LG 19100, LG 19097, LG 19136, LG 19104, LG 19015, LG 19049, LG 19096, LG 19005, LG 19109, LG 19103, LG 19025, LG 19039, LG 19165, LG 19036, LG 19033, LG 19017, LG 19107, LG 19087, LG 19142, LG 19101(44) |
| S | A-2, A-3, A-10, A-13, A-17, A-20, A-25, A-28, A-30, LG 19105, LG 19043, LG 19171, LG 19063, LG 19003, LG 19123, LG 19158, LG 19066, LG 19037(18) |

## Evaluation of zonal varieties against red rot, smut and wilt

### Location: IISR, Lucknow (North West Zone) during 2022-23

Forty one genotypes *i.e.* ten of IVT (Early), four of AVT (Early)-I Plant, 12 of IVT (Mid-late), six of AVT (Mid late)-I Plant, Nine of AVT (Mid late)-II Plant were screened against red rot, smut and natural infection of wilt and YLD at ICAR-IISR, Lucknow, along with susceptible checks *viz.*, CoJ 64 (CF08) and Co 0238 (CF13) for red rot and CoLk 7701 and Co 1158 for smut. The reaction to the diseases was recorded (Table 3.6).

### Location: IISR Regional Station, Motipur (North Central Zone) during 2022-23

Fifteen sugarcane genotypes, five of AVT (Early)-I Plant, seven of AVT (Early)-II Plant and three of AVT (Mid-late)-II Plant, were screened against red rot, smut, wilt and YLD at IISR RC, Motipur, along with two standard checks against two red rot pathotypes (CF08 and CF13 by plug and nodal methods of inoculation) and two standard checks against smut. The disease reactions were recorded (Table 3.7).

## Identification of pathotypes in red rot pathogen

During 2022-23, 12 new isolates *i.e.* 10 isolates from Co 0238 (IR-205, IR-206, IR-207, IR-208, IR-209, IR-210, IR-211, IR-212, IR-215 and IR-216) and two isolates from CoS 08272 (IR-213 and IR-214) were evaluated for their pathogenic virulence spectrum along with CF07, CF08, CF09 and CF13 on 20 designated differentials *viz.*, BO 91, Co 419, Co 975, Co 997, Co 1148, CoS 8436, Co 7717, Co 62399, CoC 671, CoJ 64, CoS 767, Co 7805, Co 86002, Co 86032, CoSe 95422, CoV 92102, Co 0238, *Khakai* (*S. sinense*), SES 594 (*S. spontaneum*) and *Bamgua* (*S. officinarum*) by plug method of inoculation. The virulence pattern of all the studied isolates was more or less matched with the existing pathotypes of this zone CF07, CF08, CF09 and CF13. Hence, there is no emergence of any new virulent pathotype in this zone.

## Survey of sugarcane diseases naturally occurring in the area of important varieties

A survey was conducted to record the disease incidence in sugarcane commercial varieties in different cane growing area of Uttar Pradesh and Bihar during 2022-23 crop seasons. In Uttar Pradesh, the command areas of KM Sugar Mills, Masaodha, Faizabad; mills of DSCL group; Balrampur Chini Mill Group; The Seksaria Biswan Sugar Mill Ltd., Biswan; Dhuriapar *Kisan* Sugar Mill Ltd.; Saraya Sugar Mills Ltd. Gorakhpur; Triveni Sugar Mill, Kushinagar and DSCL Sugar Loni,

**Table 3.6 Reaction of sugarcane genotypes against red rot, smut and wilt at IISR, Lucknow during 2022-23**

| | Genotype | Red Rot | | | | Smut | Wilt | YLD |
|---|---|---|---|---|---|---|---|---|
| | | Plug Method | | Nodal Method | | | | |
| | | CP08 | CP13 | CP08 | CP13 | | | |
| **Initial Varietal Trial (Early)** | | | | | | | | |
| 1. | CoLk 19201 | MR | MR | R | R | R | W | Y |
| 2. | CoLk 19202 | MR | MR | R | R | R | - | - |
| 3. | CoLk 19203 | MR | HS | R | S | R | - | - |
| 4. | Co 19016 | MR | S | R | S | R | W | - |
| 5. | CoPb 19181 | MR | MR | R | R | MR | - | Y |
| 6. | CoPb 19211 | S | MS | S | R | R | - | - |
| 7. | CoPb 19212 | LESS POPULATION | | | | | | |
| 8. | CoPant 19221 | MR | HS | R | S | R | - | - |
| 9. | CoS 19231 | MR | S | R | R | R | - | - |
| 10. | CoH 19261 | HS | MS | S | R | R | - | - |
| **Advanced Varietal Trial (Early) – I Plant** | | | | | | | | |
| 1. | CoS 17231 | MR | MR | R | R | R | - | - |
| 2. | CoS 17232 | MR | MR | R | R | S | - | - |
| 3. | CoPb 18181 | MR | MR | R | R | MR | - | - |
| 4. | CoLk 18202 | MR | MR | R | R | MS | - | Y |
| **Initial Varietal Trial (Mid Late)** | | | | | | | | |
| 1. | Co 19017 | MR | MR | R | R | R | - | - |
| 2. | Co 19018 | MR | HS | R | S | R | W | Y |
| 3. | CoPb 19182 | MR | MS | R | R | R | W | Y |
| 4. | CoLk 19204 | MR | MR | R | R | MR | - | Y |
| 5. | CoPb 19213 | MR | MS | R | R | - | W | Y |
| 6. | CoPb 19214 | MR | MR | R | R | R | - | - |
| 7. | CoPant 19222 | MR | HS | R | S | R | - | - |
| 8. | CoS 19232 | MR | MS | R | R | R | - | Y |
| 9. | CoS 19233 | HS | HS | S | S | R | - | - |
| 10. | CoS 19234 | MR | HS | R | S | MS | - | - |
| 11. | CoS 19235 | MS | MS | R | R | R | - | Y |
| 12. | CoH 19262 | MS | MS | R | R | R | - | - |
| **Advanced Varietal Trial (I-Plant Mid-late)** | | | | | | | | |
| 1. | Co 18022 | MS | MR | S | R | S | W | Y |
| 2. | CoPb 18213 | MR | MR | R | R | R | - | - |
| 3. | CoPb 18214 | MR | MS | R | S | R | W | - |
| 4. | CoS 18231 | MS | MS | R | R | R | - | Y |
| 5. | CoS 18232 | MR | MR | R | R | R | - | - |
| 6. | CoS 18233 | MR | MR | R | R | MS | - | - |
| **Advanced Varietal Trial (Mid-late) – II Plant** | | | | | | | | |
| 1. | Co 17018 | MR | MR | R | R | S | W | |
| 2. | CoLk 17204 | MR | MR | R | R | R | - | |
| 3. | CoPb 17215 | MR | MR | R | R | MR | W | Y |
| 4. | CoPant 17233 | MR | MR | R | R | R | W | Y |
| 5. | CoS 17234 | MR | MR | R | R | R | W | |
| 6. | CoS 17235 | MR | MR | R | R | MR | - | |
| 7. | CoS 17236 | MR | MR | R | R | R | W | |
| 8. | CoH 17261 | MR | MR | R | R | R | - | - |
| 9. | CoH 17262 | S | S | S | S | R | - | |
| Check | Co 0238* | R | HS | - | - | | - | - |
| Check | CoJ 64* | HS | R | - | - | | - | - |
| Check | Co 1156** | - | - | - | - | HS | - | - |
| Check | CoLk 7701** | - | - | - | - | HS | - | - |

*: Check for red rot; **: Check for smut

**Table 3.7 Reaction of sugarcane genotypes against red rot, smut, wilt and YLD at IISR Regional Centre, Motipur during 2022-23**

| Sl. No. | Genotype | Red Rot | | | | Smut | Wilt | YLD |
|---|---|---|---|---|---|---|---|---|
| | | Plug Method | | Nodal Method | | | | |
| | | CF08 | CF13 | CF08 | CF13 | | | |
| **Advance Varietal Trial (I-Plant, Early)** | | | | | | | | |
| 1. | CoP 18436 | S | MS | R | R | R | - | - |
| 2. | CoP 18437 | MR | MR | R | R | R | W | Y |
| 3. | CoP 18438 | R | R | R | R | MS | - | - |
| 4. | CoSe 18451 | MR | MR | R | R | R | - | - |
| 5. | CoSe 18452 | MR | MR | R | R | R | - | Y |
| **Advance Varietal Trial (II-Plant, Early)** | | | | | | | | |
| 1. | CoSe 16454 | MR | MR | R | R | R | - | - |
| 2. | CoP 17436 | MR | MR | R | R | R | - | - |
| 3. | CoP 17437 | MR | MR | R | R | R | - | - |
| 4. | CoP 17438 | MR | MR | R | R | R | - | - |
| 5. | CoP 17440 | MR | MR | R | R | R | - | Y |
| 6. | CoP 17441 | MR | MR | R | R | MS | W | - |
| 7. | CoSe 17451 | MR | MR | R | R | MR | W | Y |
| **Advance Varietal Trial (Mid Late) –II Plant** | | | | | | | | |
| 1. | CoSe 16455 | MS | MS | R | R | R | - | Y |
| 2. | CoP 17446 | MR | MR | R | R | R | W | - |
| 3. | CoSe 17452 | MS | MS | R | R | R | W | - |
| Check | Co 0238* | R | HS | - | - | - | - | - |
| Check | CoJ 64* | HS | R | - | - | - | - | - |
| Check | Co 1158** | - | - | - | - | HS | - | - |
| Check | CoLk 7701** | - | - | - | - | HS | - | - |

*: Check for red rot; **: Check for smut

Shahabad, Hardoi; Balrampur Chini Mills Ltd., Unit-Rauzagaon; Bajaj Hindustan Sugar Ltd., Rudauli, Basti and Balrampur Chini Mills Ltd., Unit- Haidergarh, Barabanki were surveyed.

- Varieties *viz*, Co 0238, CoLk 14201, Co 15023, CoS 13235, Co 0118, CoSe 95422, CoJ 64, CoS 8436, CoLk 08102, CoS 88230, CoS 95255, CoSe 01424 and CoS 91269 are being cultivated by the farmers throughout Uttar Pradesh.
- Co 0238 was the major sugarcane variety with more than 60% of the total cane acreage. In all the locations, incidence of red rot was noticed in the variety, resulting huge losses to sugarcane growers and sugar mills.
- CoS 08272, a recently released sugarcane variety was also found to succumb to red rot in Burhwal, Barabanki area.
- In general, incidence of red rot was high (30-70%) in the variety Co 0238. In some fields, the incidence was to a tune of 20% in the varieties CoSe 08272, CoLK 8102 and CoS 8436. Severe incidence of sugarcane smut was observed in Co 0238 (15-35%), Co 0118 (10-15%), CoS 08272 (5-10%) and CoSe 92423 (8-10%). Incidence of GSD (1-3%) was noticed in the varieties Co 0118, CoS 08272, CoLk 94184, Co 98014, Co 89029 CoS 91269 and CoLk 9709 in the most of the fields surveyed. In some locations, higher incidence of GSD (5-10%) was noticed in CoSe 08272 and CoLk 94184.
- The incidence of the minor diseases like Pokkah boeng is increasing substantially and it is mostly affecting the sugarcane variety Co 0238 to the tune of 15 to 40%.
- In general, incidence of viral diseases of sugarcane was observed in the fields, resulting in varietal de-generation of all the varieties and arresting their yield potential. Severe incidence of YLD and mosaic was noticed in the variety CoLk 94184, Co 0238, CoSe 08272 and Co 98014. The newly released varieties *viz*., CoLk 14201, Co 15023 and CoS 13235 were also infected with YLD. Ratoon stunting disease of sugarcane was also noticed in the several varieties like CoSe 08272, CoS 767 and Co 89029. Stray incidence of leaf scald was also observed in Co 0238.

In Bihar, the command areas of sugar mills, *viz*., HPCL, Sugauli; MSE, Narkatiyaganj; Harinagar Sugar Mills Ltd., Harinagar, Magdh Sugar and Energy Ltd. (Bharat Sugar Mills), Gopalganj, Bihar; Sasa Musa Sugar Works Ltd., Gopalganj, Bihar; Vishnu Sugar Mills Ltd., Gopalganj, Bihar were surveyed for the incidence of different diseases. Survey was carried out at ICAR-IISR Research Centre, Motipur also.

- In general, sugarcane varieties grown in Bihar areas were CoLk 94184, Co 0118, Co 0238, CoSe 1434, CoP 9301, Co 98014 and CoP 16437. Except four sugarcane varieties namely Co 0238, CoP 9301, CoP 16437 and CoSe 01423, the other varieties grown in the areas were found healthy.
- Co 0238 was found infected with red rot in 50 to 70% areas surveyed. Variety CoP 16437 was found infected with sugarcane wilt (10-20%) in all the areas surveyed. The incidence of red rot (up to 70%) was observed in most of the area in the variety Co 0238.
- Pokkah boeng was also noticed up to 30% in the variety Co 0238 in most of the locations. The varieties CoSe 1434 (5-10%), CoP 9301 (3-8%) and Co 98014 (2-5%) were also infected with pokkah boeng disease. Incidences of red rot, smut, YLD and GSD were noticed in the variety CoSe 1423 to the tune of 2 to 10%. Severe incidence of smut was found in the varieties Co 0238 (5-10%), Co 0118 (5-50%) and CoP 9301 (1-5%). Mosaic was found associated with all the varieties cultivated in Bihar.
- Severe incidence of YLD was observed in the variety CoLk 94184 (5-15%), CoP 16437 (5-10%) and Co 0238 (5-10%). Sporadic incidences of pokkah boeng, GSD, YLD and leaf scald were also observed in other varieties in many of the locations surveyed.

## Assessment of elite and ISH genotypes for resistance to red rot

Twenty four ISH genotypes namely ISH 501, ISH 548, ISH 536, ISH 524, ISH 542, ISH 526, ISH 594, ISH 585, ISH 519, IGH 823, ISH 558, ISH 545, IGH 834, IGH 833, ISH 590, ISH 562, ISH 584, ISH 587, ISH 502, ISH 528, IGH 829, ISH 554, ISH 567 and ISH 516 along with two susceptible checks CoJ 64 (CF08) and Co 0238 (CF13) were planted at ICAR-IISR, Lucknow for the evaluation against red rot disease of sugarcane pathotypes CF08 and CF13 during 2022-23.

Out of twenty-four ISH genotypes tested, 14 genotypes *viz.*, ISH 548, ISH 524, ISH 526, ISH 519, ISH 585, ISH 558, IGH 833, ISH 590, ISH 584, ISH 502, ISH 528, IGH 829, ISH 554 and ISH 567 were rated as MR to both the pathotypes (CF08 and CF13) by plug method of inoculation and resistant (R) by nodal method of inoculation.

Three ISH genotypes *viz.*, ISH 501, ISH 536 and ISH 516 were rated as MR against pathotype CF08 and susceptible (S) against pathotype CF13 by plug method whereas, resistant (R) against pathotype CF08 and susceptible (S) against pathotype CF13 by nodal method of inoculation.

Four ISH genotypes *viz.*, ISH 542, ISH 823, ISH 834 and 562 were rated as MS against pathotype CF08 and MR against pathotype CF13 by plug method whereas susceptible (S) against pathotype CF08 and resistant (R) against pathotype CF13 by nodal method of inoculation.

Genotype ISH 594 was rated as susceptible (S) against pathotype CF08 and HS against pathotype CF13 by plug method whereas susceptible against both the pathotypes (CF08 and CF13) by nodal method of inoculation.

Genotype ISH 545 was rated as MR against pathotype CF08 and HS against pathotype CF13 by plug method whereas resistant (R) against pathotype CF08 and susceptible (S) against pathotype CF13 by nodal method of inoculation.

## Management of pokkah boeng disease of sugarcane

In the mini plot study, the fungal bio-control agent, *Trichoderma harzianum* strain T6 was evaluated to manage pokkah boeng disease infection. *Trichoderma* culture ($10^7$ per ml) was applied as sett treatment, soil application, and foliar spraying at 45 days of planting. The pathogenic inoculum was sprayed over the germinated plants at 50 days of planting. Chemical fungicides (carbendazim and mancozeb) were applied foliar as standard control. Non-treated plants were considered as the negative control. Observations at 60 days, 90 days, 120 days, 150 days, and 180 days were recorded on disease severity. The per cent disease incidence was calculated. The sett treatment with *Trichoderma* culture followed by soil application recorded less disease development. The disease severity for the cane treatment was almost equivalent to a standard control (fungicide - carbendazim and mancozeb), whereas foliar applied treatment was non-significantly different from the negative control. In plant growth promoting parameters, a 7% reduction in yield loss was recorded and it was due to the shortening of internodes, plant height, and internode number as well. (Fig. 3.24). It can be concluded that sett treatment with *T. harzianum* culture has a positive effect in reducing the severity of pokkah boeng in sugarcane crop.

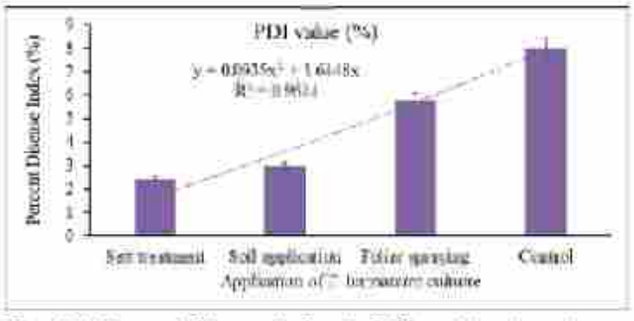



**Fig. 3.24 Percent disease index in different treatments**

## Identification and pathogenicity of *Fusarium* species associated with pokkah boeng diseases of sugarcane in Maharashtra

Twelve isolates of *Fusarium* sp. associated with sugarcane pokkah boeng disease were isolated, purified, and maintained at IISR-BCC, Pravaranagar. Pathogenicity test indicated that all the isolates produced disease symptoms in CoM 0265 cultivar with disease severity index ranging from 24.99 to 49.85 and 45.27 to 76.94 in leaf axil inoculated and sett inoculated plants, respectively (Table 3.8). Symptoms reported were chlorosis and necrosis of leaves, punctured lesions, twisted leaves, reduction of the total leaf area, death of the plantop and stalk rot. The sequence analysis of the translation elongation factor 1-α (tefα-1) gene and morphological markers revealed that all the isolates belong to *Fusarium sacchari*. The sequences of all the isolates submitted to NBC Genbank and cultures were deposited in National Agriculturally Important Microbial Culture Collection at ICAR-NBAIM, Mau, Uttar Pradesh.

## Isolation, identification and pathogenicity of wilt pathogen in sugarcane

Under glasshouse condition, Rapid Wilt Inoculation method (RWIM) is being developed and standardized for the inoculation and wilt disease development (Fig. 3.25). Two-bud setts of the sugarcane wilt susceptible cultivar Co 7717 were planted in February 2021 after MH AT in pots containing sterilized soil. The standard package of practices was followed. The temperature and humidity were maintained 28±2 °C and 80% respectively by regular spray of water. Three months old plants were inoculated with spore suspension of *Fusarium* sp. (conc. $2\times10^6$ per ml) in the 2nd internode from the soil level. The inoculated part was wrapped with wet absorbent cotton, parafilm and the plant was covered with wet polythene to create the humidity and moisture. In the control treatment, sterilized water was inoculated in the plant. Appearance of the symptom was first observed 7 days after inoculation (dai). The isolation was made from the infected plant and the same pathogen (*Fusarium* sp.) was recovered again. The work is in progress for standardization and refinement of the technique.

Precise *in vitro* cane inoculation technique (PIVCIT) (Fig. 3.26) is also being standardized for the precise, accurate and rapid inoculation of sugarcane wilt in the laboratory conditions. Twenty-five cm long canes of Co 7717 were cut from 6 months old crop, split and placed in a tray. The inoculation was done by placing the mycelial disc of *Fusarium* sp. on the canes. The canes were covered with blotting paper and regular spray of water was done to maintain the humidity (80%). The trays were again covered with moist polythene to maintain the humidity and were incubated at 28 ± 2 °C. Symptoms appeared 2 days after inoculation. The isolation was made from the infected plant and the same pathogen (*Fusarium* sp.) was recovered. The experiment was conducted in five replications. This is quick, precise and accurate technique to screen the wilt resistant varieties in the laboratory. Confirmation studies are in progress for refinement of the technique.

*Trichoderma harzianum* was evaluated using liquid culture filtrate (LCF) and dual culture method for its efficacy. The LCF method was more effective in inhibiting the wilt caused by *Fusarium* sp. (Fig. 3.27). Under *in vitro* conditions, 10 *Trichoderma* spp. showed 70-90% growth inhibition of *Fusarium* sp. with the potential for use as bio-control agents against sugarcane wilt pathogen (Fig. 3.28).

**Table 3.8 Details of the *Fusarium* sp. isolated from pokkah boeng disease of sugarcane**

| Sr. No. | Name of the isolate | Source | Growth rate | Disease Severity Index | | % Identity with *Fusarium sacchari* | Gene accession no |
|---|---|---|---|---|---|---|---|
| | | | | Leaf axial inoculation | Sett inoculation | | |
| 1 | IISRBCCF01 | Co 86032 | 2.92±0.32 | 27.91±3.92 | 76.94±1.42 | 100 | OP856491 |
| 2 | IISRBCCF02 | Co 86032 | 2.64±0.22 | 26.11±2.72 | 69.99±6.23 | 97.35 | OP856492 |
| 3 | IISRBCCF03 | Co 86032 | 3.39±0.28 | 31.66±4.15 | 59.16±3.75 | 99.8 | OP856495 |
| 4 | IISRBCCF04 | Co 86032 | 2.79±0.02 | 29.16±4.6 | 71.37±3.82 | 97.8 | OP856496 |
| 5 | IISRBCCF05 | Co 86032 | 2.70±0.08 | 30.83±5.9 | 75.88±4.13 | 100 | OP856464 |
| 6 | IISRBCCF06 | Co 86032 | 2.26±0.32 | 49.85±7.02 | 44.99±1.82 | 97.8 | OP856493 |
| 7 | IISRBCCF10 | CoM 0265 | 2.5±0.8 | 25.55±2.79 | 76.52±3.94 | 99.6 | OP856497 |
| 8 | IISRBCCF11 | CoM 0265 | 2.59±0.47 | 36.44±9.9 | 50.24±3.45 | 99.8 | OP856500 |
| 9 | IISRBCCF12 | CoM 0265 | 3.08±0.16 | 30.62±4.20 | 52.21±50.9 | 99.6 | OP856499 |
| 10 | IISRBCCF13 | CoM 0265 | 2.48±0.33 | 45.67±3.61 | 54.16±4.39 | 98.9 | OP856498 |
| 11 | IISRBCCF14 | CoM 0265 | 3.04±0.12 | 26.80±3.16 | 67.63±4.22 | 99.59 | OP856502 |
| 12 | IISRBCCF15 | CoM 0265 | 2.87±0.15 | 25.12±2.72 | 49.30±1.96 | 99.13 | OP856501 |


**Fig. 3.25 Rapid Wilt inoculation method (RWIM)**


**Fig. 3.26 Precise *in vitro* cane inoculation technique (PIVCIT)**


**Fig. 3.27 Liquid culture filtrate method**

## Artificial intelligence based detection of disease and insect pests in sugarcane

A total of 13,919 RGB images (50 different classes) of insect, healthy and injured symptoms of insect, pest, disease, and physiological disorder symptoms have been captured manually through Canon EOS 77D DSLR camera, smartphone One Plus 7T Pro HD1911 (One Plus 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 (Fig. 3.29).

**Fig. 3.28 Evaluation of *Trichoderma* spp. against *Fusarium moniliforme var. sbglutinans***

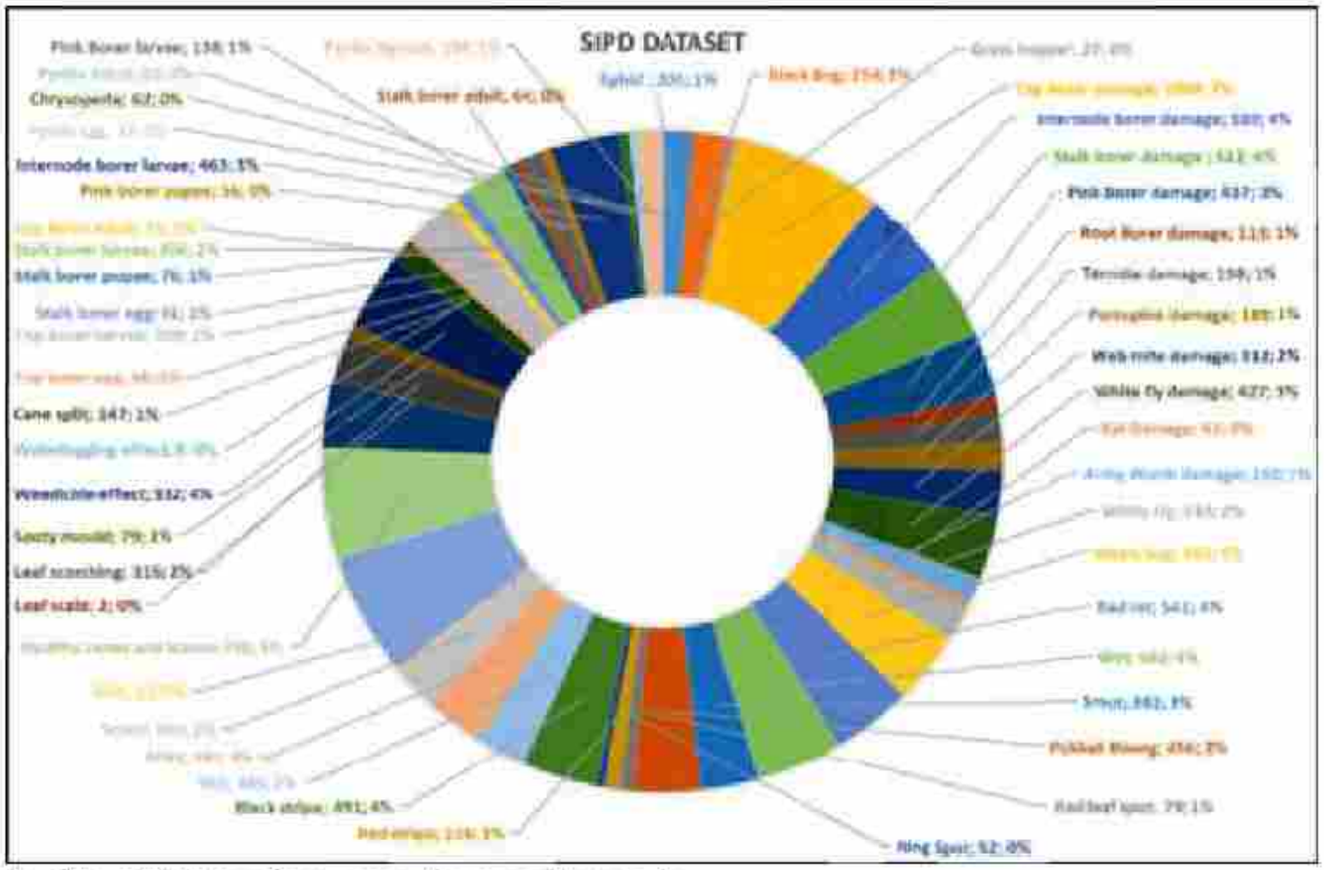



**Fig. 3.29 SIPD data set for sugarcane diseases and insect pests**

Real-time and controlled condition images were taken without and with blue backgrounds, respectively. The healthy and disease symptoms of canes and leaves of sugarcane were captured under different light conditions (*e.g.*, illumination), seasons (varying temperature and humidity), various growing phases of the crop, and at different locations. To enrich the image library, specific symptoms of diseases were collected from responding susceptible varieties of sugarcane such as Co 0238, BO 91, CoLk 8102, CoLk 13204, CoLk 94184, CoLk 14201, CoS 8436, Co 1148, CoLk 11203, CoC 671 and CoLk 11206 *etc*. The collected dataset was labelled properly and annotated to a specific folder.

In the first phase, a total of 3844 real-time (2201) and control condition (1643) images of healthy and insect-injured symptoms of sugarcane were trained, tested, and validated on five state-of-the-art deep learning (DL) models; AlexNet, ResNet 50, MobileNet V2, Inception V3 and DarkNet 53 with five different epochs (5, 10, 15, 20, 25, 30) and two different batch sizes (16, 32) (Fig. 3.30). The implemented models were evaluated based on different performance measures metrics such as accuracy, precision, recall, specificity, and F1-score. DarkNet 53 showed better performance in all the indices such as accuracy (99.38%), error (0.62%), precision (96.09%), recall (94.81%), F1-score (95.35%) and specificity (99.65%) followed by MobileNet V2 with an accuracy of 98.74%, error (1.26%), precision (94.85%), recall (94.16%), F1-score (94.48%) and specificity (99.27%). The ResNet 50 also indicated equal performance to MobileNet V2 in terms of accuracy (98.74%), error (1.26%) and specificity (99.27%), however, low values were obtained in precision (94.16%), recall (93.16%), F1-score (93.57%). Inception V3 classified the images with the accuracy, error,

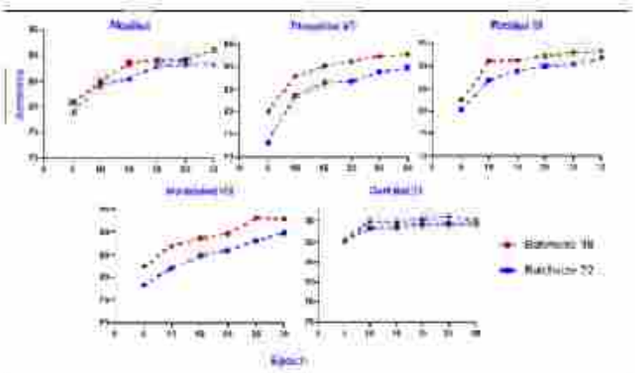


**Fig. 3.30 Performance of five different CNNs at different epoch and batch-sizes for classification of sugarcane insect pests damage image dataset**

**Table 3.9 Performance of pre-trained CNN models at epoch 25 with mini-batch size of 16**

| Model | Av. Accuracy (%) | Av. Error (%) | Av. Precision (%) | Av. Recall (%) | Av. F1 Score (%) | Av. Specificity (%) |
|---|---|---|---|---|---|---|
| AlexNet | 98.03 | 1.97 | 89.36 | 88.19 | 88.46 | 98.88 |
| ResNet 50 | 98.74 | 1.26 | 94.16 | 93.16 | 93.57 | 99.27 |
| Inception V3 | 98.58 | 1.42 | 93.57 | 91.25 | 92.30 | 99.18 |
| MobileNetV2 | 98.74 | 1.26 | 94.85 | 94.16 | 94.48 | 99.27 |
| DarkNet 53 | 99.38 | 0.62 | 96.09 | 94.81 | 95.35 | 99.65 |

precision, recall, F1-score and specificity of 98.58%, 1.42%, 93.57%, 91.25%, 92.30% and 99.18%, respectively. Compared to all the five implemented models, AlexNet expressed lower value of accuracy (98.03%), precision (89.36%), recall (88.19%), F1-score (88.46%) and specificity (98.88%) and high value of error or misclassification (1.97%) (Table 3.9)

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## Characterization of yellow leaf disease pathogen/s of sugarcane in sub-tropical India

In spring 2021, 29 sugarcane genotypes were planted at IISR, Lucknow Research Farm and evaluated for YLD incidence and all of them were infected with YLD exhibiting characteristic yellowing of mid rib symptom. Among these, 10 genotypes *viz.*, Co 8102, CoLk 14201, CoLk 94184, Co 7701, Co 7717, Co 1148, Co 0238, Co 997, CoLk 11203, CoLk 11206 and Co 13204 reported to be susceptible to YLD, were used for maintenance of the inoculum.

## Technology developed

## Mass production of pupal parasitoid *Tetrastichus howardi*

Cost-effective technology for mass production of a larval-pupal endoparasitoid *Tetrastichus howardi* (Hymenoptera: Eulophidae) was developed using larval and pupal stage of host insect *G. mellonella* under laboratory conditions. Total 417.5 and 317.0 adult parasitoids emerged with a development time of 18 and 20 days from the pupal and larval stages.

**Table 3.10 Biological attributes of *Tetrastichus* spp. in pupae and larvae of *G. mellonella* (Mean± SD)**

| Host insect stage | Body weight (mg) | Emergence of parasitoid | | | No. of parasitoid emerged/mg of body weight | Days to emergence |
|---|---|---|---|---|---|---|
| | | No. of female | No. of male | Total emergence | | |
| Pupae | 169±38.2 | 377±125.2 | 40.5±14.7 | 417.5±129.3 | 2.5±3.3 | 18.0±1.4 |
| Larvae | 209±55.0 | 263.9±100.9 | 54.7±27.9 | 317±122.3 | 1.5±2.2 | 20.3±0.7 |

CHAPTER 4

# Research in Plant Physiology and Biochemistry

## Physiological and molecular bases of multiple abiotic stress tolerance in sugarcane

Field and pot experiments were conducted to elucidate the physio-molecular traits associated with single/multiple abiotic stress tolerance. Maximum reduction in growth characters *viz.*, plant height, single cane weight, internode number and cane girth was observed in drought treatment as compared to waterlogging and salinity in both tolerant (CoS 767) and susceptible (CoJ 64) varieties studied. The total functional leaf weight of CoS 767 reduced maximum under salinity while that of CoJ 64 reduced to the maximum under drought. The extent of reduction in most of the growth parameters was less under waterlogging in both tolerant and susceptible varieties. The photosynthetic rate, stomatal conductance and chlorophyll stability index also showed maximum reduction under drought in both the varieties. As compared to the control, the lowest reduction in these traits was found under waterlogging in CoS 767, whereas in CoJ 64, the lowest reduction was observed under salinity. The root characteristics *viz.*, root weight and root volume were also reduced under different stress treatments; maximum reduction was observed under salinity while minimum was found under waterlogging in both the varieties. Root tissue density and root electrolyte leakage showed an increase under different stress treatments as compared to the control. The maximum increase in root tissue density was found under salinity, while that in root electrolyte leakage was observed under drought in both the tolerant and susceptible varieties.

Transcriptomic studies revealed that the highest decrease in photosynthetic gene expression was observed under salinity; a total of nine photosynthetic genes showed more than log 2 fold decrease in expression under salinity, whereas, under drought and waterlogging, two photosynthetic genes showed more than log 2 fold decrease in expression. The changes in photosynthetic gene expression were closely associated with measured photosynthetic rate and stomatal conductance under different stresses. Five peroxidase (POX) genes exhibited more than log 2 fold decrease in expression under drought and minimum increase in POX activity was also observed under drought as compared to the other stresses. Two peroxidase genes, each under salinity and waterlogging showed more than log 2 fold increase in expression and increase in POX activity under these stresses were also higher. Five potassium transporter genes which are common to drought, salinity and waterlogging showed more than log 2 fold decrease in expression and this resulted in lower leaf tissue K concentration under these stresses. The highest decrease in leaf tissue K concentration was found under salinity followed by waterlogging and drought. In a field experiment, eleven genotypes were evaluated for tolerance to drought, waterlogging and sequential combination of drought and waterlogging. The stress tolerance measured in terms of relative cane weight indicated that genotype A 27-12 was the most tolerant to drought, waterlogging and to their combination, while CoJ 64 was the most sensitive under these stresses. The correlation between stress tolerance and different physiological traits showed that CSI (%) and leaf tissue K concentration have a significant positive correlation with stress tolerance in different genotypes.

## Understanding mechanisms of sugar accumulation and WUE in sugarcane through physio-biochemical studies

Five varieties of sugarcane *viz.*, CoLk 94184, BO 91, CoJ 64, CoLk 14201 and CoLk 11206 were evaluated for their stress tolerance during early growth period. The plants were grown in grow bags (2×2 feet) and moisture stress spanning a period of 45 days was created by regulated supply of water during tiller growth stage. Stressed plants were maintained at 20% of field capacity while full irrigation was provided to the control. Physio-biochemical traits *viz.*, relative water content (RWC), rate of photosynthesis, photosynthetic efficiency (Fv/Fm), proline content, total chlorophyll content, catalase (CAT) and peroxidase (POX) activity were measured in both control and stressed plants. Root traits and leaf rolling behaviour were also observed (Fig. 4.1 and 4.2).

Maximum decrease in RWC was recorded in CoJ 64 (23%) followed by CoLk 14201 (15%) while CoLk 94184, BO 91 and CoLk 11206 showed a decline of 10% only. Photosythesis rate was significantly decreased in all the varieties but the decline was more in CoJ 64 under stress condition. Fv/Fm value was also drastically reduced to 0.488 in CoJ 64 under stress as compared to 0.741 under control. The per cent decrease was again more as compared to other varieties under study. Other varieties exhibited an early rolling of leaves, thus, limiting the area under direct sunlight. The varieties CoLk 94184 and BO 91 maintained greener leaves as evident by total chlorophyll content. An increase in

proline content and catalase and peroxidase activities was recorded in all the varieties, however, the increase was maximum for var. BO 91 followed by CoLk 94184. More than 50% reduction in root volume was recorded in all the varieties, however, maximum decline in number of active (live) roots was more in CoJ64 (Fig. 4.3).

**Fig. 4.1. Leaf rolling**


C : Control; S Stressed

**Fig. 4.2. Root traits**

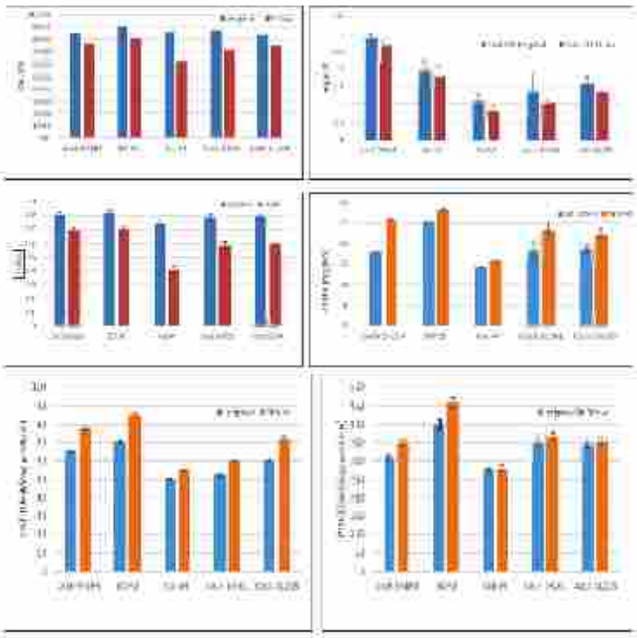


**Fig. 4.3. Physio-biochemical traits**

## 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 as a basal dose and their foliar application at 90 and 120 DAP @ 14 g/ L 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 the control (Fig. 4.4). Maximum sprouting % was found with silicic acid at the rate of 200 kg/ ha at both 20 and 45 DAP (30.15 and 42.44%). Acid Invertase activity was highly modulated with silicic acid (0.51 and 0.65 mmol/ min/ mg protein) as compared to the control (0.14 and 0.17 mmol/ min/ mg/ 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 mg/ g fw in control.

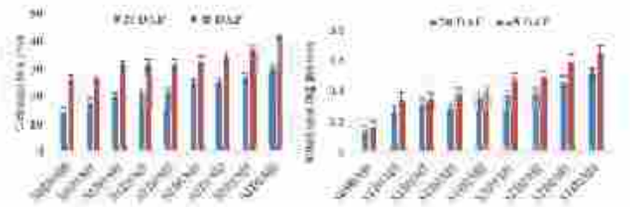


**Fig. 4.4. Effect of silica on germination (%) and acid Invertase activity**

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 %) (Fig. 4.5). 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 in the control (0.68 µmol/ g fw) while it was minimum with silicic acid (0.34 µmol/ g fw). Silicic acid @ 200 kg/ ha exhibited the highest super oxide dismutase (SOD) activity (16.23 units/ mg protein) in 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 µmolmin/ mg protein). However, during stress, silicic acid treated plants exhibited maximum catalase activity (36.65 µmolmin/ mg protein) which is more than that in their non-stress counterpart (36.65 µmolmin/ mg protein). Peroxidase activity in the control (55.03 µmol min/ mg protein) was maximum during non-stressed condition, while it was the least in stressed

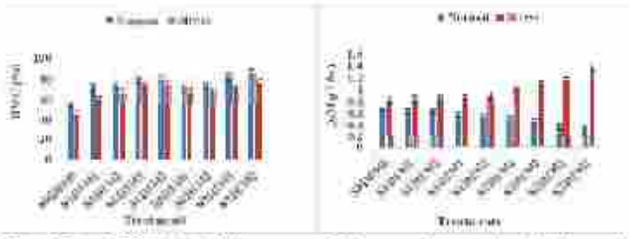


**Fig. 4.5. Effect of silica on relative water content (%) and proline content (µM/g FW)**

plant (60.09 µmol min/mg protein). A pronounced increase in peroxidase activity was observed with silicic acid (86.45 µmolmin/mg protein) in stressed plant over non-stressed (40.43µmolmin/mg protein).

## Impact of *Jeevamrutha* on sugarcane growth, yield and juice quality attributes

An experiment was conducted in autumn with ethrel, *Jeevamrutha*, and water for the setts priming and control in the sugarcane variety CoLk 94184. Prior to planting, setts were soaked overnight. 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. Invertase activity and reducing sugar content was highly increased in ethrel treated setts at both 20 and 45 DAP (Fig. 4.6). Maximum invertase activity was recorded in ethrel treated CoLk 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* treated setts (8.61 and 15.02). Both ethrel and *Jeevamrutha* augmented the number of leaf/stalk and leaf area/stalk at 180 DAP. However, it was prominent in ethrel (8 $cm^2$/stalk and 2406.82) against *Jeevamrutha* (7 $cm^2$/stalk and 2111.83).

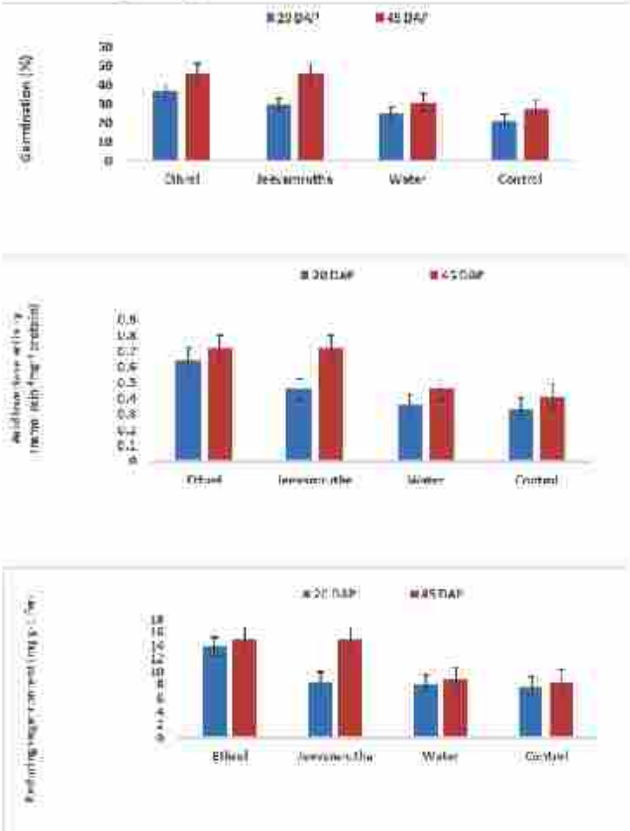



**Fig. 4.6. Effect of different sett treatments on germination (%), acid invertase activity and reducing sugar content**

Photosynthesis rate recorded in ethrel was maximum (26.15 µmol m/s) followed by *Jeevamrutha* (22.57 µmol/$m^2$ s). However, it was minimum in control (12.83 µmol/$m^2$ s). Stomatal conductance was maximum in ethrel treated setts (0.22 mol/$m^2$ s) followed by *Jeevamrutha* (0.18 mol/$m^2$ s) while in control, it was 0.107 mol/$m^2$ s (Fig. 4.7). Maximum transpiration rate was observed in control (9.11mmol/$m^2$ s). Both ethrel and *Jeevamrutha* exhibited lower transpiration rates (4.19 mmol/$m^2$ s and 6.22 mmol/$m^2$ s). Biomass accumulation in different plant parts *viz*, shoot, leaf sheath, leaf and root at 180 DAP indicated that the ethrel treatment resulted in maximum biomass accumulation (39.82, 33.20, 22.50 and 14.30 g/100 g) followed by *Jeevamrutha* treatment (38.24, 31.17, 20.73 and 13.28 g/100 g). In the control, the respective values were 32.19, 20.45, 15.36 and 10.06 g/100 g.

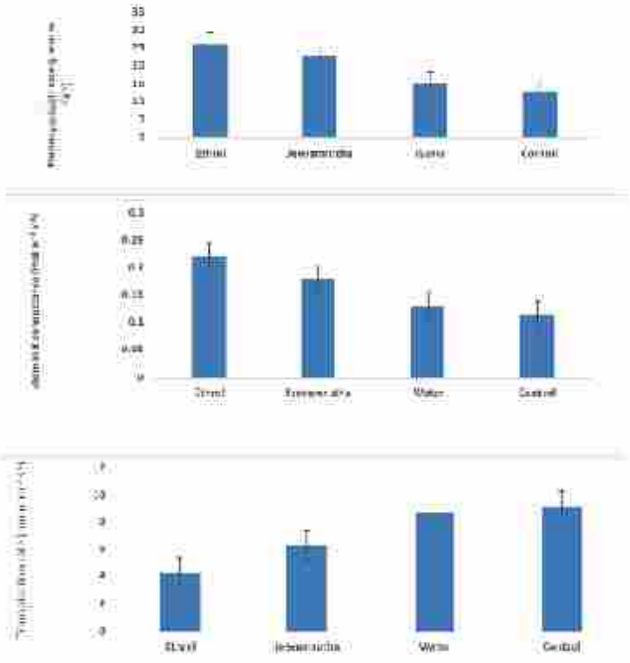


**Fig. 4.7. Effect of different sett treatments on photosynthetic rate, stomatal conductance and transpiration rate**

Juice quality attributes such as sucrose (%), purity coefficient and °Brix were 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 (3,08,000 and 2,94,000 NMC/ha) and cane length (322.25 and 275 cm), girth (2.90 and 2.90 cm), number of internodes (25 and 25), internodal length (12.89 and 11.00 cm) and single cane weight (1.03 and 0.97 kg) were highly influenced in ethrel treated setts followed by *Jeevamrutha* treated setts. However, in untreated control, both the yield (2,27,000 NMC/ha) and their attributes (232.32 cm, 2.80 cm, 22, 10.56 cm, 0.90 kg) were significantly

lower as compared to ethrel and *Jeevamrutha* treatment. The results highlight the importance of *Jeevamrutha* as a germination promoter and as an indigenous plant growth promoter and this can be a cheap and eco-friendly technology for the cane grower.

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

### Biomass dynamics during sugarcane growth cycle through plant growth regulators

A field experiment was initiated on March 08, 2022 with two doses of IBA, 6BA and NAA each along with water, ethrel and absolute control in the sugarcane variety CoLk 94184. Tiller numbers and biomass accumulation till 210 DAP indicated that maximum improvement in germination and biomass dynamics occurred with ethrel as compared to water and control. Maximum germination % was recorded with ethrel @ 100 ppm > NAA @ 50 ppm > NAA @ 100 ppm against water and control at 20, 30 and 45 DAP. Early in the growing season at 120 DAP, average initial shoot number was the highest with ethrel (1,34,523 shoots/ha) followed by NAA @ 50 and 100 ppm against 1,28,514 and 1,18, 238 shoots/ha, respectively against 81,236 shoots/ha with water. Sugarcane plants partitioned more biomass into leaves than shoots between 60 and 120 DAP. Biomass partitioning into leaves decreased from about 75% at 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. While the effects of plant population on biomass partitioning were not remarkable, the differences in partitioning with the PGRs were clear cut. *Ethrel* @100 ppm partitioned more biomass into the stalks than NAA at both the concentrations assessed. The trend was especially clear after partitioning to stem had peaked during the grand growth stage (GGP) at 210 DAP while stalk to total biomass ratios were close for Ethrel and NAA @ 50 ppm, ranging from 56.0 to 52.1%. Stalk to total biomass ratios were 43.0-44.9% for ethrel and NAA @ 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. Accordingly, average initial shoot numbers were the highest with *Ethrel* (14,8,816 shoots/ha) followed by NAA @ 50 and 100 ppm at 120 DAP with 1, 32,415 and 1, 23,865 shoots/ha, respectively against 98, 817 shoots/ha with water. The biomass accumulation pattern remained the same till 180 DAP. Thus, biomass accumulation was the highest in ethrel against all compounds at all concentrations. Tiller numbers/ha were 1,76,618, 1,41,185, 1,21,618 shoots $ha^{-1}$ with ethrel @ 100 ppm, NAA @ 50 & 100 ppm against 1,28,341 shoots/ha with water at 180 DAP. Other biometric traits showed similar trends with maximum impact with sett soaking with ethrel followed by NAA @ 50 and 100 ppm till 240 DAP. Number of plants/ha, per cane weight and cane weight (t/ha) indicated maximum effect of ethrel, followed by NAA @ 50 & 100 ppm with 1,42,854, 1,27,306, 1,39,597 plant numbers/ha against 1,15,735 plant numbers/ha in water.

### Demonstration of PGR technology

Two field demonstrations of PGR Technology were conducted with sugarcane varieties, CoLk 94184 and CoLk 14201 in autumn and spring seasons (Fig. 4.8A, B &C). Exogenous application of ethrel & $GA_3$ stimulated


**Fig. 4.8. Demonstration of PGR technology**

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 and cane yield (t/ha).

The PGR technology developed 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.

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

Sugarcane lignocellulosic biomass is an attractive renewable feedstock for future Ethanol Blending Programmes. Efficient and cost-effective production of bioethanol from lignocellulosic biomass depends on the development of a suitable pretreatment system. A new pretreatment method was attempted and found to be highly efficient and effective for downstream biocatalytic 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 processes under the same conditions, the pretreatment 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 in removing lignin from lignocellulosic cell walls, resulting in enhanced enzymatic accessibility of the substrate and more efficient cellulose hydrolysis. This pretreatment 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.

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

The sugarcane genotypes CoLk 94184 and CoJ 64 in waterlogged and normal conditions (control) were used for trancriptome analysis.

## Transcriptome analysis

Using NCBI Primer3/BLAST tool, 30 primer pairs were designed and synthesized. Transcriptome analysis of the leaf tissues of four samples (S1, S2, S3, S4) control and waterlogging induced plants of the varieties CoLk 94184 and CoJ 64 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 4.1). Unigenes showed 49.2% similarity with *Sorghum bicolor*, 14.9% % with *Zea mays*, 2.1% with *Oryza sativa*, 4.1% with *Setaria italica*, 1.87% with *Saccharum* hybrid and 19.48% with others (Nr annotation) (Fig. 4.9). Based on GO annotation, genes were 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 "Post-translational modification, protein turnover, chaperones (O). In Pfam analysis, the 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.

**Table 4.1. Number of Unigenes annotated with different sets of databases**

| | No of Unigenes | Percentage (%) |
|---|---|---|
| NR | 66731 | 22.6 |
| Uniprot | 47817 | 16.2 |
| GO | 31893 | 10.8 |
| KOG | 29933 | 10.1 |
| Pfam | 29243 | 9.89 |
| Transcription factor database | 33,082 | 11.19 |
| KEGG | 10380 | 3.51 |
| All four databases | 20261 | 6.85 |
| At least 1 database | 66785 | 22.59 |
| Total no of Unigenes | 295618 | |

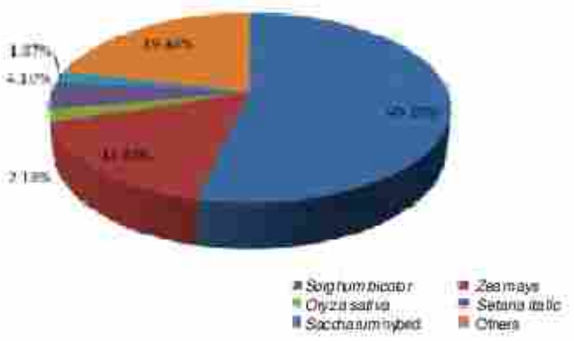
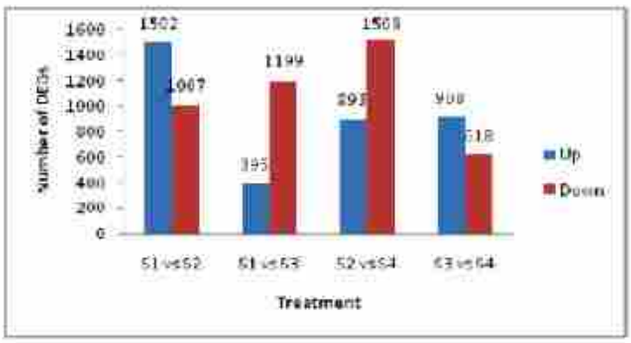



**Fig. 4.9. Species classification of Nr distribution**

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. 4.10).




S1 = CoLk 94184 Control leaf tissues; S2 = CoLk 94184 waterlogging exposed Leaf tissues; S3 = CoJ 64 control leaf tissues; S4 = CoJ 64 waterlogging exposed leaf tissues

**Fig. 4.10. Differentially expressed genes (DEGs) of four sets of sample**

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. Fifteen primers based on novel transcript 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 (Unigene5311), 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.


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

CHAPTER 5

# Mechanization of Sugarcane Farming

## Development of cane node planter

The metering mechanism of the developed cane node planter was modified. Performance of metering at different speeds, lug shape, height and spacing was recorded. The design of metering mechanism was finalized based on its performance during different combinations. The spring loaded pushers have been been incorporated for efficient metering of cane nodes during planting. The cane node planter with modified metering mechanism was tested in the field condition at IISR farm. The machine performs deep furrow opening, metering of pre-soaked cane nodes, fertilizer application and covering of planted cane nodes with soil simultaneously in a single pass.

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

## Development of sugarcane trash management machinery

The new prototype machine comprises of trash mulcher unit, stubble shaving unit and chemical spraying unit which cover two rows of sugarcane. The chemical spraying unit is for applying trash decomposer for its faster decomposition. The tractor PTO power is utilized to operate the machine. The reduced rpm through gearbox is transmitted by belt and pulley power transmission system to trash mulcher and stubble shaver. The rear roller ensures uniform depth control while covering two rows of sugarcane and trash in between the rows. The prototype was field tested at the IISR farm with satisfactory performance. A patent has been filed with the Patent Office, New Delhi, India vide Application No. 202211007706 A February 14, 2022 for the machine.

## Development of e-Powered multipurpose equipment adapted to controlled traffic farming (CTF)

Design development of the matching implements for various farm operations in the field for CTF was studied. The tractor track width was adjusted to 175 cm instead of 150 cm to suit the various machines. Two-row IISR deep furrow sugarcane cutter planter for 60 cm spacing was developed. The performance of the planter was satisfactory in accomplishing the unit operations that involved cane planting, application of fertilizer and chemical insecticide, covering of setts with soil and pressing the covered soil; in a single pass of the equipment. An experiment was laid in the IISR farm for one hectare to study the CTF and conventional sugarcane cultivation. A new two cane row machine, Furrower-cum-packer which will make ridges and firm it to avoid lodging is under fabrication.

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

**Ergonomic evaluation of IISR sett cutting machine:** The ergonomic evaluation of IISR sett cutting machine was carried out for cutting of three (Fig 5.2) bud setts. This machine has two circular stainless-steel blades of diameter 40.6 cm. An electric motor of one horsepower (240 V) is used to operate the machine. Power to the blades is through flat belt pulley and double grooved V pulley from the motor. The speed of blades is 960 revolutions per minute. The height of the platform from the ground to put cane for sett cutting is 105 cm. Two people can perform sett cutting operation simultaneously. Two individuals, male and female, were selected for sett cutting operation. The data of sett cutting was taken for 20 minutes continuous work by the operator. The number of setts cut by the male and female operators varies depending upon the sugarcane variety selected.

**Table 5.1 Performance of the sett cutting machine**

| Parameter | Variety I (CoLK 11203) | | Variety II (CoLK 14201) | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| Time, min | 20 | 20 | 20 | 20 |
| Average no. of sett cut | 3500 | 2840 | 3480 | 2904 |
| Average weight of the sett cut, kg | 196 | 175 | 254 | 218 |
| Damage, % | 8-10 | 8-10 | 8-10 | 8-10 |

The number of setts cut by a person with manual conventional cutting blade in 20 minutes was 250-370 whereas it was 2,840-3,500 with the machine. The overall capacity of machine for sett cutting by two operators was 8,520-10,500 sett/ h. However, the bud damage of 8-10% during sett cutting was observed.

**Fig. 5.2 Sett cutting machine operation at the Institute farm**

The physiological workload in terms of working heart rate and energy expenditure rate was in the range of light category for male and female workers. However, female operator had slightly higher energy expenditure rate (8%) and overall discomfort rate (31%) than the male operator (Table 5.2).

**Table 5.2 Ergonomic evaluation of the sett cutting machine and the sugarcane manual stripper cum detopper**

| S. No. | Parameter | Gender operating | | | |
|---|---|---|---|---|---|
| | | Sugarcane sett cutting machine | | Sugarcane manual stripper cum detopper | |
| | | Male | Female | Male | Female |
| 1. | Working heart rate (beats/min) | 98.6 | 102.4 | 99.6 | 102.0 |
| 2. | Δ Working heart rate (beats/min) | 25.8 | 27.2 | 25.0 | 25.6 |
| 3. | Oxygen consumption rate (l/min) | 0.44 | 0.48 | 0.45 | 0.48 |
| 4. | Δ Oxygen consumption rate (l/min) | 0.29 | 0.31 | 0.28 | 0.29 |
| 5. | Energy expenditure rate, EER (kJ/min) | 6.95 | 7.56 | 7.11 | 7.49 |
| 6. | Δ Energy expenditure rate, kJ/min | 4.1 | 4.33 | 3.97 | 4.07 |
| 7. | Overall discomfort rating (ODR) | 3.5 | 4.6 | 3.2 | 3.5 |

**Ergonomic evaluation of manual sugarcane stripper-cum-detopper.** Stripper-cum-detopper is used to remove dry or green leaves from the harvested cane and cutting of green top. The newly developed IISR manual stripper-cum-detopper having 225 g weight was ergonomically evaluated with male and female operators at the Institute farm in three different sugarcane varieties (Fig. 5.3). After harvesting of cane, data of cane stripping and de-topping was taken for 20 minutes of continuous work by the operator. The physiological responses of selected subjects were also studied. The average number of cane stripped and detopped per hour by male and female operator were 234 to 285 with an average weight of cleaned cane of 114 to 243 kg (Fig. 5.4).

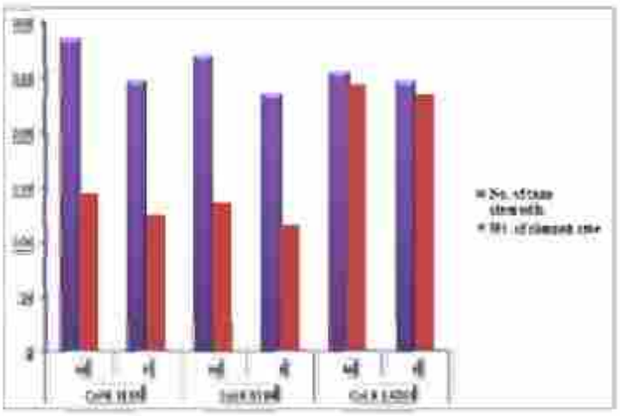


**Fig. 5.3 Performance of manual stripper-cum-detopper in different varieties**

**Fig. 5.4 Operation of sugarcane stripper cum detopper in the field**

The physiological workload in terms of working heart rate and energy expenditure rate was in the range of light category with both male and female farm workers.

## Development of inter-intra row weeding system for transplanted sugarcane

The existing weeding machinery and their working function for sugarcane weed management have been

studied. In order to develop the intra-row weeding system, sensors such as ultrasonic sensors equipped with Arduino/Raspberry Pi were identified and computer programming was done. In addition, six AI-based deep learning models (AlexNet, DarkNet53, GoogLeNet, InceptionV3, ResNet50, and Xception) were trained for identifying weeds in sugarcane crops using field imagery followed by their performance evaluation in terms of accuracy and F1 score. AI-based deep learning-driven classification of sugarcane and weed is shown in Fig. 5.5. Out of these, DarkNet53 delivered a high F1 score value (~99%) and outperformed other models for weed identification with a higher level of confidence (~98%) at mini-batch size of 16 and epochs of 20. Post-training, DarkNet53 was tested with another separate dataset of 200 images and >96% net accuracy was obtained when compared with naked-eye weed identification. This developed model was incorporated into the weeding system. Further, the design of the new prototype machine has been conceptualized.

## Inter Institutional collaborative research project on testing and evaluation of selected IISR sugarcane machineries under tropical conditions

Two machines of IISR *viz*, deep furrow sugarcane cutter planter and disc type ratoon management device were developed after carrying out modifications to make it suitable for tropical region. Both machines were supplied to ICAR-Sugarcane Breeding Institute, Coimbatore for field testing and performance evaluation.

## Deep furrow sugarcane cutter planter

Design modifications were carried out and a new prototype of two row deep furrow sugarcane cutter planter was developed with adjustable row spacing of 120 and 150 cm (Fig. 5.6). Design modifications were done to make it suitable for tropical region. It was equipped with deep furrow opener to facilitate furrow method of sugarcane planting. The designed planter consisted of deep furrow opener, sharp edged blades to cut whole cane into 350 mm long pieces as seed material, metering device for application of fertilizer and insecticide, soil covering shovels and tamping roller for pressing soil cover. It could be operated by a 30 kW power tractor. It was a mounted type equipment rigidly attached with tractor through three-point linkage. The planter was pulled by the tractor and its cutting blades as well as fertilizer metering rollers were driven by PTO shaft. Planter was fabricated in the workshop of ICAR-IISR, Lucknow and supplied to ICAR-SBI, Coimbatore for conducting its field adoptability trials in tropical region. Performance trials of the planter are in progress at SBI farm (Fig. 5.7).

A Memorandum of Agreement (MoA) was signed with M/s Pishon Technologies, Coimbatore for commercial production of deep furrow sugarcane cutter planter.

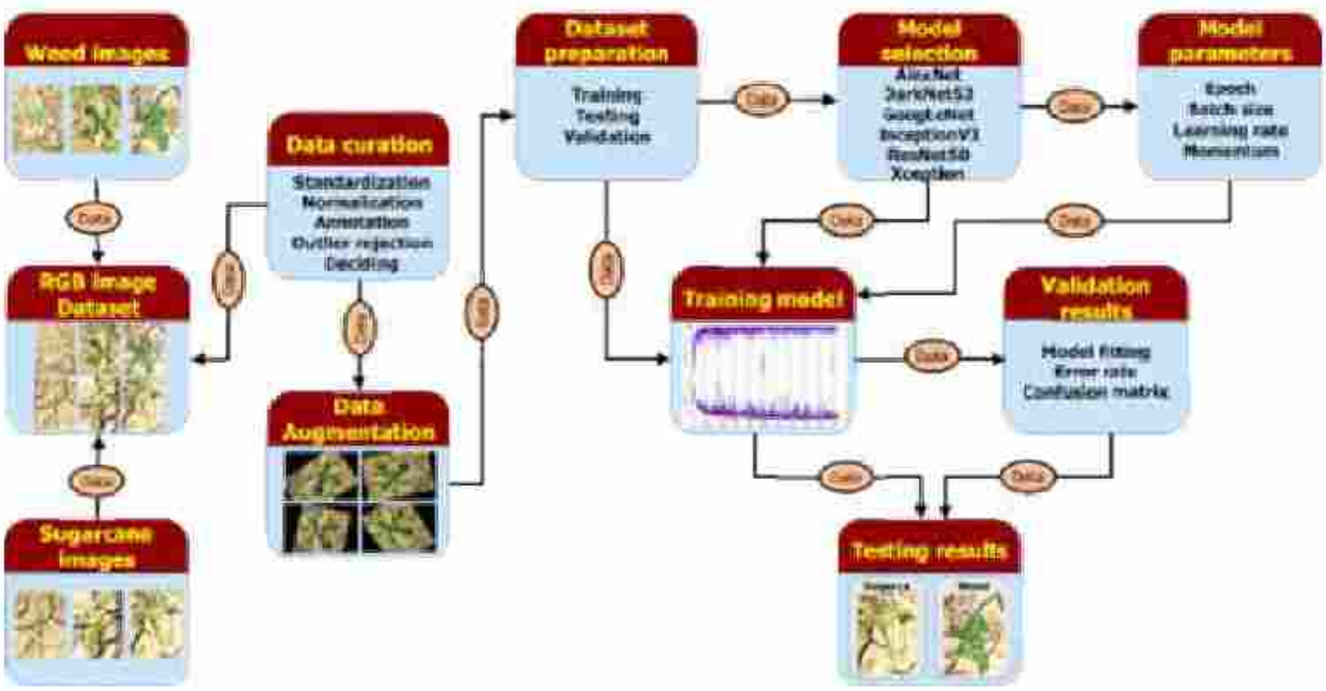



**Fig. 5.5 AI-based deep learning-driven classification of sugarcane and weed**

Fig. 5.6 Developed prototype of tractor operated wide spaced deep furrow sugarcane cutter planter

Fig. 5.7 Sugarcane planting with IISR - two row deep furrow cutter planter at ICAR-SBI, Coimbatore farm

## Disc type ratoon management device (Disc RMD)

The prototype of disc type ratoon management device (Disc RMD) was modified (Fig. 5.8). Fertilizer metering mechanism was modified to make it suitable

Fig. 5.8 Developed prototype of tractor operated disc type ratoon management device (Disc RMD)

Fig. 5.9 Ratoon management using IISR-Disc RMD in the field at ICAR- SBI, Coimbatore farm

for metering of fertilizer in high ridge fields prevalent in tropical region. It was equipped with stubble shaving serrated blades mounted on a disc, two tillage discs for off-barring (pruning of old roots) on either side of the stubbles and fertilizer metering device for application of fertilizer at root zone. Modified prototype of Disc RMD was fabricated and supplied to ICAR-SBI, Coimbatore for conducting its field adoptability trials in tropical region (Fig. 5.9).

## AICRP on Farm Implements and Machinery (FIM)

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

**Prototypes fabricated**

| Machine/Implement | Source of Power | Number |
|---|---|---|
| Deep furrow sugarcane cutter planter | Tractor | 2 |
| Wide spaced deep furrow sugarcane cutter planter-cum-multicrop seeder | Tractor | 1 |
| Trench opener | Tractor | 1 |
| Deep furrower | Tractor | 1 |
| Disc type sugarcane management device | Tractor | 2 |
| Manual cane stripper-cum-detopper | Manual | 20 |
| Manual cane node cutter-cum-bud scooper | Manual | 60 |
| Motor operated paddy thresher | Motor | 1 |
| Pedal operated paddy thresher | Manual | 1 |
| Cane juice extractor | Manual | 2 |
| Manual grass cutter | Manual | 10 |
| Manual customized soil auger | Manual | 1 |
| **Total** | | **102** |

### Prototype feasibility testing

#### Prototype Feasibility Testing of Automatic potato-cum-sugarcane trench planter

Prototype feasibility testing of tractor operated automatic potato-cum-sugarcane trench planter (Fig. 5.10) was conducted at IISR farm. Soil of the field

**Prototypes supplied**

| Name of prototype | Number | Supplied to |
|---|---|---|
| IISR TO deep furrow sugarcane cutter planter | 5 | Sugarcane Research Institute (SRI), DRPCAU Samastipur, Bihar |
| IISR TO disc type sugarcane ratoon management device (Disc RMD) | 3 | Sugarcane Research Institute (SRI), DRPCAU Samastipur, Bihar |
| IISR pedal operated paddy thresher | 1 | College of Agriculture, Kyrdemkulai, P.O. Umsning, Distt. Ri Bhoi, Meghalaya |
| IISR manual bud chipper | 1 | Mr Manoj Kumar, Vill. Bhan Nagar, Govindpuri, Modi Nagar, Ghaziabad |
| IISR manual cane node cutter-cum-bud scooper | 1 | Mr. Satya Prakash Mishra, Mehamoodabad, Sitapur, U.P. |
| IISR manual cane node cutter-cum-bud scooper | 1 | Mr Yogesh Singh, Jaitpur, Bulandshahar, U.P. |
| IISR manual cane stripper-cum-detopper | 10 | KVK, Amroha, U.P. |
| IISR manual cane stripper-cum-detopper | 7 | KVK, Gopalganj, Bihar |
| **Total** | **29** | |

**Fig. 5.10. Automatic potato-cum-sugarcane trench planter under field operation**

was sandy loam. Crop parameters like variety, average length and weight of whole seed-cane stalks, average seed potato tuber, field parameters like length and width of field were recorded. 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. A 30 kW tractor was used for operating the planter in first low gear at 1100 engine rpm.

At forward speed of 0.5 m/s, mean overlapping between two successive setts were 68 mm, which was within the desired overlapping range of 50-100 mm for the study area. The average spacing between seed potato tubers was 192 mm. Missing of seed potato tubers in the cups of metering unit was 7.1%. Picking of more than one seed potato tubers was 5.4%. Missing and multiple picking of seed potato tubers complemented each other and therefore, desired seed rate was maintained. The slight variation due to missing and multiple picking did not affect the uniformity of the crop stand.

The field capacity of the planter was 0.27 ha/h. Time lost in filling of seed, insecticide solution, turning, miscellaneous settings and other activities in terms of total planting time was 47% of total operating time. It was observed that maximum time was lost in filling of inputs followed by turning of the tractor. The effective field capacity of the planter was 0.127 ha/h, thus, to plant one ha area, it would take eight hours. The cost of planting operation with developed planter was 3,160 per ha whereas it was ₹ 13,600 per ha when planting was done manually. Thus there was 76.8% cost saving in planting with the developed machine. The labour requirement with planter was significantly low as compared to manual planting. It required 56 man-h/ha to plant with the planter, whereas manual planting required 567 man-h/ha. Thus saving in labour by planting with the developed machine was 90%.

## Prototype Feasibility Testing of Pedal operated paddy thresher

Prototype Feasibility Testing of Pedal operated paddy thresher (Fig. 5.11) was conducted at the Institute farm as well as at farmers' field of Lucknow and Sitapur districts. It was operated for 25 hours at the institute farm and 30 hours at farmers' field. The performance of the thresher was compared with the conventional practice *i.e.* beating the paddy bundle on stones or wooden platform in bending posture in term of threshing

**Fig. 5.11. Pedal operated paddy thresher in operation**

capacity, threshing efficiency and energy requirement under different moisture content and stalk length. The machine 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.

The performance of the thresher was evaluated in respect of three parameters namely threshing capacity, threshing efficiency and energy requirement. The performance result is presented below:

| Variety of paddy | Kalanamak | Basmati |
|---|---|---|
| Threshing capacity, kg/h | 60 | 85 |
| Threshing efficiency, % | 97 | 98 |
| Moisture content of paddy gram, % | 19 | 20 |
| Weight of 1000 gram, g | 16 | 25 |

## Centre of Excellence in farm machinery

### Development of motor operated paddy thresher

The testing of the developed prototype of motor operated paddy thresher (0.373 kW) was carried out at KVK, ICAR-IISR, Lucknow farm in variety HUR-917 (Fig. 5.17). Two persons were used to perform threshing operation on this machine at a time. The threshing capacity and threshing efficiency was observed to be 280 kg/h and 97.2%, respectively.

**Fig. 5.17 Testing of motor operated paddy thresher**

### Development of manual interculturing-cum-earthing up equipment

A new prototype of manual interculturing-cum-earthing up equipment (Fig. 5.17-5.18) for vegetable crops having overall dimensions LxWxH: 1600x260x900 mm was developed. The equipment is having two wheels (diameter 400 mm) made of MS flat of size 25x3 mm. The equipment has a base plate having holes where there is a provision of attaching interculturing and earthing-up tools. The width of interculturing can be adjusted from 150 to 300 mm. The equipment has been fabricated and tested at institute farm.

**Fig. 5.18 Prototype of manual interculturing and earthing-up equipment**

CHAPTER 6

# Diversification and Value-addition in Sugarcane

## Development of integrated drying system for jaggery drying

A solar collector unit has been designed. It consisted of a frame having dimensions 2.4 m length, 1.0 m width and is made of 25x6 mm angle iron. It has inclination of 27° and base of the collector was made of mild steel sheet. There was a provision of entering ambient air through channel width of 2.5 cm. The length of collector has been divided into three parts. Each part was covered with 4 mm plain glass. To reduce heat loss, glass wool was filled. The exit vents were provided for entry of hot air in drying chamber. Provision of hot air from waste heat recovery system and mechanical dryer had also been attached in the input air to the drying chamber.

## Refinement of sugarcane cleaner cum washer for jaggery

Sugarcane cleaner-cum-washer was found to clean cane when canes are fed three times. A safety cover has also been designed for the machine.

## Development of IISR model jaggery unit for enhanced capacity

The unit was evaluated for its performance on the basis of total consumption of bagasse, total time consumption and water evaporation rate during the preparation of six batches of jaggery. The overall consumption of bagasse per batch was 240 kg for production of 100 kg jaggery from 600 kg juice. The thermal efficiency of the furnace was estimated as 28.4%.

## Development of small powder jaggery cubes

The machine was evaluated. Problem of cube breakage was noticed due to non uniform manual pressure application. Jaggery powder cube sticks to the bottom plunger plate resulting in cube breakage. Also the base plate needs fixing. To overcome the problem, the bottom plunger plate has been made with non stick material. Efforts have been made to apply pressure through motor to resolve the problem of cube breakage.

## Establishment of ABI unit at ICAR-IISR, Lucknow

Upgradation of PHET lab and renovation of ABI office space was done. The ABI unit for jaggery was made operational. One incubatee got graduated and one new incubatee was admitted. Expression of interest was uploaded on IISR website.

## Development of process technology protocol for manufacturing of protein rich jaggery using natural source

A protocol for manufacturing of protein rich jaggery using soybean as a natural source has been developed. During third year, only 100 and 150 g soybean (400 and 600 g paste without seed coat) was used. Protein content of jaggery with 150 g and 100 g soybean was 6.27 and 5.23 per cent, respectively. However, protein concentration was only 0.87 per cent.

## Technology/Process development

A study was undertaken to prepare a jaggery-based low sugar apple jam with no added chemicals or preservatives. Fresh and mature apples were cleaned, peeled, cut into slices and grated and weighed. Grated pulp was taken in a pan and put on a low flame, 400 g of jaggery was added into the pulp and mixed thoroughly. TSS (°Brix) was measured and sheet/drop test was performed to check the doneness of the product. Five ml of lemon juice was added and the jam was packed in sterilized glass jar and stored.

## Jaggery making using silicon moulds

Silicon moulds were developed with the help of a private manufacturer for making 2 g jaggery candy. The cost of one mould was ₹ 2,000.

CHAPTER 7

# Developing Sugar Beet Varieties Suitable for Indian Agro-climates

## Seed production and maintenance of sugar beet germplasm at Sugar beet Breeding Outpost, Mukteshwar (Nainital)

Sustained growth in sugar beet production and productivity necessitates the constant development of new and superior crop varieties, as well as an efficient system of seed production and distribution to farmers. It is critical for the expansion/dissemination of sugar beet seed and crop popularization that Indian farmers have access to a diverse selection of high-quality seeds in sufficient quantities on a timely basis. With this objective, the seeds of varieties LS 6, LKC 2020 and IISR Comp 1 are being produced for need-based supply to the sugar beet growers of the country. Seeds of indigenous genotypes, LKC 2020 (better ethanol recovery under water limiting condition), LKC 2000 (improved juice quality under post-harvest technology), LKC LB (fodder purposes with low brix and water deficit tolerant), LKC 2020-1 (*Spodoptera litura* resistant), LKC 2006 and LKC 2007 (water deficit tolerant) are being produced for experimental purposes. Four new crosses, *viz.*, Shubra (CMS) × LS 6; IN 13 × LK 4; 7112 × BTS 605; SYT/06/11 × SVEB 616 were attempted at Mukteshwar in order to generate indigenous types for the Indian subtropical climate. Segregating populations of previous year cross combinations (IN 17 × LK 4, LK 0501 × LS 6, LK 9503 × LS 6 and LK 0503 × LK 27) are being evaluated during the period under report.

Storage of sugar beet seed is important for maintaining the viability and quality of the seed. Considering this, 149 germplasm accessions of sugar beet are being preserved in cold storage at IISR, Lucknow and every alternate year, the seeds are sown to maintain viability. One third of sugar beet germplasm has been sown this year at Sugar beet Breeding Outpost, Mukteshwar by steckling/direct sowing methods.

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

Drought stress disrupts multifarious morpho-physio-biochemical-molecular and ecological processes, resulting in a quantitative and qualitative loss in sugar beet yield. Considering thus, priority should be given to maintain its quantitative and qualitative performance under drought stress. In this context, to identify the sugar beet germplasm for water limiting conditions having high yield potential and drought tolerance, an experiment was carried out with 14 genotypes including two checks (LS 6 and IISR Comp 1) in three replications. Drought was imposed by withdrawal of irrigation and was regularly monitored. Meanwhile, irrigated plot was well saturated with desired irrigation. The genotypes namely LKC 2006 and LKC 2007 maintained their superiority for single root weight, root length, and the root diameter against checks (LS 6 and IISR Comp 1) under irrigated and drought conditions, respectively. Relative water content and chlorophyll content were measured, and variability for these attributes was observed among the investigated germplasm under both the conditions. Under drought-stress environment, malonaldehyde levels increased in all the genotypes. The checks, LS 6 and IISR Comp 1 maintained their superiority for this trait. Furthermore, LKC 2006 and LKC 2007 had the highest sucrose content, brix, and purity coefficient against check varieties under drought conditions. Additionally, LKC 2006 and LKC 2007 showed improved performance for dry matter generation from leaves and roots.

## Screening of diseases and insect pests in sugar beet

Disease and insect pest incidences have a considerable impact on yield and juice quality of sugar beet. The knowledge of the non-target as well as beneficial insect pest populations is also essential and works as a management measure. Therefore, in order to screen out the various foliar/root diseases and insect pests under natural conditions and to identify the tolerant/resistant germplasm of sugar beet for Indian climatic conditions, a trial of 56 sugar beet genotypes was conducted to screen against diseases and insect-pests at IISR, Lucknow farm.

Higher incidence of *Alternaria*, *Cercospora*, *Phoma* spp., *Fusarium* yellows, and viral disease complex has been observed. Appearance of symptoms of *Cercospora* leaf spot, in minor patches, started in sugar beet germplasm during the month of February, however, plants recovered from this disease and by April, 2022 the disease was almost negligible resulting in plants showing resistant response. Five genotypes *viz*, Hilma, LS 6, IISR Comp 1, LK 4, and SV 887 exhibited resistance towards the major foliar diseases (Table 7.1). Incidence of *Alternaria* leaf spot disease was almost negligible till

February, 2022 but later, there was a sudden upsurge during March-April, 2022 when the plants became susceptible. A similar pattern was observed for *Fusarium* yellow disease as well.

The pure cultures of the foliar pathogens were obtained on Potato Dextrose Agar (PDA) and Oat Meal Agar (OMA) media. These pure cultures were sent for morphological identification to HCIO-ITCC, ICAR-IARI, New Delhi. The results revealed association of two species of *Fusarium oxysporum* and *Fusarium pallidoroseum*; and two species of *Alternaria alteranata* and *Alternaria radicina* (Table 7.2).

**Table 7.1. Evaluation of sugar beet genotypes for foliar diseases**

| Disease | Resistant germplasm | Susceptible germplasm |
|---|---|---|
| Viral disease complex | 15 | 41 |
| *Fusarium* yellows | 14 | 11 |
| *Alternaria* leaf spot | 9 (Hilma, FAC 60008) | 25 |
| *Cercospora* leaf spot | 53 | 3 |

**Table 7.2. Disease symptoms in sugar beet genotypes**

| Disease | Identified pathogen | No. of isolates | Symptoms | Conidia | Pure Culture |
|---|---|---|---|---|---|
| *Fusarium* yellows | *Fusarium oxysporum* | 2 |  |  |  |
| | *F. pallidoroseum* | 1 | | | |
| Leaf spot | *Alternaria radicina* | 4 |  |  |  |

Among the insects, thrips and ladybird beetles appeared 30 days after sowing (DAS), whereas the infestation of Army worm (*Spodoptera* sp.) was noticed at 110 DAS. The higher incidence rate of *Spodoptera* (80-95%) during the months of April to May completely damaged the foliar portion of sugar beet. Lady bird beetles and spiders have been observed from the month of January to April in sugar beet crop. Three different species of *Micrapis* were collected and identified. *Menochiluss exmaculatus* was also identified based on the morphology. Spiders were also collected for identification and three different species, Stripped lynx, Ground crab and Divine bell were identified. Minor incidences of *Myzus* spp. and *Pegomya* spp. (larval stage in the newer leaves) were also recorded. Among the 56 genotypes, LKC 95 was found to be the most susceptible variety towards *Spodoptera* infestation, whereas LKC 2020-1, IN 06, LKC 2020, and IN 07 were significantly tolerant to army worm.

The screening of insect pests in sugar beet also helped in the selection of insecticides and their application. Different concentrations of quinolphos were found to be effective against different larval stages of *Spodoptera* sp. Application of 2% quinolphos was highly effective against first and second larval stages of *Spodoptera* sp., whereas at 5%, 95-99% mortality was recorded against third to fifth larval stages. Application of Imidaclopnd (2-5%) was not effective against 2nd to 5th larval stages of *Spodoptera* sp.

## Weed identification and management in sugar beet

Weeds in beet crops reduce productivity in the field. Weed seeds are harmful because they germinate during crop cultivation. *Commelina bengahalensis, Rumex dentatus, Argemone mexicana, Sepergula arvensis, Cyperus rotundus,* and *Convolvulus arvensis* were identified. *Argemone mexicana,* and *Cyperus rotundus* were found to be the most common weeds in sugar beet fields. Trash mulching through paddy straw was used in sugar beet to culminate the weed growth. As a result, weeds do not have a favourable environment for early germination, rapid growth, and development.

## Sugar beet performance at different locations

To check the performance of sugar beet in tropical conditions, an experiment was conducted at University of Agricultural Sciences, Bangalore with five sugar beet germplasm namely LS 6, LKC 2020, IISR Comp 1, SZ 35 and SV 2495. The highest root weight was recorded with LKC 2020 having 1.67 kg. Leaf weight, juice weight and

pulp weight were highest in LKC 2020 compared to other varieties.

## Performance of sugar beet in high temperature and hot conditions

An experiment with eight germplasm, LKS 10, LK 27, LKC 2000, LKC 2006, LKC 2007, IISR Comp 1, LKC 2020, LS 6 was sown at Agricultural Research Station, Basanthpur. The highest germination was recorded in LKC 2020 as compared with others. Sucrose content varied from 17.4 to 18.9 among these sugar beet genotypes. The highest sucrose content was recorded in LS 6 and IISR Comp 1 with 18.8 and 18.9 per cent, respectively. The yield ranged from 21.1 to 73.9 t $ha^{-1}$ in the tested genotypes. The highest yield was recorded in both LS 6 and IISR Comp 1.

## Technologies developed

Two nucleotide sequences of *Spodoptera litura* were submitted in National Center for Biotechnology Information (NCBI):

- Srivastava S, Mall AK, Misra V, Pandey H, Pathak AD and Baitha A (2022) *Spodoptera litura* isolate A cytochrome c oxidase subunit 1 (COX 1) gene, partial cds; mitochondrial. (Accession No.: OP117231.1).
- Srivastava S, Mall AK, Misra V, Pandey H, Srivastava S and Pathak AD (2022) *Spodoptera litura* isolate Sequence 2 cytochrome c oxidase subunit I (COX1) gene, partial cds; mitochondrial. (Accession No.: OP420870).

CHAPTER 8

# Statistics, Economics and ICT

## International sugar trade and export opportunities for Indian sweeteners

### Growth and instability in sweeteners export

The compound growth rates (CGRs) and instability in sugar, molasses, jaggery and confectionary export were worked out for the second decade of 21st century. There were wide variations in quantity and monetary value earned through export of Indian sweetener products (Table 8.1). Similarly, instability index for sugar, molasses and jaggery products illustrates patterns of sugar export from India. It is evident that the jaggery export has increased from 2 lakh tonnes to 6.32 lakh tonnes during year 2011-2022, with CGR of 13.18 and 15.54% in quantity and monetary value earned with instability index 0.95 and 0.79, respectively. Similarly, sugar and molasses export under different sugar HS code heads have also increased substantially with CGR 13.24 and 12.61% which was significant at 1% level. Sugar production decline in other major exporting nations such as Brazil and Thailand. The farmers and Indian sugar sector have benefited with sugar & jaggery export as global prices showed an upward trend. It gave an opportunity to export sweetener products due to its logistical advantages in the traditional overseas markets. Indian share in world sugar exports has increased from 3.5 to 10.2 per cent during 2011 to 2022. India has become the 2nd largest sugar exporter. The sugar export was highly concentrated as the top five exporter countries account for 72.9% of aggregate sugar export.

**Table 8.1. CGR and instability in sweetener export**

| S. No. | Sweetener Products | CGR | T value | Coefficient of Variation (C.V.) | Instability Index |
|---|---|---|---|---|---|
| 1. | Sugar (2011-12 to 2021-22) | | | | |
| | Quantity | 13.24* | 3.887 | 67.629 | 0.972 |
| | Value | 12.06* | 3.356 | 73.295 | 0.989 |
| | Value | 7.38 | 1.989 | 59.784 | 1.027 |
| 2. | Jaggery & Confectionary (2011-12 to 2021-22) | | | | |
| | Quantity | 13.18* | 5.733 | 47.874 | 0.954 |
| | Value | 16.16* | 8.749 | 49.950 | 0.911 |
| | Value | 15.54* | 7.199 | 42.796 | 0.794 |
| 3. | Molasses (2011-12 to 2021-22) | | | | |
| | Quantity | 12.61** | 2.267 | 41.723 | 0.039 |
| | Value | 18.72* | 3.225 | 98.679 | 0.027 |
| | Value | 13.79** | 2.367 | 85.716 | 0.041 |

Note:* Significant at 5 and ** 1 per cent probability level

The sugar importing countries are diversified. Indonesia, the largest sugar importer, accounts for 9.5% of world aggregate sugar import followed by China (8.5%), USA (5.8%), Algeria (4.4%) and Bangladesh (4.4%).

India had exported 104 LT sugar during year 2021-22 and earned $ 4602 million (Fig 8.1). India has also exported jaggery and confectionary products of 6 LT and earned $ 376 million (Fig. 8.2). Besides India has also exported 14 LT molasses and earned foreign exchange of $ 217 millions as illustrated in Fig. 8.3. The prospects of sugar and other sweetener exports could be better on account of international prices prevailing higher than domestic sugar prices. The comparative price advantage in world sugar market has also obviated the need of export subsidy to mills by the government to offload surplus sugar stocks.


**Fig. 8.1. Growth and instability of sugar export**


**Fig. 8.2. Growth and instability of jaggery export**

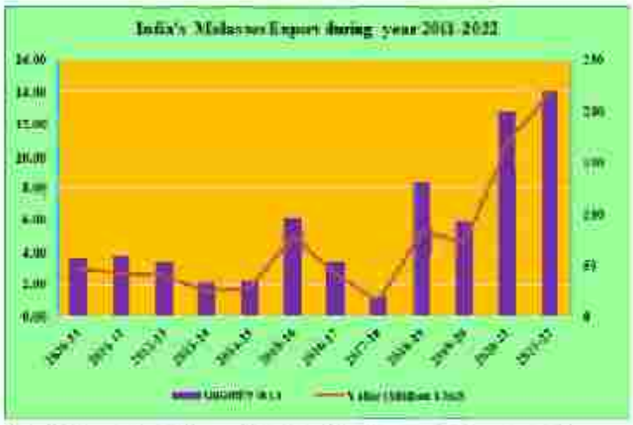



**Fig. 8.3. Growth and instability in molasses export**

## Indian sugar export competitiveness

Indian economy has transformed from mixed economy to middle-income developing social economy with government participation in strategic segments. Globally, it is the 5th largest economy in terms of Gross Domestic Product (GDP) and 3rd largest in terms of Purchasing Power Panty (PPP) after USA and China. India's GDP was 3.177 trillion USD, per capita income 2277 USD and 8.95% growth during year 2021. India's aggregate export was 335.44 billion USD and import was 495.83 billion USD, services imports 135 billion USD during year 2021-22. The export-import trade indicators were high as compared to other seven South Asian countries (SAC) collectively. The analysis of world trade indicators related to trade and logistic friendly environment reveal that India was in comfortable condition. India's position in ease of doing business, trading across borders, LPI score, LPI rank and CPIA rating was high as compared to SAC. India's LPI rank was 44 with LPI score 3.18, while other SAC have LPI rank beyond 80. India, Maldives and Sri Lanka have CPIA rating of 4, while other SACs have 3.5 CPIA score. The value of HHMC at 0.06 indicates that India has diversified trade products. 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 and it was quite high as compared to major sugar and jaggery exporting countries (Table 8.2).

Revealed Comparative Advantage Index (RCA) for sugar exports was worked out for India as well as for all the South Asian Countries. The RCA for commodity export from a country means the importance of the commodity in the export trade in comparison with the importance of the commodity in world export. RCA-II gives an idea as to whether the proportion of sugar import was more than expected, in terms of share of sugar in world import. Another indicator, Trade Intensity Index (TII) was also worked out as the share of India's export to SAC partner divided by the share of world exports to that SAC partner.

India's sugar, jaggery and confectionary export was worth 5089 million USD during 2021-22. India has exported sugar worth 1134.46 million USD to all SACs which constituted 22.30% of India's aggregate sugar export earnings (Table 8.3). The analysis of composition of sugar export reveals that more than 96% of sugar, jaggery and confectionary was under Harmonized System Code (HS Code 1701), sugarcane or sugar beet chemically pure sucrose in solid form.

The Indian sugar export competitiveness amongst South Asian countries was analyzed. The analysis of indicators pertaining to trade and logistic friendly environment (Table 8.2) reveals that India is in comfortable position. India's position in ease of doing business, trading across borders, LPI score, LPI rank and CPIA rating was quite comfortable compared to other SACs. These indicators were high as compared to the seven SACs collectively. Total exports of SAC in monetary terms (Table 8.3) varies from 0.74 billion USD in Nepal to 323.25 billion USD in India. The exports to

**Table 8.2. Indian sugar trade competitiveness and trade conducive environment in SA countries**

| Country | Ease of Doing Business rank 2019 | Trading Across Borders rank 2019 | CPIA trade rating | LPI score 2019 | LPI rank 2019 | Perform-er % | IEMP | HHMC | RCA 2021 | RCA-II 2021 | TII |
|---|---|---|---|---|---|---|---|---|---|---|---|
| India | 63 | 68 | 4 | 3.17 | 44 | 67.98 | 31.14 | 0.06 | 13.57 | 0.29 | - |
| Maldives | 147 | 157 | 4 | 2.66 | 86 | 52.02 | 1.51* | 0.09* | 0.002 | 2.28 | 1.07 |
| Sri Lanka | 99 | 96 | 3.5 | 2.59 | 94 | 49.91 | 6.00** | 0.08** | 0.032 | 7.57 | 6.21 |
| Bangladesh | 168 | 176 | 3.5 | 2.57 | 100 | 49.24 | 6.09$ | 0.07$ | 0.132* | 10.15 | 1.17 |
| Nepal | 94 | 60 | 3.5 | 2.51 | 114 | 47.26 | 3.55** | 0.31** | 0.052* | 1.07 | 1.38 |
| Pakistan | 108 | 111 | 3.5 | 2.41 | 122 | 44.32 | 7.97 | 0.05 | 1.43 | 1.77 | 12.34 |
| Bhutan | 89 | 30 | 3.5 | 2.16 | 149 | 36.51 | 1.15@ | 0.75@ | 0.00 | 4.23 | 0.904 |
| Afghanistan | 173 | 177 | 3.5 | 1.94 | 160 | 29.62 | 2.01 | 0.30 | 0.152* | 14.11 | 20.29 |

Note: The indices for export market penetration (IEMP) and Hirschman Herfindahl Market Concentration index (HHMC) pertain to the year 2019 otherwise specified as with (*) mark pertain to the year 2018, mark (**) for 2017, mark (@) for 2012 and mark ($) pertains to the year 2015. This is due to the availability of the latest data pertaining to that country. RCA values with asterisk (*) mark pertain to pre 2019 years as latest data is not available. TII= Trade Intensity Indices are w.r.t India.

**Table 8.3. Sugar export to SACs and share of different HS sub-heads under major HS 1701 head**

| Countries | Value (Million USD) | % Share in total sugar export | Sugar share in total export (%) | Export under 1701 heading (% of total sugar export) | Exports under different sub-headings of 1701 heading | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2021-22 | 2021-22 | 2021-22 | 2021-22 | 170112 | 170113 | 170114 | 170191 | 170199 |
| Afghanistan | 139.5 | 2.74 | 25.17 | 99.99 | 0.00 | 0.31 | 3.91 | 1.71 | 94.06 |
| Bangladesh | 572.35 | 11.25 | 3.54 | 98.82 | 0.00 | 0.00 | 84.09 | 1.51 | 14.40 |
| Bhutan | 6.88 | 0.14 | 0.78 | 75.58 | 10.96 | 9.62 | 14.42 | 0.58 | 64.23 |
| Maldives | 2.52 | 0.05 | 0.38 | 92.06 | 0.00 | 0.00 | 25.43 | 0.00 | 74.57 |
| Nepal | 100.51 | 1.97 | 1.04 | 82.98 | 0.08 | 3.06 | 29.27 | 1.95 | 65.62 |
| Pakistan | 135.92 | 2.67 | 26.25 | 99.99 | 0.00 | 0.12 | 21.95 | 1.16 | 76.76 |
| Sri Lanka | 177.01 | 3.48 | 3.05 | 96.01 | 0.00 | 0.01 | 14.45 | 3.83 | 81.72 |
| Total SAC | 1134.69 | 22.29 | 3.31 | 97.42 | 0.06 | 0.33 | 50.81 | 1.88 | 46.91 |
| Total sugar export | 5089.33 | - | - | 90.04 | 0.12 | 0.62 | 42.68 | 2.45 | 54.14 |
| Share of SACs % | 22.30 | - | - | 24.12 | 11.83 | 12.78 | 28.72 | 18.55 | 20.90 |

Note: The sugar exports are carried out under different heading. The codes for sugar exports are as follows: 1701: Cane or beet sugar and chemically pure sucrose, in solid form; 1702: Sugars, including lactose, maltose, glucose or fructose in solid form; sugar syrups without added flavouring or colouring matter; artificial honey, whether or not mixed with natural honey; caramel; 1703: Molasses; resulting from the extraction or refining of sugar, and 1704: Sugar confectionery (including white chocolate), not containing cocoa. The major sub-headings under 1701 are : 170112 Beet sugar raw not containing flavoring /coloring material ; 170113 Cane sugar specified in subheading note 2 to chapter 17 (jaggery and Khandsari); 170114 other cane sugar (raw sugar); 170191 sugar refined containing flavoring or coloring matter; and 170199 sugar refined not containing flavoring or coloring matter.

SACs have increased over last 5 years by registering significant growth rate per year. Sri Lanka, Bangladesh and Afghanistan were amongst top 10 countries demanding Indian sugar export. The percentage share was 3.48, 11.25 and 2.74 for the year 2021-22. Analysis of composition of sugar export reveals that 90.04% of total sugar and confectionery export are under the head 1701. Under this head, 54.14% of Indian 1701 sugar exports to world are under 170199 sub-head followed by 42.68% under 170114 sub-head. However, for SACs, around 50.81% sugar 1701 export are under 170114 followed by 46.91% under 170199. While majority of 1701 sugar export to most of SACs were of 170199 (refined) category, these are of 170114 (raw) category to Bangladesh. Analysis of sugar trade competitiveness reveals that India has a huge comparative advantage in supply-side for sugar export to the SAC (since RCA >1) while other SACs are not having comparative advantage in sugar export. Analysis over a period of time reveals that India has gained comparative advantage in sugar exports. Similarly, RCII >1 for SACs indicates a higher than average appetite for sugar import from India than rest of the world. The Trade Intensity Index (TII) more than one for Indian sugar import in SACs indicates that bilateral trade flow is larger than expected, given the partner country's importance in world trade.

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

District-level time-series data for 12 years (2007-08 to 2018-19) w.r.t. area, production and productivity of sugarcane was prepared, and the growth (compound annual growth rates, CAGRs) for the period was worked out for individual districts. Based on the criteria of sugarcane intensiveness and the growth rates in sugarcane area and sugarcane productivity, these districts were grouped into different categories (Table 8.4). The most intensive sugarcane growing districts (each having sugarcane area of more than 1 lakh ha) had exhibited higher yield growth of 2.92% to 5 % per year during the period under consideration. The positive and significant growth in area has been observed only in two districts (Sitapur, 2.84% and Lakhimpur Kheri, 1.64%) out of six districts in this category. Thus, it highlights that six districts accounting for 47.2% of the total sugarcane area in UP have exhibited high growth in their productivity levels. The state has seven districts, each growing sugarcane in an area ranging from 50,000 to 1,00,000 ha and collectively accounting for 24.2% of the total sugarcane area in the state. Three districts, *viz.*, Pilibhit, Bareilly and Gonda have experienced positive and high growth rates in both acreage and productivity. Nine districts in the state have sugarcane area ranging from 25,000 to 50,000 ha and these districts account for 16.1% of sugarcane area. The districts in the group of sugarcane intensiveness from 10 to 25 thousand ha, 5 to 10 thousand ha and from 2,000 to 5,000 ha area are 7, 12 and 10 districts accounting for 6.3%, 4.2% and 1.3% of the total sugarcane area, respectively.

Further, the efficient districts growing sugarcane in UP state were considered as those areas which have high spread and high crop productivity. Accordingly, relative spread indices (RSI) and relative yield indices (RYI) of sugarcane were worked out for all the districts in the state. On the basis of RSI and RYI, these districts were grouped in four types of zones; MECZ if RSI >100

**Table 8.4. Delineation of districts in UP as per CAGR (%) for area under sugarcane (A) and sugarcane productivity (Py)**

| Extent of sugarcane area (ha) | Share (%) | Districts as per CAGR (%) for sugarcane area (A) and productivity (Py) | | | |
|---|---|---|---|---|---|
| | | A (>) and Py (>1) | A (<1 but +ve) and Py (>1) | A (-ve) and Py (>1) | A (+ve) and Py (-ve) |
| >1,00,000 | 47.2 | Sitapur, Lakhimpur Kheri | Saharanpur, Muzaffarnagar | Meerut, Bijnor | - |
| 50,000 -1,00,000 | 24.2 | Pilibhit, Gonda, Bareilly | Kushinagar, Baghpat, Amroha | - | - |
| 25,000 -50,000 | 16.1 | Hardoi, Shahjahanpur | Badaun, Basti | Balrampur, Moradabad, Bulandshahar | - |
| 10,000 -25,000 | 6.3 | Bahraich | Ambedkar Nagar, Maharajganj, Faizabad and Rampur | Azamgarh, Ghaziabad | - |
| 5,000 -10,000 | 4.2 | Shravasti, Ghazipur, Kasganj | Sultanpur, Farrukhabad | Ballia, Mau, Aligarh, Jaunpur, Deoria, Barabanki | Fatehpur |
| 2,000- 5,000 | 1.3 | - | - | GB Nagar, Siddharth Nagar, Kanpur Dehat, Gorakhpur, Kanpur Nagar, Rae bareli, Varanasi, Sant Kabir Nagar | Mahoba, Hamirpur |

Abbr*= A and Py stand for compound annual growth rates (CAGRs) in percentages (from 2008-09 to 2018-19 period) in area under sugarcane and sugarcane productivity, respectively. The coverage under different categories is the per cent share of 2.206 million ha total sugarcane area in TE year 2018-19.

and RYI>100; ECZ if RSI <100 and RYI>100; LECZ if RSI>100 and RYI <100; and NECZ if RSI<100 and RYI <100. The most efficient sugarcane cropping zone (MECZ) districts constituted 62.90% of area under sugarcane in UP. The yield levels in these districts were high at an average level of 83.79 t/ha. As per this criterion, thirteen (13) districts were delineated as the most efficient sugarcane growing (MECZ) districts in the state (Table 8.5). In addition, three districts were identified as efficient, seven districts as less efficient, while 52 districts grouped as non-efficient for sugarcane cultivation. These 52 NECZ districts having less area under sugarcane are not producing sugarcane for the sugarmills but to meet out the requirements of chewing juice and jaggery making. Hence, policy requires to encourage other alternative crops in non efficient growing (NECZ) districts or encourage appropriate training programmes to farmers and entrepreneurs in quality jaggery production and marketing through FPO's.

**Table 8.5. Sugarcane area and yield levels according to efficiency crop zones in Uttar Pradesh**

| Sugarcane Growing Zone | Abbr. | Share in area under sugarcane (%) | Yield level (t/ha) | No. of districts |
|---|---|---|---|---|
| Most Efficient Cropping Zone | MECZ | 62.90 | 83.79 | 13 |
| Efficient Cropping Zone | ECZ | 2.54 | 81.12 | 3 |
| Less Efficient Cropping Zone | LECZ | 20.75 | 72.98 | 7 |
| Not Efficient Cropping Zone | NECZ | 13.81 | 67.63 | 52 |
| State Total | | 100.00 | 79.25 | 75 |

## Impact of IISR technologies in sustaining sugarcane production in India

The quantification of the benefits of the four proven technologies on farmers' fields was undertaken. Studies for impact assessment of IISR developed sugarcane cutter planter revealed that the returns to research due to sugarcane cutter planter were estimated at ₹ 35.1 per rupee invested in research. The technology has an impact on labour displacement and the extent of labour displaced (labour saving) was worked out at 45.20 lakh man days at the national level. The monetary contribution of the machine in terms of extent of cost reduction in sugarcane cultivation was estimated upto ₹ 180 crores per annum. The impact study on the cultivation of IISR developed variety CoLk 94184 highlights that the annual economic gains due to cultivation of this variety were to the tune of ₹ 510 crore per year in sub-tropical region. The returns per rupee invested were worked out at ₹ 24.7. Its impact with respect to labour absorption was neutral. For assessing the impact of bio-control technology, analysis was carried out with respect to the bio-control of woolly aphid in sugarcane. The management practice "Biological control only" was found to be practiced by 2% farmers and the loss reported was 23.86% in comparison to the practice "chemical control only" followed by 35.5% farmers and mean loss reported was 9.84%. The impact studies on intercropping in sugarcane revealed that the ratios of gross returns to cost incurred were higher for autumn planted crop as compared to spring planted sugarcane. The average added benefits per ha due to intercropping varied from ₹ 3,750 to ₹ 67,565 as per crop selected under central UP conditions. The intercropping of vegetables including potato has led to significant increase in labour absorption per ha.

## Growth analysis of early and mid-late varieties of sugarcane in sub-tropical India

An exploratory trial was conducted to compare monthly growth in six early maturing varieties, CoPk 05191, UP 05125, CoLk 94184, CoS 8272, CoLk 14201, Co 0238, and six mid-late maturing, CoLk 9204, CoS 12232, CoS 08276, CoLk 14203, Co 05011 and CoSe 11453, during crop season 2021-2022. Two clumps were selected randomly to record the observation on fresh and dry characters of leaves, stalk and root of the twelve sugarcane varieties. Every month data on per clump leaves were pooled for each variety. Analysis of variance of two classification was performed for 19 characters of leaves, stalk and root. The rate of growth was also worked out for each character at each month. Correlation studies among the characters were also done to study the relationship between the characters of leaves, stalk and roots.

The growth rate for all the growth characters were estimated as positive and more for mid-late varieties than early varieties except for number of green leaves/ clump and fresh leaf weight (gm). In case of stalk, highest growth was observed in dry stalk weight (gm) followed by fresh stalk weight (gm) and stalk length. In case of root, highest growth rate was in dry root weight (gm) followed by fresh root weight (gm) and root density (gm/ $cm^3$). In case of leaf, the highest growth was observed for dry leaf weight (gm) followed by fresh leaf weight (gm) and mean leaf length (cm). The growth pattern was same for both early and mid-late varieties. Average no. of tillers/ clump was 5.57% more for early than mid-late varieties. Similar observation was also noticed for length of middle internode (cm) and average leaf width. The moisture content in roots, stalk and leaf were also found more in early varieties than mid-late varieties. It is inferred that in initial stages (February to July), number of tillers/ clump were more in early varieties than mid late varieties. Tiller mortality was more in early than mid late varieties in the month of August and September.

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

Review of 643 research articles about Internet of Things (IoT) in agriculture shows IoT research contribution in agriculture from 2010 onwards with more than 50% contribution during 2017-2022. The articles were classified under seven classes related to field operations *viz.* planting and related operations, soil monitoring, irrigation management, crop protection, growth stage monitoring & harvesting, environment monitoring and supply chain management. These IoT applications relate to field crops including sugarcane and horticultural crops.

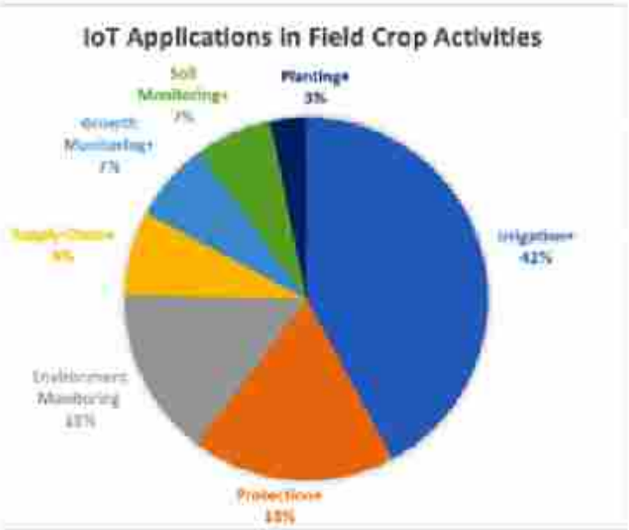



**Fig. 8.4. IoT applications in field crop activities**

Irrigation management accounts for almost 42% of total IoT applications in field crops including sugarcane and stands as number one application (Fig. 8.4). Parameters measured in these solutions are soil moisture, soil temperature and weather data with aim to optimize the water resources usage. Extensive use of neural network was found in data analysis to predict current soil moisture level to decide irrigation schedule and monitor water quality. Advance technologies such as big data, block chain and cloud computing have been used for managing data.

IoT solutions for crop protection forewarning systems for occurrence of disease and insect-pest outbreaks was found to be at 2nd position with approximately 18% contribution aiming to identify, prevent and control stresses caused by insect-pest and diseases. Deep learning algorithms such as CNN, ResNet, LSTM and YOLO have been used to predict the occurrence and location of pests, using visual features.

IoT solutions for soil monitoring/ nutrient application aimed to optimize the application of fertilizers in field crops, were 7%. Major parameters measured in these solutions are NPK, micronutrients, pH, moisture level, soil temperature, and tilth. Few examples of such applications are calorimetry based miniaturized device for precise determination of soil nitrogen and phosphorus; sensor-based sheets to analyze real-time soil nitrate concentration; chlorophyll meter to check nitrogen and chlorophyll contents in leaves. Machine learning models have also been used to estimate leaching requirement of saline soil; to predict the hotspots and hot moments of $N_2O$ in agroecosystems.

Review of IoT applications in field crop growth monitoring, harvesting quality monitoring and harvesting quantity monitoring was worked out to be approximately 7%. Crop growth monitoring was found

to be of prominence followed by studies to predict crop yield, harvesting crop character/ harvest quality. Parameters monitored/collected for these sorts of applications were multiple environmental data, crop data and image data.

Around 3% IoT contribution was by planting related activities. Applications found were related to crop selection, seed species identification and sowing. Internet of things, knn-based machine learning and rule-based classification algorithms and robots application were seen for soil digging, sowing, closing and controlling of other planting activities.

Supply chain and logistics management is one of the important IoT applications (8.1%) in food industry. However, only 8% articles were found on this aspect relevant to the field crop applications. Use of RFID and NFC technologies was found for identification and real-time tracking of agricultural products in supply chain.

Agricultural environment monitoring was found in approximately 15% field crop articles. Temperature and humidity were found to be the most important environmental parameters recorded, followed by recording of light intensity and $CO_2$ concentration. The parameters related to substrate monitoring were soil moisture, soil pH, electrical conductivity and dissolved oxygen, along with environmental parameters.

CHAPTER 9

# All India Coordinated Research Project on Sugarcane

To develop 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. For developing abiotic stress tolerant varieties, ISH & IGH programmes are also being executed at certain centres. During the year 2022, 12 sugarcane varieties have been developed (8 identified and 4 released & notified) for different zones of the country. A brief description of the developed varieties is as follows:

## Sugarcane varieties released and notified

1. **Co 14012 (Avani)**: This variety has been developed by ICAR-SBI, Coimbatore in mid-late group for Peninsular Zone and was released and notified in 2022. The variety has exhibited cane yield of 109.82 t/ha, CCS yield 16.16 t/ha and 20.63% sucrose in juice. The variety showed resistance to smut and YLD. This variety is non-flowering and is a good ratooner.

2. **CoLk 15201 (*Ikshu*-11)**: This sugarcane variety has been developed by ICAR-IISR, Lucknow in early group for the North West Zone and was released and notified in 2022. The variety has exhibited cane yield of 93.92 t/ha, CCS yield 11.44 t/ha and 17.64% sucrose in juice. Reaction against red rot was moderately resistant through plug method & resistant through cotton swab method. The clone showed less susceptible reaction for major insect-pests.

3. **CoLk 15207 (*Ikshu*-12)**: This sugarcane variety has been developed by ICAR-IISR, Lucknow in mid-late group for the North West Zone and was released and notified in 2022. The variety has exhibited cane yield of 84.53 t/ha, CCS yield 10.97 t/ha and 18.71% sucrose in juice. The reaction against red rot was moderately resistant through plug method and resistant through cotton swab method. The variety showed less susceptible reaction against major insect-pests.

4. **CoLk 15466 (*Ikshu*-13):** This variety has been developed by ICAR-IISR, Lucknow in early group for the North Central & North East zones and was released and notified in 2022. The variety has exhibited cane yield of 85.97 t/ ha, CCS yield 10.41 t/ ha and 17.54% sucrose in juice. Reaction against red rot was moderately resistant through plug method and resistant through cotton swab method. The variety showed less susceptible reaction against major insect-pests.

## Sugarcane varieties identified

1. **MS 14082 (Phule Sugarcane 13007) (Parentage: CoM 0265 X CoM 0254):** The variety has been developed by the Central Sugarcane Research Station (MPKV), Padegaon (MS) in mid-late group for Peninsular zone and was identified in 2022. The variety has exhibited cane yield of 128.60 t/ ha, 19.47 sucrose % in juice, CCS of 17.58 t/ ha & Pol (%) in cane 14.85. The reaction against red rot was moderately susceptible (MS) and the reaction against major insect-pests was also found to be less susceptible (LS).

2. **Co 14005 (Arunima) (Parentage: Co 86032 x Co 86011):** The variety has been developed by ICAR-Sugarcane Breeding Institute, Coimbatore in mid-late group for Peninsular Zone and was identified in 2022. The variety has exhibited cane yield of 118.77 t/ ha, sucrose % in juice of 20.15, CCS of 16.61 t/ ha & Pol % in cane 15.35. The reactions against red rot and other major diseases were resistant (R). For major insect-pests, the variety was found less susceptible (LS) to moderately susceptible (MS).

3. **Co 11015 (Atulya) (Parentage: CoC 671 x Co 86011):** The variety has been developed by ICAR-Sugarcane Breeding Institute, Coimbatore in early group for Peninsular Zone and was identified in 2022. The variety has exhibited cane yield of 109.29 t/ ha, sucrose % in juice of 21.29, CCS 16.32 t/ ha and Pol % in cane 16.31. The variety was marginally superior in CCS (t/ ha) by 0.68% over the best check Co 09004. The reaction against red rot and other major diseases like smut, wilt and YLD was resistant (R).

4. **CoLk 14201 (*Ikshu*-10) (Parentage: Co 0238 GC):** The variety has been developed by ICAR-Indian Institute of Sugarcane Research, Lucknow for the North West Zone in early group and was identified in 2022. The variety has exhibited cane yield of 91.65 t/ha, sucrose % in juice 18.11, CCS 11.43 t/ha and Pol(%) in cane (13.69). The reaction against red rot was moderately resistant through plug method, however, it was resistant through cotton swab method.

5. **CoLk 15206 (*Ikshu*-14) (Parentage: LG 95053 GC):** The variety has been developed by ICAR-IISR, Lucknow for the North West Zone in mid-late maturing group and was identified in 2022. The variety has exhibited cane yield of 89.81 t/ha, sucrose % in juice 18.42, CCS 11.64 t/ha and Pol % in cane 14.32. The reaction against red rot was resistant (R) through plug and cotton swab methods. The variety showed less susceptibility against major insect-pests.

6. **CoLk 16466 (*Ikshu*-15) (Parentage: BO 91 x Co 86002):** The variety has been developed by ICAR-Indian Institute of Sugarcane Research, Lucknow for the North Central & North East Zone in early group and was identified in 2022. The variety has exhibited cane yield of 85.35 t/ha, sucrose % in juice 17.33, CCS 10.27 t/ha and Pol % in cane 13.31. The reaction against red rot was resistant (R) through plug as well as cotton swab methods. The variety showed less susceptible reaction against major insect-pests.

7. **Co 16030 (Karan-16) (Parentage: Co 0238 x Co 8347):** The variety has been developed by ICAR-SBI Regional Centre, Karnal (Haryana) for the North West Zone in mid-late group and was identified in 2022. The variety has exhibited cane yield of 94.97 t/ha, sucrose % in juice 17.90, CCS 11.96 t/ha and Pol % in cane 13.89. The reaction against red rot was moderately resistant (MR) through plug method and resistant (R) through cotton swab method.

8. **Co A 17321 (2012 A 319) (Parentage: Co A 92082 GC):** The variety has been developed by the Regional Agricultural Research Station (ANGRAU), Anakapalle (AP) for the East Coast Zone in early group and was identified in 2022. The variety has exhibited cane yield of 114.37 t/ha, sucrose % in juice 16.93, CCS of 13.44 t/ha and Pol % in cane 11.72. The reaction against red rot was resistant (R) through both the plug and the cotton swab methods.

## Events/Meetings/Trainings Organized

### Zonal Breeders' & Plant Protection Scientists' Meet of AICRP on Sugarcane

The Breeders' and Plant Protection Scientists' Meet-2023 of All India Coordinated Research Project (AICRP) on Sugarcane was organized at ICAR-Indian Institute of Sugarcane Research, Lucknow on January 20, 2022 to shortlist the promising sugarcane clones in the Initial Varietal Trial (IVT) for their further evaluation in Advanced Varietal Trials (AVT) and to 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.

Delivering the inaugural address, 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. Singh congratulated the scientists for developing eight new varieties of sugarcane during 2022-23 and being instrumental in improving Indian economy by export of 11 million tonnes of sugar worth Rs. 40,000 crore. He urged the scientists to start prebreeding work in sugarcane as more than 4,000 germplasm is available in India and to replace degenerated old varieties by other improved varieties such as CoLk 14201, Co 15023 and CoS 13235 etc. in Uttar Pradesh.

### Brain Storming Session on Management of Red Rot disease

A Brain Storming Session on 'Status of Red Rot of Sugarcane in India and its Management' was organized at ICAR-IISR, Lucknow on May 23, 2022 through hybrid mode. The session was chaired by Dr T.R. Sharma, DDG (Crop Sciences), ICAR, New Delhi. The Chairman mentioned that the red rot disease of sugarcane was

reported 120 years ago but still the epidemic devastates sugarcane cultivation in the country. He also added that the country has witnessed more than 10 red rot epidemics. However, he highlighted that every epidemic has led to quality research in this area. He mentioned that our research team is working hard and has made available, a number of new sugarcane varieties at par to Co 0238 to replace it in the country. During the session, the following recommendations were made for further implementation:

- Red rot is a highly manageable disease and there is no need to press the panic button for the red rot incidences reported during the year. An early detection of any disease helps in its better management. A concern was raised about the early warning given during 2016-17 by the pathologists on the breakdown of resistance in Co 0238 being ignored and this ultimately led to major disease epidemic in UP and Bihar. Hence in future, efforts should be made to contain the disease when it is first cited. This will prevent build-up of pathogen virulence and avoid huge losses to the farming community.

- The historical red rot epidemics of 1930s, 1940s, 1980s and present (year 2021-22) epidemics in UP and Bihar as well as in variety CoC 671 in the tropical states in 1990s followed a path of boom and bust cycle and this reiterates avoidance of monoculture of a single variety in a large command area.
- The red rot affected fields along with surrounding fields (due to the presence of incipient infection) should be harvested immediately. The severely affected fields must be brought under crop rotation to reduce inoculum load in the soil. A wheat crop may be taken up after removal of red rot affected stubbles. The plant crops should not be ratooned, even if few red rot affected clumps are noticed.
- In the affected area, planting of the variety Co 0238 may be avoided and CoLk 14201, Co 15023, CoS 13235 and Co 0118 may be promoted.
- A close vigil (regular surveillance) on the apparently healthy sugarcane crops adjoining the affected fields has to be kept for the detection of red rot incidence, especially during the summer months (up to July). Many a times, in the affected plant (at tillering stage), symptoms of spindle infection may be visible. Removal and destruction of the affected clumps have to be carried out religiously without fail. Once an infected plant is detected, the rest of the crop may be sprayed with a systemic fungicide like Carbendazim, Thiophanate methyl, *etc* at three weeks interval (three sprays before the onset of monsoon).
- A robust and dedicated seed replacement programme has to be initiated especially for the red rot affected areas and the farmers have to be educated adequately to use quality and healthy seed. Encouragement has to be given for the development of entrepreneurship in the production and distribution of disease free and healthy seed cane to the farmers.
- Farmers may also be advised to have seed cane nurseries, if possible for their own use. A separate field or area may be marked for the raising of seed crops. The seed cane crop preferably be raised using single bud setts of apparently healthy canes. The single bud setts should be dipped, at least for half an hour in a suspension of a systemic fungicide like Carbendazim or Thiophanate methyl @ 1 g/ litre before planting. Further, the nursery crop of seed cane may be raised with *Trichoderma* culture fortified with organic manures or vermicompost.
- Mechanized sett treatment with fungicides should be made mandatory to reduce disease build-up in the field and additional sprays (drone application) are needed to arrest secondary spread of the disease.
- Sugar industry and other seed producing organizations should follow the MHAT- based Three-Tier Seed Production Programme to provide commercial seed cane to the farmers. The farmers are required to replace their seed after every five years in a routine by getting seed cane from authentic and reliable source.
- It is reiterated that the age-old advice to have a mosaic of varieties in the command area is the need of the hour. It is further advised that the sugar mill should restrain itself from increasing the acreage of a variety beyond 40% in the command area and should have a judicious blend of varieties to realize the productivity and profitability in a sustainable manner.

## 34th Biennial Workshop of AICRP on Sugarcane

34th Biennial Workshop of AICRP on Sugarcane was organized through hybrid mode (physical and virtual) at ICAR-IISR, Lucknow during October 14 - 15, 2022. The objective of the Meet was to review the research progress of AICRP on Sugarcane for 2021-22, to frame the Technical Programme for 2023-24 and to deliberate on all pertinent issues relating to increasing yield of


sugarcane and sugar in India with a view to arrive at actionable recommendations. The 34th Biennial workshop was inaugurated by the Chief Guest, Dr. A.N Mukhopadhyay, Ex. Vice- Chancellor, AAU, Jorhat, Assam. Among other dignitaries, Dr. S. Solomon, Ex. Vice-Chancellor, CSAUA&T, Kanpur; Dr. A.R. Sharma, Director Research, RLBCAU, Jhansi; Dr. R.L. Yadav, Ex. Director, ICAR-IISR, Lucknow. Dr. A.D. Pathak, Director and Project Coordinator, ICAR-IISR, Lucknow graced the occasion. About 160 participants including scientists associated with AICRP on Sugarcane and working at the different regular and voluntary centres attended the inaugural session.

The plenary session was chaired by Dr. T.R. Sharma, Deputy Director General (Crop Sciences), ICAR, New Delhi and Co-chaired by Dr. R.K. Singh, ADG (CC), ICAR, New Delhi. Dr. G. Hemaprabha, Director, ICAR-

SBI, Coimbatore and Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow were also present. The members of Programme Advisory & Monitoring Committee, Dr. A.R. Sharma, Director Research, RLBCAU, Jhansi and Dr. R.L. Yadav, Ex. Director, ICAR-IISR, Lucknow were also present during the session. Principal Investigators or Rapporteurs of Crop Improvement, Crop Production, Plant Pathology and Entomology disciplines presented the proceedings of the respective technical sessions. Dr. T.R. Sharma, Chairman, made the following suggestions:

- Sugarcane breeders should concentrate more on developing climate resilient and high yielding varieties with more than 12.4% sugar recovery.
- Develop water and nitrogen efficient sugarcane varieties
- Produce high quality breeder seed of sugarcane
- Develop high biomass sugarcane varieties
- Develop various programmes under public-private-partnership mode in collaboration with sugar industry and agricultural universities for undertaking sugarcane research and development under AICRP (S) programme. It was suggested that release of technologies under Crop Production and Crop Protection should be done. For this, a specific proforma similar to varietal release proposal is to be developed.

## Varietal Identification Committee Meeting

The Varietal Identification Committee Meeting was held under the chairmanship of Dr. R.K. Singh, ADG (CC), ICAR, New Delhi on October 15, 2022 at ICAR-IISR, Lucknow through hybrid mode during 34th Biennial Workshop of AICRP(S). In the meeting, the following eight sugarcane clones *viz.*, MS 14082, Co 14005, Co 11015, CoLk 14201, CoLk 15206, CoLk 16466, Co 16030 and CoA 17321 were identified for release and notification.

CHAPTER 10

# Outreach Programmes and Technology Management

## Entrepreneurship development for sugarcane seed production and multiplication

A concerted effort was applied under the project to develop entrepreneurial ability of cane growers in healthy seed cane production and marketing. A successful agri-entrepreneurial venture opens the opportunity for entrepreneur to earn profit and at the same time it provides a social outfit for creation of employment to youths and dwellers in rural settings. With these objectives, entrepreneurship development activities were implemented during the year 2022, mainly focusing to solve the problems like unavailability of healthy seed materials of new cane varieties; lack of entrepreneurial ability among farmers to venture out in seed cane production enterprise and lack of technical know-how in seed cane production and multiplication among farmers.

## Production and multiplication of healthy seed material

- Seed cane crop of varieties *viz.*, CoLk 94184, CoLk 09204, CoLk 11206, CoLk 11203, CoLk 14201, CoLk 12207, CoLk 12209, Co 98014, Co 0118, CoLk 15201, CoLk 9709, CoLk 14204, CoLk 15207, CoLk 15466, CoS 13235 and Co15023 was planted in farmers' fields in Sitapur, Lakhimpur, Pilibhit, Bareilly, Hardoi and Ayodhya districts of Uttar Pradesh and Samastipur, Motihan and Begusarai districts of Bihar. A total of 108 seed cane plots in 44.5 ha area were maintained in fields of more than 56 farmers (Fig. 10.1).

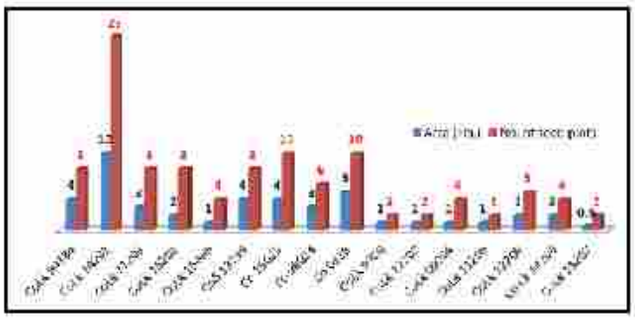


**Fig. 10.1. No. of plots and area under seed cane of each variety (2022-2023)**

- The average yield obtained for seed cane crops of different varieties planted in 2021-2022 and harvested in 2022-2023 is shown in Table 10.1 and Fig. 10.2. However the average seed cane yield for all the varieties was 110.38 t/ha. A total of 5105 tonne seed cane was produced out of which 76.04% (3882 t) was utilized as seed material through sale to other farmers or on own farm to raise seed cane crop in order to multiply the quantity of seed cane of new varieties and rest of the harvested cane *i.e.* 1223 t (23.96%) was supplied by farmers to sugar mill/jaggery unit for crushing (Table 10.1).

**Fig. 10.2. Yield of different cane varieties (t/ha)**

- The overall average net profit and B:C ratio recorded for seed cane crops was ₹ 3,29,769 per ha and 2.54, respectively. The average net profit of ₹ 1,67,000 per ha and B:C ratio of 1.39 was recorded under conventional method in the study areas. The maximum net profit of ₹ 3,68,750/ha was obtained for variety CoLk 14201 and minimum was obtained for CoS 08279 *i.e.* ₹ 2,75,419/ha (Table 10.1 & Figure 10.3).
- The maximum yield and utilization for seed purpose was recorded for varieties CoLk 14201, Co 15023 and CoS 13235. These varieties are gaining popularity among farmers and hold good promise in future for replacement of Co 0238, which is now slipping out of farmers' favour due to haevy pest and disease infestation.
- Farmers who raised seed cane crops, earned 97.47% more profit over conventional method. The target of doubling farmers income can easily be achieved by introducing the intervention like

**Table 10.1. Seed cane yield, seedcane production & utilization, economics of seed cane crop (planted in 2021-2022 and harvested in 2022-2023)**

| S. No. | Name of variety | Yield (t/ha) | Total seed cane produced (t) | Seed cane utilization pattern in t (%) | | Gross return (₹/ha) | | | Net profit (₹/ha) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Seed | Crushing | Seed | Crushing | Total | |
| 1 | CoLk 94184 | 102 | 510 | 320 (62.74) | 190 (37.26) | 2,79,956 | 1,35,000 | 4,12,956 | 2,82,956 |
| 2 | CoLk 14201 | 114 | 912 | 912 (100) | 0 | 4,98,750 *14,82,000 | 0 0 | 4,98,750 *14,82,000 | 3,68,750 *13,32,000 |
| 3 | CoLk 11203 | 110 | 440 | 300 (68.18) | 140 (31.82) | 3,28,116 | 1,22,507 | 4,50,623 | 3,20,623 |
| 4 | CoLk 12207 | 110 | 110 | 75 (68.18) | 35 (31.82) | 3,18,741.50 | 1,19,006.80 | 4,37,748 | 3,07,748 |
| 5 | CoLk 09204 | 110 | 110 | 65 (59.09) | 45 (40.91) | 2,76,245.75 | 1,53,000 | 4,29,246 | 2,99,246 |
| 6 | CoLk 11206 | 112 | 224 | 130 (58.03) | 94 (41.97) | 2,76,207.50 | 1,59,800 | 4,36,008 | 3,06,008 |
| 7 | CoLk 12209 | 108 | 216 | 120 (55.55) | 96 (44.45) | 2,54,974.50 | 1,63,200 | 4,18,175 | 2,88,175 |
| 8 | Co 08272 | 110 | 330 | 200 (60.60) | 130 (39.40) | 2,91,637.50 | 1,51,690 | 4,43,325 | 3,13,328 |
| 9 | Co 98014 | 115 | 345 | 240 (69.56) | 105 (30.44) | 3,49,973.75 | 1,22,500 | 4,72,474 | 3,42,474 |
| 10 | CoS 13235 | 110 | 440 | 440 (100) | 0 | 4,81,250 | 0 | 4,81,250 | 3,51,250 |
| 11 | Co 15023 | 110 | 440 | 440 (100) | 0 | 4,81,250 | 0 | 4,81,250 | 3,51,250 |
| 12 | Co 0118 | 116 | 812 | 550 (67.73) | 262 (32.27) | 3,43,729.75 | 1,31,016.20 | 4,74,746 | 3,44,746 |
| 13 | Co 08279 | 108 | 216 | 90 (41.66) | 126 (58.34) | 1,91,219.40 | 2,14,200 | 4,05,419 | 2,75,419 |
| All varieties | | 110.38 | 5105 | 3882 (76.04) | 1223 (23.96) | 3,76,194 | 92,575 | 4,59,769 | 3,29,769 (B:C-2.54) |
| Conventional | | 82 | | 0 | 82 | 0 | 2,87,000 | 2,87,000 | 1,67,000 (B:C-1.39) |
| Percentage increase in net profit of the farmers | | | | | | | | | 97.47 |

*Production cost @ ₹ 1,30,000/ha (for seed cane crop) & ₹ 1,20,000/ha (for conventional method)
Price of seed cane : early- ₹ 4,375/t, mid-late- ₹ 4,250/t
Cane price (crushing): early- ₹ 3,500/t, mid-late- ₹ 3,400/t

***CoLk 14201: sold @ ₹ 1 per single bud sett, 13000 single bud setts in one tonne & production cost is ₹ 1.5 lac per ha**

entrepreneurship in seed cane production in cane growing areas.

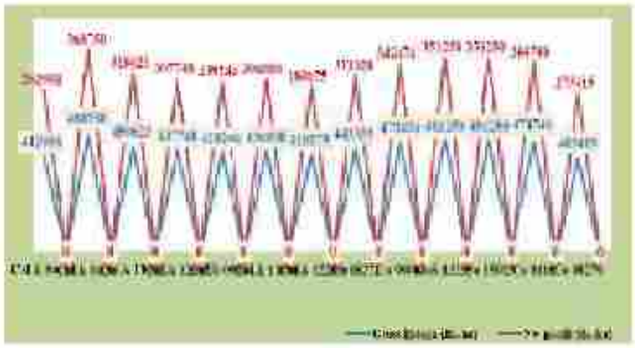


**Fig. 10.3. Variety-wise gross return and net profit (₹/ha)**

## Entrepreneurship development

- The Entrepreneurship training for beneficiary farmers was organised in the month of January, February, March, September, October, November and December 2022 to provide information on seed cane crop raising, new cane varieties, motivate the farmers for enterprising in cane seed production and multiplication of new sugarcane varieties.
- Farmers' visit to model farm on seed crop and integrated farming was organised for experiential learning of farmers in true spirit of *"Seeing is believing"*. Seed cane producer club was formed in the villages and a meet was organised for motivating them for seed cane business.
- The data on entrepreneurial ability of farmers (50) was collected with the help of interview schedule comprising 10 parameters/traits of entrepreneurial behaviour (EB) *viz.*, risk taking, innovativeness, hope of success, persuasibility, manageability, self confidence, knowledgeability, persistence, use of feedback, achievement motivation. The collected data was compiled and analysed and entrepreneurial behaviour index (EBI) are presented in Table 10.2 and Figure 10.4.
- Table 10.2 reveals that overall EBI increased by 35.56%, however, the maximum increase of 67.02% was recorded in Achievement Motivation attribute of entrepreneurial behaviour. However, considerable increases in all the attributes of EB was recorded, which was helpful in enhancing entrepreneurial spirit among farmers. The remarkable increase in Achievement Motivation had greatly contributed in inculcating entrepreneurial quality among farmers. Overall, the positive outcome clearly depicts the success of interventions introduced in the project area.

**Table 10.2. Entrepreneurial behaviour index of farmers (n=50)**

| S. No. | Attributes | Entrepreneurial behaviour index (%) | | % Increase | Rank |
|---|---|---|---|---|---|
| | | Pre | Post | | |
| 1 | Risk taking | 52.8 | 74.0 | 40.15 | II |
| 2 | Hope of success | 55.5 | 70.2 | 26.49 | X |
| 3 | Persuability | 51.5 | 70.0 | 35.92 | III |
| 4 | Manageability | 55.20 | 74.0 | 34.06 | VIII |
| 5 | Self confidence | 53.2 | 73.0 | 37.22 | V |
| 6 | Knowledgeability | 58.25 | 77.5 | 33.04 | VII |
| 7 | Persistency | 52.5 | 68.0 | 29.52 | IX |
| 8 | Feedback usage | 53.0 | 71.2 | 34.34 | VI |
| 9 | Innovativeness | 52.0 | 70.0 | 34.61 | IV |
| 10 | **Achievement motivation** | **46.7** | **78.0** | **67.02** | I |
| **Entrepreneurial Behaviour Index** | | **54.0** | **73.20** | **35.56** | |

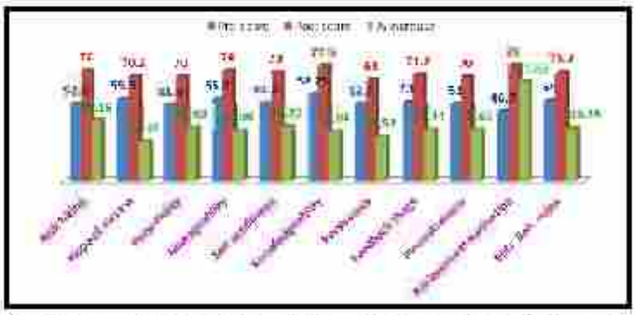


**Fig. 10.4. Entrepreneurial behaviour index of farmers (n=50)**

## Model implemented: Public-Private-Farmer Partnership (PPFP) model in sugarcane

In recent times, the public-private-farmer partnership (PPFP) has emerged as the most crucial and effective extension approach in achieving speedy growth in agriculture. The sugarcane sector in India operates under the public-private-farmer partnership arrangement for cane cultivation and marketing. So, this sector has vast potential to achieve higher productivity and profitability through partnership. To harness this potential, Public-Private-Farmer Partnership (PPFP) model was developed and implemented under outreach programme of the Extension and Training unit of The Institute. The outcome of the programme is not only encouraging but also depicts unparalleled success achieved by the growers and sugar mills of the state. More than 5000 progressive farmers and development workers from other states visited farmers' fields where

interventions were introduced in PPFP mode and interacted with beneficiary farmers, leading to farmer-to-farmer extension.

## Collaborative programme on "Doubling Farmers' Income"

As per an Addendum to the Memorandum of Understanding (MoU) between ICAR-IISR, Lucknow and DCM Shriram Limited, New Delhi signed on 27th September, 2019 in New Delhi, the collaborative programme on "Doubling Farmers' Income" was initiated in 20 villages; 5 villages in each of 4 sugar mills (Ajbapur, Loni, Rupapur and Hariyawan) of DCM Shriram Group.

The interview schedule was developed, a pilot study was executed and the schedule was finalized. With the help of the schedule developed, the baseline survey was conducted in the selected villages to assess the current scenario with respect to yield, income, demography, resource condition *etc.*, in the villages. Data regarding cane area, ratoon area, cane area under autumn/spring, trench planting, cane intensity, cane supply, intercropping, composting, green manuring, drip irrigation, soil condition and bio-control *etc.* was collected.

Selected villages in each of the 4 sugar mills:

- DSCL Sugar- Ajbapur, District- Lakhimpur Kheri

  Selected villages- Ajbapur, Mahmoodpur Bhagat, Jasmadi, Mastipur, Jalalpur Gopi
- DSCL Sugar-Rupapur, District- Hardoi

  Selected villages- Munder, Kanhari, Amirta, Timirpur, Rawatpur
- DSCL Sugar-Hariawan, District- Hardoi

  Selected villages- Hariawan, Ahmdi, Kayampur, Jiyo, Kuiyan
- DSCL Sugar- Loni, District- Hardoi

  Selected villages- Loni, Nagla Bhagwan, Dharmapur, Naglakallu, Rebha Muradpur

## Additional income from sugarcane

Due to introduction of cane-based interventions in the eight selected villages, the average yield of cane increased from 670 q/ha to 820 q/ha and net income of farmers from cane cultivation increased by 2.5 times (from ₹ 70,000 per ha in the year 2016-17 to ₹ 1,77,000 per ha in the year 2020-2021) (Table 10.3).

All the interventions related to sugarcane introduced in the all the eight villages gave impressive dividend in terms of increased cane yield and enhanced profit from sugarcane cultivation. This has resulted in an increase of 152.86% in net profit earned by virtue of cultivating sugarcane with suggested or introduced component cane technology.

**Table 10.3. Sugarcane yield and net profit from sugarcane**

| Particulars | 2016-2017 | 2021-2022 | Net increase | % increase |
|---|---|---|---|---|
| Sugarcane yield (q/ha) | 670 | 820 | 110 | 22.39 |
| Net profit from sugarcane (₹/ha) | 70,000 | 1,77,000 | 1,07,000 | 152.86 |

## Increase in income of farmers

The introduction of agri-enterprises based interventions like water saving irrigation, soil health management, mechanization, compost making, vaccination & de-worming of animals, silage & hay making, milk procurement through cooperatives/ sugar mills, vegetable marketing *etc.*, paid dividend in terms of income enhancement of farmers. The income of marginal, small and large farmers enhanced by 105.87, 63.73 and 50.14%, respectively in short span of three to four years (Table 10.4).

With this kind of increase in income, a total of ₹ 130.11, 76.78 and 22.40 million additional net income was earned by 2,300 marginal, 1,578 small and 258 large farmers, respectively, dwelling in the project areas. Thus a total of ₹ 229.29 million additional income was accrued to the 4,136 farm families in a year.

## An analysis of gender perspective in sugarcane cultivation

The data from the 30 farmers (men and women) were collected, tabulated and analyzed. Results revealed that the majority of the farmers were of middle age, studied up to intermediate, having medium family education status, maintaining small families, having joint family system, medium social participation, with agriculture + dairy as main occupation, growing sugarcane, paddy, black gram, wheat, mustard, maize, chari, berseem and mango, had medium annual income, maintained, small herd size, having medium mass media exposure and high extension contact in majority.

In case of role performance, social and economic roles were mainly performed by the men, however, the roles pertaining to sugarcane production was performed by both men as well as women. Further, the roles like cane survey, *satta*, cane supply, *etc.*, were mainly performed by the male members of the family. In case of control and access to the resources as well as the benefits,

**Table 10.4. Additional annual income by different category of farmers**

| Farmers' category | Annual Income (₹) | | Net increase in annual income (₹) | No. of farmers | Additional total annual income earned (₹) |
|---|---|---|---|---|---|
| | 2016-2017 | 2021-2022 | | | |
| Marginal (less than 01 ha) | 53,432 | 1,10,000 | 56,568 (105.87%) | 2,300 | 130.11 |
| Small (01-02 ha) | 76,346 | 1,25,000 | 48,654 (63.73%) | 1,578 | 76.78 |
| Large (more than 02 ha) | 1,73,168 | 2,60,000 | 86,832 (50.14%) | 258 | 22.40 |
| | | | | Total | 229.29 |

the men were in dominating position. Decisions related to farming, sale, purchase, community function and political matters were mainly taken by the men. Further, education, family functions & housing related decisions were taken by both jointly.

## Technology and information utilization pattern among the sugarcane growers

An interview schedule comprising the list of important sugarcane technologies *i.e.* use of high yielding variety, seed treatment, planting methods, inter-cropping, harvesting and value addition available for the farmers has been prepared. WhatsApp group of "sugarcane stakeholders" has also been created and responses are being collected through messages/videos and telephonic and video calls. Inventory of innovative sugarcane technologies transferred among the sugarcane growers during last 10 years is being prepared with the discussion with experts and from the secondary sources. Information related to high yielding varieties, insect/ pest &disease management and other information related to sugarcane crop are being provided through WhatsApp, telephonic calls, messages, internet and technology folders among the farmers and other stakeholders of sugarcane. Data shows that more than 90% farmers acquired information related to availability of high yielding varieties of sugarcane followed by insect and pest management (47%). WhatsApp was the most important information tool followed by telephone calls by the farmers.

## Technology assessed in farmers' fields

### Intercropping in sugarcane

Intercropping of pulses, oilseeds, vegetables, spices and fruits with sugarcane has been established as one of the viable options for increasing farmers' income. Technology package for cultivation of different intercrops with sugarcane has been developed by the research institutions. Intercropping technology was demonstrated in farmers' fields to assess its impact on enhancing system yield under real farming situations. During 2022-2023, 13 crops (vegetable pea, potato, tomato, mustard, lentil, chickpea, cabbage, cauliflower, pigeonpea, garlic, frenchbeans, mungbean and banana) were intercroped with autumn/spring planted sugarcane was demonstrated in the fields of 30 farmers of Sitapur, Lakhimpur Kheri, Hardoi, Pilibhit and Bareilly districts of Uttar Pradesh, covering a total of 20 ha area.

The highest net profit of ₹ 6,71,000/ha with B:C ratio 3.35 was recorded for banana grown as intercrop with sugarcane and the lowest net profit of ₹2,62,000/ha with B:C ratio 1.87 was earned by the farmers with chickpea intercropping. The net profit for all intercrops was much higher than the profit recorded with sole cane crop *i.e.* ₹ 1,67,000/ha (Table 10.5). This clearly establishes sugarcane based intercropping as profitable cropping system in comparison to sole cane crop. In addition to higher profit, the intercrops also provided pulses and vegetables to the farmers for their family consumption and thus ensuring food and nutritional security for village dwellers. The intermittent income earned by farmers from intercrops also helped them in better management of sugarcane crops and meeting out their emergent household expenditure.

### Ratoon promoter

As many as 20 demonstrations on ratoon promoter were conducted to assess its benefit in enhancing yield and profit from ratoon crop. It was assessed in farmers' fields in command area of Biswan Sugar Mill, Biswan, Sitapur (U.P.) and DCM Shriram Sugar Mill, Loni, Hardoi (U.P.) covering 06 villages, 25 cane growers and 10.00 ha area. Under all ratoon plots where ratoon promoter machine was operated, cane yield enhanced by 12-15 t/ha, cost saving was upto ₹ 6,000/ha and profit was enhanced by ₹ 45,000-55,000/ha.

## Frontline demonstrations

### Frontline demonstrations on newly released cane varieties

For fast spread of newly released cane varieties, 50 FLDs on seed cane production technology were conducted in farmers' fields in Sitapur, Lakhimpur, Hardoi, Pilibhit and Bareilly districts of Uttar Pradesh and Samastipur, Motihari and Begusarai districts of Bihar.

**Table 10.5. Economic analysis of intercrops grown with sugarcane**

| Cropping system | Yield (t/ha) | | Return (₹/ha) | | Gross return (₹/ha) | Net Profit (₹/ha) | B:C Ratio |
|---|---|---|---|---|---|---|---|
| | Cane | Intercrop | Cane | Intercrop | | | |
| **Sole Sugarcane** | 82 | - | 2,87,000 | - | 2,87,000 | 1,67,000 | 1.39 |
| **Intervention – Intercropping in sugarcane** | | | | | | | |
| Sugarcane + Vegetable Pea | 86 | 7.2 | 3,01,000 | 1,44,000 | 4,45,000 | 2,95,000 | 1.96 |
| Sugarcane + Potato | 88 | 28 | 3,08,000 | 2,80,000 | 5,88,000 | 4,28,000 | 2.67 |
| Sugarcane + Lentil | 86 | 1.8 | 3,01,000 | 1,08,000 | 4,09,000 | 2,69,000 | 1.92 |
| Sugarcane + Chickpea | 85 | 1.90 | 2,97,500 | 1,04,500 | 4,02,000 | 2,62,000 | 1.87 |
| Sugarcane + Mustard | 86 | 1.80 | 3,01,000 | 1,11,600 | 4,12,600 | 2,72,600 | 1.94 |
| Sugarcane + Pigeon Pea (arhar) | 87 | 2.0 | 3,04,500 | 1,28,000 | 4,32,500 | 2,87,500 | 1.98 |
| Sugarcane + Cabbage | 90 | 21.0 | 3,15,000 | 2,73,000 | 5,88,000 | 4,28,000 | 2.67 |
| Sugarcane + Cauliflower | 90 | 20.0 | 3,15,000 | 2,50,000 | 5,65,000 | 4,05,000 | 2.53 |
| Sugarcane + Garlic | 88 | 5.0 | 3,08,000 | 2,20,000 | 5,28,000 | 3,78,000 | 2.52 |
| Sugarcane + Frenchbeans | 92 | 8.0 | 3,22,000 | 2,08,000 | 5,30,000 | 3,80,000 | 2.53 |
| **Sugarcane + Banana** | **86** | **38.0** | **3,01,000** | **5,70,000** | **8,71,000** | **6,71,000** | **3.35** |
| Sugarcane + Mung | 81 | 2.5 | 2,83,500 | 1,85,000 | 4,68,500 | 3,23,500 | 2.23 |
| **Sugarcane + Tomato** | **102** | **30** | **3,57,000** | **3,30,000** | **6,87,000** | **5,17,000** | **3.04** |

Sale price (₹/q): Sugarcane – 350, Vegetable Pea – 2000, Potato – 1000, Lentil – 6000, Chickpea – 5500, Mustard – 6200, Pigeon Pea – 6400, Cabbage – 1300, Cauliflower – 1250, Garlic – 4400, French beans – 2600, Banana – 1500, Mung – 7400, Tomato – 1100.

## Frontline demonstrations on intercropping with sugarcane and cane node technology

To popularize intercropping of pulses, vegetables, oilseeds *etc.*, with sugarcane and to economize the use of seed rate, a total of 30 FLDs on intercropping with sugarcane and cane node technology were conducted in 20 ha area in Uttar Pradesh.

## Frontline demonstrations on ratoon manager machine

To popularize the use of Ratoonmanager machine for propermanagement of ratoon crop a total of 20 FLDs in 10 ha area were conducted in Sitapur and Hardoi districts of Uttar Pradesh.

## Frontline demonstrations of IISR tractor operated modified sugarcane cutter planter

IISR tractor-operated modified sugarcane planter was demonstrated at farmers' field of Lakhimpur and Sitapur in 12.0 ha area covering 15 farmers (Fig. 10.5). With the help of this planter two rows of sugarcane are planted in a single pass at a row spacing of 75/90 cm. The performance of the planter was satisfactory for planting of sugarcane (including sett cutting) at farmer's field. Cost of planting operation was ₹ 3,500 per ha by using the planter as compared to ₹ 8,500 per ha in conventional method.

**Fig. 10.5. IISR tractor operated modified deep furrow sugarcane planter in field operation**

## Frontline demonstrations of IISR tractor operated two row disc type RMD

The frontline demonstration of IISR ratoon management device was conducted in Sitapur district (Fig. 10.6). Approximately seven ha area was covered by IISR RMD in 10 farmers' fields. Feedback information

from the farmers' field emphasized the necessity of simplifying the metering and power transmission system of the equipment. Farmers were happy with the performance of the machine. They found better ratoon initiation using the machine. The machine performs stubble shaving, off barring, interculture, fertilizer and insecticide application and soil covering after the harvest of sugarcane during initiation of the ratoon crop. The machine was also used by the farmers for subsequent interculture, fertilizer application and earthing up after removing the stubble shaving blades.

Fig. 10.6. 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 multicrop seeder

IISR tractor operated raised bed seeder-cum-sugarcane planter was operated at farmer's field at Biswan sugar mill area of Sitapur district in 5.5 ha area covering 14 farmers (Fig. 10.7). The planter makes two furrows at a spacing of 75 cm and two raised beds (one full raised bed + two half raised beds) in a single pass. Two furrows are planted with the cane and the seed of companion crop of pulses are sown on the two raised beds. Performance of the planter was satisfactory with the effective field capacity of 0.20 ha/h.

Fig. 10.7. Tractor operated deep furrow sugarcane cutter planter-cum-multicrop raised bed seeder

## Frontline demonstrations of IISR tractor operated multipurpose interculturing equipment

The equipment was demonstrated at farmers' field of Sitapur district (Fig. 10.8 &10.9). A total of 7.4 ha area was covered covering 15 farmers. Results were in agreement with that obtained during field trials at IISR farm. Cost of operation of furrow opening with the developed equipment was ₹ 2,442 per ha as against ₹ 2,387 per ha in conventional ridger. The cost of furrow opening marginally increased in the developed equipment but it opened deep furrows to facilitate furrow method of sugarcane planting. The furrow method of planting is considered as superior planting technique in terms of water saving, reduced lodging and better ratooning. The cost of performing combination of operations during weeding/interculturing and fertilizer application in the conventional system was ₹ 4,328 per ha whereas with the developed equipment it was ₹ 1,841 per ha. The saving in cost of operation was 57%. The corresponding labour saving was 129 man-h per ha (97%).

Fig. 10.8. IISR tractor operated multipurpose interculturing equipment

Fig. 10.9. IISR multipurpose interculturing equipment during earthing

**Technology demonstration**

| Sponsoring agency | Date | Number of farmers | | |
|---|---|---|---|---|
| | | Male farmers | Female farmers | Total |
| *Ganna Kisan Sangathan*, Gonda | March 2022 | 21 | 09 | 30 |
| People Action for National Interaction, Balrampur | May 2022 | 30 | 11 | 41 |
| Indian Potash Limited | July 2022 | 17 | 03 | 20 |
| *Kisan Shakti Sangathan*, Lakhimpur Kheri | August 2022 | 18 | 12 | 30 |
| ATMA, Ballia | October 2022 | 35 | 17 | 52 |
| *Prgya Gramothan Seva*, Fatehpur | November 2022 | 48 | 14 | 62 |

## Field day organized

- February 24, 2022, Shankarpur, Manpur and Khambhapurwa villages in Biswan Sugar Mill area, Sitapur, Uttar Pradesh
- March 5, 2022, Payodhi Farmers, Producer Company in Bharsula village, Datiya, Madhya Pradesh
- March 6, 2022, Vridawan Dham, Datiya, Madhya Pradesh
- March 30, 2022, Kuraiyakhurd and Narayanpur villages, Pilibhit, Uttar Pradesh
- March 31, 2002, BHSL Barkhera, Pilibhit, Uttar Pradesh
- April 08, 2022, Rajepur Dhawan, Akbarpur, Ambedkarnagar, Uttar Pradesh
- September 29, 2022, *Kangar Sanskrutik Bhavan* of Pravaranagar Sugar Mill, Maharashtra
- December 05, 2022, Udnapur village, Hargaon Sugar Mill, Sitapur, Uttar Pradesh
- December 18, 2022, Village-Etmadpur Sonik, Haidergarh, Barabanki, Uttar Pradesh
- December 22, 2022, Natkur, Sarojini Nagar, Lucknow, Uttar Pradesh

## Students visit under Inter-institutional HRD activities

Under inter-institutional HRD activity, visits of students and teachers were conducted from SHUATS, Allahabad, BHU, Varanasi, AMITY, Lucknow, GD Goenka School, Lucknow, SRITM, Lucknow, NDUAT, Faizabad, and other institutions. More than 600 UGs/PGs and school students visited IISR. During the visits, they were imparted information on IISR research infrastructure, achievements and technologies developed through orientation lecture and visit to labs and fields.

## Linkages developed

1. Collaboration with *Shukla Bandhu Organic Producer Company Limited*, Biswan, Sitapur (U.P.) was developed to establish a "sugarcane based Model Farm" at Purwa Dasapur, Sitapur for promoting agribusiness among rural youth.
2. MoU was signed with PAYODHI FARMERS PRODUCER COMPANY LIMITED (PFPCL) Datia (Madhya Pradesh) to promote agri-business among farmers, rural youth and agri-graduates in the area of jaggery production, value addition, marketing, intercropping, organic farming, compost making, etc.
3. An MoU was signed with Tara Blooms Private Limited, Coimbatore.

This Memorandum of Understanding (MOU) was signed to use the "NamFarmers.com" a social media platform/website/mobile application for communicating with various farmers and agri-stakeholders for knowledge, content dissemination and extension purposes.

## Entrepreneur farmers developed

- Four farmers were trained as entrepreneurs and they are doing seed cane business.

**Exhibitions organized**

| Date | Organizer & Place | Event | No. of Visitors |
|---|---|---|---|
| March 04, 2022 | IISR, Lucknow under SCSP component | One day Training on Natural Farming | 150 Farmers |
| March 08, 2022 | NSI, Kanpur U.P. at NSI, Kanpur | National Conference on Sugar & Health-Myth & Realities MEETHA | 200 Farmers + 100 Students + 100 Officers |
| March 12, 2022 | IIAST, Integral University, Lucknow at University Campus | National Farmers Day | 1000 Farmers |
| March 15, 2022 | Indian Institute of Seed Science, Mau, Uttar Pradesh | *Kisan Mela* | 4000 Farmers |
| March 31, 2022 | IISR, Lucknow under SCSP component at BHSL, Barkheda, Pilibhit | One day Training on Sugarcane Production Technology | 250 Farmers |
| April 8, 2022 | IISR, Lucknow under SCSP component at Rajepur Dhawan, Distt. Ambedkarnagar | One day Training on Sugarcane Production Technology | 200 Farmers |
| April 23, 2022 | ICAR-IISR, Lucknow | *Annidata Devo Bhav* Programme | 50 Scientists & Development Officers and 100 Farmers |
| April 24, 2022 | ICAR-IISR, Lucknow | *Annidata Devo Bhav* Programme | 100 Scientist & Development Officers and 200 Sugarcane farmers |
| April 26, 2022 | ICAR-IISR, Lucknow under SCSP component | One day Training on Sugarcane Production Technology | 200 Farmers |
| October 16-19, 2022 | 7th IAPSIT International Sugar Conference and Sugarcon 2022 | Four day Exhibition at IISR, Lucknow | 500 Farmers + 200 Students + 150 Scientists + 150 Officers |
| October 19-20, 2022 | Govt. of Uttar Pradesh, Patherdeva, Deoria, U.P. | Regional Agricultural Fair | 500 Farmers |

## Outreach activities at IISR Biological Control Centre, Pravaranagar

Five activities were undertaken at the centre :

### 1. *Kisan Sangoshthi*

*Kisan Sangoshthi* was organized by the IISR-Biological Control Center, Pravaranagar in Kamgar Sanskrutik Bhavan of Pravaranagar sugarmill. While addressing the farmers and sugarmill officers, Dr. T.R. Sharma, Deputy Director General (Crop Science), ICAR, New Delhi said that in view of the increasing demand for sugar and ethanol in the country, sugarcane farmers need to obtain high production of sugarcane by using modern technology developed and advocated by the ICAR-IISR. Dr. Sharma also advocated the use of bio-agents for the management of pests and diseases in sugarcane. Smt. Shalinitai Vikhe Patil, Former President, Zila Parishad, Ahmednagar chaired the farmers' *goshthi*. In the *goshthi*, more than 250 farmers and factory personnel participated and interacted with the scientists.

### 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 moth borers of sugarcane (early shoot, internode and top shoot borer). The egg parasitoid

was reared on its natural insect host (rice mealworm, *Corcyra cephalonica*) in the laboratory. Three hundred green trichocards were produced and a total of 177 trichocards were distributed to the 108 farmers. This intervention of the centre brought 61.6 ha sugarcane growing area under biological control of borer complex.

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

In the insectary unit, the rice mealworm were reared as a host insect on the broken rice grains for the continuous supply of eggs for the mass production of trichocards. The pure culture of *C. cephalonica* were also maintained and supplied 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, *G. mellonella* was reared on an artificial sem-isolid diet in the insectary unit, however, the pure culture of *G. mellonella* were supplied to researchers, academicians and entrepreneurs.

### 5. Frontline demonstration on IISR combo insecttrep was conducted at Pravaranagar in collaboration with Micoplex India Ltd to assess and update the traps against the white grub beetles

## Management of IP portfolio and commercialization of technologies

The institute Logo was submitted to the Patent office, New Delhi for its registration as Trademark. The trademark under class Trademark registration under Class-30 is under consideration at IP office. The details of IP granted, patents submitted and commercialization of technologies are given in Table 10.6. These activities are being strengthened under National Agricultural Innovation Fund (Component-I).

## Commercialization of technologies

The Institute has signed two MoAs/MoUs for commercialization of newly developed technologies and agricultural machinery with different manufactures for their large scale production and their supply to the famers and other end-users (Table 10.7).

**Table 10.6. Details and status of IP applications submitted for registration of Trademark**

| IPRs | Name of Institute | Application/ Registration No. | Name of innovation/ technology/ product/ variety | Date of filing/ Registration | Status |
|---|---|---|---|---|---|
| **Patent** | ICAR-IISR, Lucknow | TEMP/E-1/ 2917/ 2022-DEL | Ethrel primed sugarcane top as planting material for reducing cane cultivation cost and improving cane and sugar productivity | January 17, 2022 | Under examination process |
| | | TEMP/E-1/8897/2022-DEL | Sugarcane Trash Manager-cum-Stubble Shaver | February 14, 2022 | First examination report (FER) generated |
| **Trademarks** | ICAR-IISR, Lucknow | 4877880 | Under Class-30 | February 24, 2021 | Accepted/ Published in Trademark Journal |
| **Copyrights** | ICAR-IISR, Lucknow | Diary No. 3560/ 2022-CO/ SW | ***Ikshu Kedar"*** mobile app for precise irrigation scheduling for sugarcane cultivation in sub-tropical India | February 18, 2022 | Re-Scrutiny |
| | | Diary No. 3776/2022-CO/L | Image database of sugarcane insect, pests and diseases | February 18, 2022 | Registered with the registration number (L-117221/2022) |

**Table 10.7. Details of MoA/MoUs signed for transfer of newly developed technologies**

| S No. | Name of technology | Name of contracting party | Mode of partnership** | Date of licensing | Revenue earned (₹) |
|---|---|---|---|---|---|
| 1 | IISR, Combo Trap for the management of sugarcane insect pests | SKR Agro-Tech, Maharashtra | MoU | December 29, 2021 | ₹ 2.0 lakh as license fee and royalty @ 5% of gross value of each device sold |
| 2 | IISR Blue Bull Repellent | SKR Agro-Tech, Maharashtra | MoU | January 24, 2022 | ₹ 1.00 lakh + royalty @ 2% of gross value of each device sold |

## Contract research project and Professional Services

The Institute has signed a number of MoUs with different organizations for testing of their products under contract research project during year 2022.

## Establishment of ABI Unit at ICAR-IISR, Lucknow under National Agricultural Innovation Fund (Component-II)

Upgradation of PHET lab and renovation of ABI office space was done. The ABI unit for jaggery was made operational. One incubatee graduated and one new incubatee was admitted. Expression of interest was uploaded on IISR website.

CHAPTER 11

# Krishi Vigyan Kendra, Lucknow

## On Farm Testing/Trials (OFTs)

Nine OFTs on major thrust areas were conducted during the year as per the details given below:

- **Integrated pest management in paddy crop:** OFT on evaluation of IPM for overcoming the insect pest problems in paddy crop. It showed that treatment T2- Profenophos 50 EC @1 ml./l water+ Yellow sticky trap (10 No.) + Pheromone trap (10 No.) resulted in insect incidence up to 4.5% and the yield level was 68.98 q/ha. Cost benefit ratio of demonstration plot and farmers practice were 2.99:1 and 2.78:1, respectivily.
- **Management of root rot and powdery mildew in vegetable pea:** Seed treatment (*Trichoderma viridae* @ 5 gm/kg seed) and spray of wetable sulphur (3.0 gm/l) reduced root rot and powery mildew up to 10% and 17-18%, respectively and the yield increased by 16.64%. Cost benefit ratio of demonstration plot and farmers, practice were 2.18:1 and 1.60:1.
- **Evaluation of different methods of button mushroom composting:** An OFT was conducted to assess the different methods of button mushroom composting at village Ramgarh (Amethi), Gosaiganj block of Lucknow district. The short method of compost preparation was found to perfom well in comparision to long (28 days) method. The compost was prepared in 18 days; production duration and yield both was more *i.e.* 120 days and 7.38 q/50 q compost in comparison to long method *i.e.* 100 days and 6.5 q/50 q.
- **Preservation of vegetable pea:** An on-farm trial to assess the feasibility of preservation of vegetable green pea through blanching techniques was compared with marketing of pea green pod. The OFT was conducted at ten farmers' households with original taste. The blanched pea retained olive green colour when it was stored in deep freezer for one year with original taste. The benefit cost ratio of such preservation was 2.04:1.
- **Performance evaluation of broccoli varieties:** A study was conducted during *Rabi* season 2021-22 at farmers fields. The results revealed that the treatment T2 (var. Sakhi) recorded maximum plant height (40.8 cm) at 45 days after transplanting (DAT), number of leaves (13.8) at 45 DAT, average curd weight (690 g), average circumference of head (48.8 cm) and yield per hectare (230.0 q). The days taken for head initiation (62.5 days) and for first head harvest (77.8 days) were minimum. The broccoli variety, Sakhi fetched maximum remuneration. The gross and net return were ₹ 2,76,000.00 and ₹ 1,69,666.00 and output: input ratio was 2.60:1. An OFT was also conducted on farmers' fields.
- **Performance of fortified variety of wheat in Lucknow district:** ICAR-IIWBR, Karnal developed fortified variety of wheat *i.e.* DBW-187 (Karan Vandana), having additional nutrients *i.e.*, Mn (52.1 ppm), Cu (5.32 ppm), Fe content (50.3 ppm) and one of the best Zn content (43.7 ppm) in comparison to other varieties. An OFT to evaluate the performance this fortified variety, in comparison to HD 2967 variety was carried out.
- **Performance of sugar rich green fodder round the year:** An OFT was conducted to see the performance of different combination of sugar rich green fodder in the cropping system. Sweet sorghum (July to September) – *Barseem* (November to February) and sugar beet (March to June) provided green fodder for the longest duration (300 days) and the per cent increase in milk was 24% due to sugar rich fodder followed by farmers practice of cultivating *Barseem-Jowar*-MP *chari* (228 days) cropping system.
- **Assessment of cultivation practices of natural farming and organic farming in comparison with conventional farming in rice-wheat cropping system:** An OFT to evaluate the cultivation practices of natural farming and organic farming in comparison with conventional farming in rice-wheat cropping system was conducted.
- **Performance of artificial insemination through sex sorted semen in cows to increase the female calving ratio and milk production of Lucknow district:** An OFT was conducted to evaluate the performance of different types of sex sorted semen with particular reference to Gir and Sahiwal breed semen.

## Frontline demonstrations conducted

### Frontline demonstrations on oilseed crops

| Crop | Thematic Area | Technology demonstrated | Variety | No. of farmers | Area (ha) | Yield (q/ha) | | | | % Increase in yield | Economics of demonstration (₹/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Demo | | | Check | | Gross cost | Gross return | Net return | BCR (R/C) |
| | | | | | | High | Low | Average | | | | | | |
| Sesamum | ICM | Improved variety | GJT-5 | 69 | 10 | 10.5 | 5.8 | 8.1 | 5.4 | 50.00 | 28085 | 63423 | 35338 | 2.3:1 |
| Mustard | ICM | Improved variety+ fertilizer +NPKS: 40:60:80:20 + Insecticide Imidachloprid @.3 ml/lit | RH-749 | 87 | 20 | 17 | 14 | 15.5 | 11.6 | 33.62 | 30000 | 78275 | 48275 | 2.6:1 |

### Frontline demonstrations on pulse crops

| Crop | Thematic Area | Technology demonstrated | Variety | No. of farmers | Area (ha) | Yield (q/ha) | | | | % Increase in yield | Economics of demonstration (₹/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Demo | | | Check | | Gross cost | Gross return | Net return | BCR (R/C) |
| | | | | | | High | Low | Average | | | | | | |
| Green-gram | ICM | Improved variety | Shikha | 78 | 10 | 11.1 | 7.6 | 9.3 | 6.9 | 34.78 | 34675 | 72121.5 | 37446.5 | 2.1:1 |

### Frontline demonstrations on other crops

| Category & Crop | Thematic Area | Name of the technology | No. of farmers | Area (ha) | Yield (q/ha) | | | | % Change in yield | Economics of demonstration (₹/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Demo | | | Check | | Gross cost | Gross return | Net return | BCR (R/C) |
| | | | | | High | Low | Average | | | | | | |
| **Cereals** | | | | | | | | | | | | | |
| Wheat | ICM | Improved variety (DBW 187) | 334 | 63.35 | 57 | 42 | 49.5 | 39 | 26.92 | 30000 | 100237.5 | 70237.5 | 3.34:1 |
| Paddy | IPM | Management of yellow stem borer | 22 | 5.0 | 61.3 | 50.9 | 55.2 | 48.3 | 14.29 | 44875 | 112608 | 67733 | 2.51:1 |
| **Horticulture 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 | 11.44 | 125000 | 408000 | 283000 | 3.26 |
| Bottle gourd | IPM | Use of fruit fly trap (10 trap/ha) through fruit fly trap | 12 | 2 | 395.1 | 305.75 | 375.13 | 268.7 | 39.61 | 65500 | 262591 | 197091 | 4.0:1 |
| Mango | IPM | Spray of Lamdacylothrsen 5% | 4 | 2 | 124.2 | 116.3 | 120.15 | 103.7 | 15.86 | 82500 | 180225 | 97725 | 2.18:1 |
| Cauliflower | ICM | Improved variety (Madhuri) NPK: 100: 80:60, Foliar spray of boron @ 2.5 g/l | 10 | 0.5 | 353.5 | 295.5 | 340.5 | 298.8 | 13.96 | 102000 | 238350 | 136350 | 2.3 |

| Category & Crop | Thematic Area | Name of the technology | No. of farmers | Area (ha) | Yield (q/ha) | | | | % Change in yield | Economics of demonstration (₹/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Demo | | | Check | | Gross cost | Gross return | Net return | BCR (R/C) |
| | | | | | High | Low | Average | | | | | | |
| Chilli | ICM | Improved variety (Suryamukhi), NPK @ 100:80:60 kg/ha, Two foliar spray of NPK (19:19:19) | 10 | 0.5 | 135.6 | 122.5 | 131.5 | 115.5 | 13.85 | 95500 | 236700 | 141200 | 2.5 |
| Brinjal | ICM | Improved variety (Navkiran), NPK @ 120:80:60 kg/ha, Two foliar spray of NPK (19:19:19) | 10 | 1 | 335.5 | 315.9 | 320.8 | 240.5 | 33.39 | 91250 | 256640 | 165390 | 2.8 |
| Tomato | ICM | Improved variety (NS-4266) NPK @ 120:80:80 kg/ha, Two foliar spray of NPK (19:19:19) | 10 | 0.5 | 623.5 | 585.6 | 590.5 | 514.2 | 14.84 | 126950 | 295250 | 168300 | 2.3 |
| Vegetable pea | ICM | Improved variety (Kashi Uday) Sulphur 10 kg/ha | 108 | 10 | 85.5 | 69.5 | 78.4 | 62.8 | 24.84 | 49700 | 117600 | 67900 | 2.4 |
| Onion | ICM | Agrifound Light Red, Combined application of 110:40:60:20 kg NPKS along with 15 t FYM | 34 | 1 | 295.5 | 265.8 | 272.8 | 215.8 | 26.41 | 65500 | 136400 | 70900 | 2.1 |
| Fodder Sorghum Multicut | ICM | Improved variety (NSC-1084F) | 142 | 10 | 1380 | 1760 | 1660 | 1230 | 34.96 | 125000 | 398000 | 273000 | 3.2:1 |
| Barseem | ICM | Improved variety (BL-42) | 186 | 10 | 926.1 | 754.5 | 842.8 | 560 | 50.50 | 217021 | 421400 | 204379 | 1.94:1 |
| Perennial grasses | ICM | Napier-3108 | 47 | 2.5 | 890 | 760 | 865 | 585 | 47.86 | 29830 | 129750 | 99920 | 4.3:1 |
| Oat | ICM | Improved variety (Kent) | 19 | 5 | 480 | 390 | 435 | 340 | 27.94 | 30000 | 282750 | 252750 | 9.4:1 |

## Frontline demonstrations on livestock

| Category | Thematic area | Name of the technology demonstrated | No. of farmers | No. of units (Animal/ Poultry/ Birds, etc) | Major parameters | | % change in major parameter |
|---|---|---|---|---|---|---|---|
| | | | | | Demo | Check | |
| Deworming | Endoparasite management | All clear: Fenbendazole BP (vet) 3 g | 29 | 29 | Endoparasite controlled 100% | Endoparasite controlled 15% | 90% |

## Frontline demonstrations on other enterprises

| Category and crop | Thematic area | Name of the technology demonstrated | No. of farmers | No. of Units | Yield (kg) | | Economics of demonstration (₹/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Demons-ration | Check | Gross cost | Gross return | Net return | BCR (R/C) |
| Kitchen gardening | ICM | Nutritional kitchen gardening | 400 | 400 | 180 | - | 1500 | 3600 | 2100 | 2.4:1 |
| Rooftop gardening | ICM | Rooftop kitchen gardening | 86 | 86 | 276 | - | 3650 | 8280 | 4630 | 2.27:1 |

**Training Pogrammes:** KVK has conducted 102 training programmes for participating farmers and farm women, rural youth and extension funtioneries on various topics with an objective to improve skill and to upgrade their knowledge about developed and potent products. All training programmes were fully skilled oriented and were conducted following the principles of "Learning by doing".

| Clientele | No. of courses | Male | Female | Total participants |
|---|---|---|---|---|
| Farmers & farm women | 93 | 1419 | 960 | 2379 |
| Vocational trainings | 07 | 188 | 47 | 235 |
| In-service trainings | 02 | 68 | 12 | 80 |
| Sponsored training | 0 | 0 | 0 | 0 |
| **Total** | **102** | **1675** | **1019** | **2694** |

## Other extension activities conducted by KVK

| Activity | No. of programmes | No. of farmers | No. of Extension Personnel | Total |
|---|---|---|---|---|
| Advisory Services (Mobile) | 4018 | 179372 | 0 | 179372 |
| Diagnostic visits | 5 | 210 | 6 | 216 |
| Field days | 12 | 282 | 0 | 282 |
| Group discussions | 7 | 138 | 3 | 141 |
| *Kisan Goshthi* | 5 | 545 | 54 | 599 |
| Film Show | 16 | 328 | 18 | 346 |
| *Kisan Mela* | 5 | 1468 | 23 | 1491 |
| Exhibition | 8 | 2489 | 35 | 2524 |
| Scientists' visit to farmers field | 240 | 2606 | 22 | 2628 |
| Plant/ animal health camps | 1 | 20 | 5 | 25 |
| Farmers' seminar/ workshop | 2 | 472 | 15 | 487 |
| Method demonstrations | 120 | 1500 | 30 | 1530 |
| Celebration of important days | 6 | 469 | 55 | 524 |
| Special day celebrations | 2 | 145 | 45 | 190 |
| Live telecast | 3 | 411 | 36 | 447 |
| Others | 90 | 3242 | 164 | 3406 |
| **Total** | **4540** | **193697** | **511** | **194208** |

## Soil sample analysis

| Samples | No. of samples | No. of farmers | No. of villages |
|---|---|---|---|
| Soil | 280 (Grid basis) | 280 | 18 |

## Seed and planting material production

| Seed production | Quantity (q) |
|---|---|
| Oilseed (Mustard) | 10.0 |
| Pulses (Pigeonpea and Fieldpea) | 17.3 |
| Cereal (Wheat & Paddy) | 45.5 |
| Sugarcane | 500.0 |
| Spices (Coriander, Nigella, Fenugreek & Fennel Seed) | 6.0 |
| **Total** | **578.8** |
| **Planting material production** | **Quantity (No.)** |
| Vegetable seedlings | 25,736 |
| Fruit saplings | 34,150 |
| Root slips of different perennial fodder grasses | 40,000 |
| **Total** | **99,886** |
| **Production of bio-products and produce** | **Quantity (kg or Litre)** |
| Vermicompost | 70,000 |
| Mushroom | 77 |
| Cow milk | 3045 |

CHAPTER 12

# Krishi Vigyan Kendra, Lakhimpur Kheri

To upgrade the knowledge of farmers, farm women and rural youth, KVK organized 40 training programmes benefitting 1,408 farmers including farm women and rural youth. The training programmes were on plant protection, horticulture & animal science.

- Six technologies related to plant protection, horticulture and animal sciences were assessed at 27 farmers' field covering three ha area.
- Six Frontline demonstrations (FLD) were conducted with the participation of 25 farmers including farm women covering over 5.50 ha area to demonstrate the production potential of technologies.
- In order to increase the pulse and oilseed production in the district, demonstration on improved variety of oilseeds and pulses were conducted on 159 farmers' fields covering over 60 ha area.
- A total of 447 other extension activities were conducted which benefited 6,198 farmers including farmers, farm women, rural youths and extension personnel from line departments, for mass awareness through, *Kisan Mela*, *Kisan Ghosthi* and celebration of important days etc. The details are given in Table 12.1:
- The planting material (seedlings) of different vegetable crops, ornamental crops, sugarcane setts and potato tubers were produced and sold to farmers.
- Two days *Chaupal*-cum-Animal Health Camp and public awareness programme was organised on May 28-29, 2022 in the village Bellaparsua and Kadiadanga of Lakhimpur Kheri district. During this animal health camp, cattle, buffaloes, Sheep and goats were clinically examined and tentatively diagnosed for conditions like tick infestation, endoparasitism, mastitis, infertility, repeat breeding, inappetence, lameness, conjunctivitis, bloat, diarrhoea, *etc.* These tentatively diagnosed conditions in animals were given on the spot (specific and supportive) treatment. All the animals reporting for the camp were dewormed with broad-spectrum anthelmintic with appropriate dosing. Reproduction related problems were advised and provided with the mineral mixture, herbal heat inducers, microminerals and other specific management measures. The animal health camp was carried out with the help of the officials of State Department of Animal Husbandry and around 158 farmers and farm women participated and a total of 272 animals were treated for different ailments.

**Table 12.1. Extension activity-wise participation of farmers at the IISR KVK, Lakhimpur-Kheri**

| Type of activity | No. of programmes | No. of farmers | No. of Extension Personnel | Total |
|---|---|---|---|---|
| Advisory Services | 163 | 198 | 24 | 222 |
| Diagnostic visits | 4 | 32 | 6 | 38 |
| Field Day | 1 | 25 | 2 | 27 |
| Group discussions | 48 | 988 | 3 | 991 |
| *Kisan Ghosthies* | 15 | 404 | 12 | 416 |
| Film Shows | 9 | 502 | 21 | 523 |
| *Kisan Mela* | 3 | 370 | 13 | 383 |
| Exhibition | 6 | 504 | 12 | 516 |
| Scientists' visit to farmer's fields | 148 | 1184 | 62 | 1246 |
| Plant/animal health camps | 6 | 308 | 19 | 327 |
| Farmers' seminar/workshop | 1 | 67 | 4 | 71 |
| Method demonstrations | 11 | 126 | 15 | 141 |
| Celebration of important days | 7 | 362 | 12 | 374 |
| Special day celebration | 7 | 362 | 12 | 374 |
| Exposure visits | 2 | 120 | 8 | 128 |
| Others | 16 | 400 | 21 | 421 |
| **Total** | **447** | **5952** | **246** | **6198** |

**Table 12.2. Seed and planting material production**

| Crop | Name of the crop | Name of the variety | Quantity | Value (₹) | Number of farmers |
|---|---|---|---|---|---|
| Commercial and other crops | Sugarcane | CoLk 11206 & CoLk 14201 | 18.50 q (7,800 bud) | 20400 | 24 |
| | Potato | Kashi Bahar | 12.40 q | 12400 | 22 |
| Vegetable seedlings | Brinjal | Kashi Sandesh | 850 No. | 1275 | 17 |
| | Chilli | Kashi Anmol | 1840 No. | 2760 | 29 |
| | Tomato | Arka Abhed & Kashi Abhiman | 7590 No. | 11385 | 99 |
| | Cabbage | Admiral | 6920 No. | 10380 | 90 |
| | Cauliflower | Maharani & Garima | 8355 No. | 12532.5 | 120 |
| | Broccoli | Saki & Fantasy | 16785 No. | 25177.5 | 232 |
| | Capsicum | Ahsa & Delisha | 4210 No. | 6315 | 98 |
| | Onion | ADR | 3500 No. | 5250 | 39 |
| Ornamental plants | Mengold | Pusa Narangi & Pusa Bahar | 2490 No. | 3735 | 47 |
| | China Aster | A. Archna & A. Poornima | 1700 No. | 2550 | 42 |

Glimpses of extension activities

Demonstration on compost preparation and bags filling for button mushroom cultivation

World soil day celebration

CFLD on Soybean

Training on Oyster mushroom cultivation at Mohaddipur, Nakaha

CHAPTER 13

# 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 13.1.

**Table 13.1. 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: ₹ 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: ₹ 48.00 lakh) |
| Bayer Crop Science 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: ₹ 13.00 lakh) |
| Bayer Crop Science Pvt. Ltd., Mumbai | Bio-efficacy and phytotoxicity evaluation of Solomon 300 OD against black bug infestations in sugarcane (Y.E. Thorat, D.N. Borase, S.N. Sushil; 10/21-09/23, Budget: ₹ 13.0 lakh) |
| Bayer Crop Science Pvt. Ltd., Mumbai | Bio-efficacy and phytotoxicity evaluation of pre and post-emergent application of Aclorufe 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: ₹ 20.00 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: ₹ 20.0 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: ₹ 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. Jaiswal; 2022-2024, Budget ₹ 12.00 lakh) |
| UPL Ltd., Mumbai | Bio-efficacy and phytotoxicity evaluation of GPH 1020 against complex weed flora of sugarcane and its effect on succeeding crop (D.N. Borase, S.K. Yadav, Dileep Kumar, Y.E. Thorat, 11/22-12/24, Budget: ₹ 15.00 lakh) |

| Contracting party | Contract research |
|---|---|
| UPL Ltd., Mumbai | Bio-efficacy and phytotoxicity evaluation of GPH 1521 against complex weed flora of sugarcane and its effect on succeeding crop (D.N. Borase and Dileep Kumar; 2021-23, Budget: ₹ 18.0 lakh) |
| FMC India Pvt. Ltd. | Efficacy of E 2Y45 600 SC against major insect pests of sugarcane (S.N. Sushil, Shamila Roy and A. Baitha; Budget: ₹ 15.00 lakh) |
| FMC India Pvt. Ltd. | Efficacy of F4337-500 g/l SC against major insect pests of sugarcane (Y.E. Thorat, D.N. Borase, S.N. Sushil; 7/21-6/23 Budget: ₹ 15.00 lakh) |
| ISK Biosciences India Pvt. Ltd., New Delhi | Bio-efficacy evaluation of SL-160 25% WG herbicide against weed complex of sugarcane (V.P. Singh, K.K. Singh, Dileep Kumar and A.D. Pathak; 03/20-12/22, Budget: ₹ 12.0 lakh) |
| IFL Biological Ltd., Gurugram | Evaluation of *Pseudomonas fluorescens* 1.0% W.P (Strain No. IFL/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: ₹ 15.00 lakh) |
| IFL Biological Ltd., Gurugram | Bio-efficacy and evaluation of biofertilizer - *Cane Master* (*Gluconoacetobacter diazotrophicus sp.*) in sugarcane crop (V.P. Jaiswal, Lalan Sharma, S.K. Shukla, A.P. Dwivedi and A.D. Pathak; 2020- 2022, Budget: ₹ 10.00 lakh) |
| Narmada Biochem Limited | Assessing efficacy of Narmada PROM (Phosphorus rich organic manure) as an organic source of P on soil quality and productivity of cane and sugar in Indian sub-tropics (S.N. Singh, A.D. Pathak, V.K. Singh and R.K. Singh; 03/19-07/22 Budget ₹ 10.0 lakh) |
| Ingen Pvt. Ltd., Mumbai | Evaluation of the effect of Nanozim Xtrude on crop health yield in sugarcane. (A.P. Dwivedi; 2022/2023, Budget ₹ 5.00 lakh) |
| P.I. Industries | Evaluation of PIX 10042 76.75 WG against important weeds of sugarcane and its effect on soil microflora, succeeding crop and yield (A.P. Dwivedi, S.K. Shukla, V.P. Jaiswal, A.D. Pathak, M.K. Tripathi; 09/19-12/22; Budget: ₹ 15.0 lakh) |
| Sirius Minerals India Pvt. Ltd. | Efficacy of POLY 4 on growth behaviour, yield attributes, yield and soil health of sugarcane (autumn and spring season) (M.K. Tripathi, S.K. Shukla, S.R. Singh, A.P. Dwivedi and A.D. Pathak), 2018-22, Budget: ₹ 42.20 lakh) |
| Patanjali Bio-Research Institute, Haridwar | 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 : ₹ 10.00 lakh) |
| Acadian Seaplants Ltd., West Mumbai | Evaluation of the effect of SoliGro GR on growth and yield of sugarcane (S.R. Singh, M.K.Tripathi, A.P. Dwivedi and A.D. Pathak; 2020-2022, Budget: ₹ 10.00 lakh) |
| UPL Ltd., Mumbai | Bio-efficacy and phytotoxicity evaluation of sett treatment product UPFI 116 against insect pests and diseases of sugarcane (D.N. Borase, Arun Baitha, Shweta Singh, Y.E. Thorat, 11/22-12/24, Budget: ₹ 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: ₹ 15 lakh) |
| UPL Ltd., Mumbai | Bio-efficacy evaluation of GPI 818 & GPI 418 against major insect pests in sugarcane. (S.N. Sushil, Shamila Roy and A. Baitha; Budget: ₹ 20.00 lakh) |

| Contracting party | Contract research |
|---|---|
| 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, Y.E. Thorat, 03/21-02/23, Budget: ₹ 18 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, Y.E. Thorat; 01/21-08/23, Budget: ₹ 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 : ₹ 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, S.N. Sushil, 20/21-01/23, Budget: ₹ 5.0 lakh) |
| Zydex India Pvt. Ltd., Vadodara | Effect of Zytonic M and microbial consortia on sustaining soil health and sugarcane yield in subtropical India (M.K.Tripathi, Mona Nagargade, S.K. Shukla, V.P. Jaiswal and A.D. Pathak; 2020-22, Budget: ₹ 6.0 lakh) |

CHAPTER 14

# Human Resource Development

## Training programme on establishment matters for LDC and UDC of ICAR

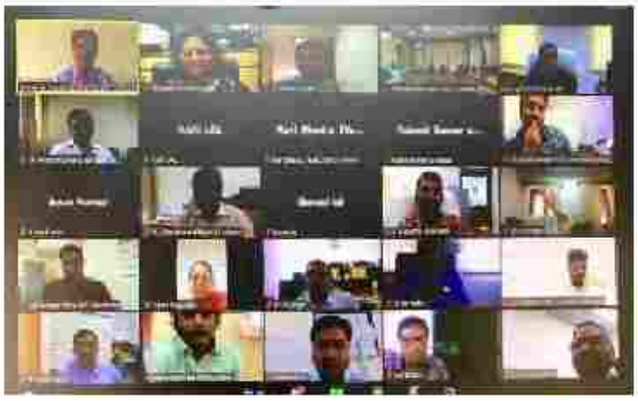
A six-days "Training Programme on Establishment Matters for LDC and UDC of ICAR" was organized by the ICAR-Indian Institute of Sugarcane Research, Lucknow in collaboration with HRM Unit of ICAR HQ during January 17-22, 2022 through Online Mode with Sh. S.K.Singh CAO as Master Trainer & Course Director, Smt. AnjaliSharma, US HRM as Course Coordinator & Sh. R.K. Yadav, AAO as Co-course Coordinator. The various topics related to Establishment like, Governance in ICAR, Noting & Drafting, Office Procedure, Financial Management, CCS (Conduct) Rules, Leave Rules, TA/TTA Bill Processing, CS(MA) Rules, Scientific & Technical Assessment, Leave Rules, ACP/MACP Guidelines, Right to Information Act-2005, Time Management, Team Work, Motivation, Official Language Acts & Rules, *etc.*, were covered during these six days. In his valedictory address, Dr. A.D. Pathak, Director, IISR, Lucknow emphasized the need of such trainings and conveyed that the ICAR-IISR is well equipped with the required infrastructure to host such training programmes in online and offline modes. Dr. A.K.Vyas, ADG (HRM) congratulated HRD Cell of IISR for successful conduct of training and stated that the LDC/UDC are the foundation of the official hierarchy and thus it's the need of the hour to focus on their competency enhancement for optimum utilization and better outcome of human resource. More than 40 participants participated in the training programme.

## 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 21-23, 2022. 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. A.D. Pathak, Director, IISR, Lucknow on March 21, 2022. Various topics related to e-office, team-work, time management, cyber security, purchase procedures, CS (MA) rules, stress management, positive attitude, and financial discipline *etc.*, were covered during these three days. The resource persons included Dr. R.V.S. Rao from ICAR-NAARM, Hyderabad; Sh. M. Jagadish Babu, CDAC, Hyderabad; Sh. S.K. Singh, CAO, ICAR-IIWBR, Karnal; Sh. Kumar Rajesh, CAO (SG), ICAR Hq; Dr. Bhartendu Nandan, Scientist 'E', DRDO, Delhi; Sh. G.P. Sharma, Director (F), ICAR HQ and Sh. S.K. Singh, CAO, IISR, Lucknow. All the scientists, technical, administrative and supporting skilled staff participated in the training.

## Capacity building of IISR officials

| Name | Training Programme | Venue | Date |
|---|---|---|---|
| Dr. D.N. Borase | ICAR sponsored Short Course on "Bioprospecting of Plant Microbiome- A Novelty to Plant Health Management in Organic Production System" organized by Assam Agriculture University, Jorhat, Assam | Online mode | January 19-28, 2022 |
| Dr. A.K. Dubey | Recent Technologies of Livestock-based Integrated Farming System for Doubling Farmers Income organized by College of Veterinary Science & Animal Husbandry, Birsa Agricultural University, Ranchi, Jharkhand and ICAR-NAHEP and NADCL, Baramulla (UT of J & K) | Online mode | February 1-21, 2022 |
| Dr. Y.E. Thomat and Dr. Rajesh U Modi | Twenty-one days ICAR sponsored Winter School on 'Artificial Intelligence in Agriculture' organized by ICAR-IASRI, New Delhi | Online mode | February 15 – March 7, 2022 |
| Dr. Swapna M. | DBT sponsored Training on QTL Analysis and Genome-wide Association Studies by ICAR-IASRI, New Delhi | Online mode | February 15-24, 2022 |
| Dr. A.K. Dubey, Dr. Deepak Rai, Dr. S.K. Pandey and Sh. Ram Lakhan | Virtual Training Programme on Natural Farming organized by Shoonya Farms, Gautam Buddh Nagar, U.P. with technical support of UPCAR, Lucknow | Online mode | February 26, 2022 |
| All the Scientists, Officers and Staff | Capacity Building Programme for IISR Staff organized by IISR, Lucknow | ICAR-IISR, Lucknow | March 21-23, 2022 |
| Dr. Sangeeta Srivastava | Virtual Training Programme on Plant Taxonomy for Plant Genetic Resources Management organized by ICAR-NBPGR, New Delhi | Online mode | March 21- 26, 2022 |
| Dr. Y.E. Thomat | Training in 'Adaptation of Pest Management Strategies in Changing Climate Scenario' organized jointly by ICAR-CRIDA and MANAGE, Hyderabad | Online mode | May 9-13, 2022 |
| Dr. Sangeeta Srivastava | National Workshop-cum-Webinar on Genome Editing organized by Glostem in association with INYAC | Online mode | June 27-July 03, 2022 |
| Dr. Y.E. Thomat | Training programme on Advances in web and mobile application' organized by ICAR-NAAFM, Hyderabad | Online mode | August 2-6, 2022 |
| Dr. Rajesh U. Modi | DGCA-approved drone pilot training with Remote Pilot Certificate No. PC09220000088. | Drone Destination Private Limited, Bhora Kalan, Gurugram, Haryana | September 8-15, 2022 |
| Dr. Niranjan Lal, Dr. A.K. Dubey, Dr. S.K. Yadav, Er. V.A. Blessy, Dr. G.K. Singh, Dr. Ram Kishor, Mr. Adil Zuber Dr. Vivek Kumar Pandey | Winter School on Recent Approaches for Doubling Farmers' Income in Sugarcane Cropping System | ICAR- IISR, Lucknow | December 8-28, 2022 |
| Sh. Ram Lakhan | Training Programme on Content Management System | ICAR-ATARI, Kanpur | December 16, 2022 |
| Er. V.A. Blessy | Groundwater Potential Zoning and Identification of Suitable Sites for GWR organized by Centre for Advanced Agricultural Science and Technology, JNKVV, Jabalpur | Jabalpur | December 23-30, 2022 |



## Winter school on "Recent Approaches for Doubling Farmers Income in Sugarcane Based Cropping System"

A winter school on "Recent Approaches for Doubling Farmers Income in Sugarcane Based Cropping System" was organized at the ICAR-Indian Institute of Sugarcane Research, Lucknow (UP) during December 08-28, 2022 with Dr Sudhir Kumar Shukla, PS & Head (I/c) Crop Production as Course Director. Twenty-five participants from various universities & ICAR institutes, and subject matter specialists from Krishi Vigyan Kendras belonging to U.P., Karnataka, Bihar, Gujarat, Madhya Pradesh and Maharashtra participated in the Winter School. There were seventy-three lectures and


practical sessions besides outside field visits. Further, visits of the KVK, Sitapur and fields of progressive farmers in village Amethi, Block Gosainganj in Lucknow district were also organized. Dr. R. Viswanathan, Director, ICAR-Indian Institute of Sugarcane Research, Lucknow & Chairman of Valedictory Session of Winter School emphasized on the new advancements in sugarcane production system and issues of accumulation of pathogens inside the canes and carryover of pathogenic inoculum through planting materials due to vegetative propagation in sugarcane. Dr Lalan Sharma, Senior Scientist (Plant Pathology) & Course Coordinator of Winter School proposed vote of thanks to Chairman, resource persons, all HoDs/ Incharges for providing input to conduct winter school at ICAR-IISR, Lucknow.

## Internship of trainings organized

- Dr. Swapna M. organised a two-month *Vritika* internship on "Study of genetic diversity for sugar content in sugarcane" sponsored by SERB-DST, under Accelerate *Vigyan* programme for two students of SHUATS, Prayagraj from September 02-October 31, 2022.
- Dr. Swapna M. initiated a one month *Vritika* internship on "Molecular diversity studies in sugarcane using DNA based markers" sponsored by SERB-DST, under Accelerate *Vigyan* programme for two students of IGKV, Chhattisgarh and RPCAU, Samastipur from December 27, 2022.

## Sponsored sugarcane extension trainings to farmers and students organized

| Duration | Topic | Sponsoring Agency | No. of Participants |
|---|---|---|---|
| January 01-05, 2022 | Sugarcane Technology and Management | BHU, Varanasi (Uttar Pradesh) | 29 Students |
| February 24-26, 2022 | Sugarcane and Jaggery Production Technology | Department of Agriculture, Datiya, Madhya Pradesh at Datiya | 150 Farmers |
| March 04, 2022 | Natural Farming of Sugarcane Production | IISR, Lucknow-SC/ST Sub-Plan Component Budget (2021-2022) at IISR | 150 Farmers |
| March 31, 2022 | Sugarcane Production Technology | IISR, Lucknow-SC/ST sub-plan component budget (2021-2022) at BHSL, Barkheda, Pilibhit (Uttar Pradesh). | 150 Farmers |
| March 28-30, 2022 | Sugarcane Production Technology | ATMA, Aurangabad, Bihar | 44 Farmers |
| April 08, 2022 | Sugarcane Production Technology | IISR, Lucknow-SC/ST sub-plan component budget (2021-2022) at Rajepur Dhawan, Akbarpur, Ambedkarnagar (U.P.) | 200 Farmers |
| April 23, 2022 | Interactive Meeting on Natural Farming and Organic Farming under Annadata Devo Bhavah | ICAR-IISR, Lucknow | 100 Farmers |
| April 24, 2022 | Interactive Meeting on Bioethanol, co-generation and jaggery production | ICAR-IISR, Lucknow | 150 Farmers |
| April 19-20, 2022 | Orientation on IISR technologies and activities | SNSI, Belgavi, Karnataka | 15 Officers |
| June 08, 2022 | Organic Farming in Sugarcane Crop | Belsar Organic Farming Producer Company Ltd. Gonda | 25 Farmers |
| June 20-26, 2022 | Sugarcane Technology and Management | B.Sc. (Hons.) Agriculture BHU, Varanasi and B.Sc. (Hons.) Hort. and B.Sc. (Hons.) Ag. SHUATS, Prayagraj, Uttar Pradesh | 20 Students |
| September 07-09, 2022 | Capacity building for adoption of technology | Aayurved Research Foundation, Kaushambi, Ghaziabad, UP | 25 Farmers |
| September 13, 2022 | Improved Sugarcane Production Technology | *Sujalaam-Sufalaam Aur Savera* Project under Peoples' Action for National Integration (PANI), Balrampur, UP | 50 Farmers |
| September 17-18, 2022 | *Krishak Jagrukta Prashikshan Karyakram* | ICAR-IISR, Lucknow | 65 Farmers |
| October 1 - November 4, 2022 | Rural Agricultural Work Experience (RAWE) | Students of Rama University Kanpur; NIAS (GNSU), Jamuhar, Sasaram, Rohtas (Bihar) and Integral University, Lucknow | 41 Students |
| December 14-17, 2022 | Sugarcane Production Technology | ATMA, Narsinghpur, M.P. | 25 Farmers |

## One day training-cum-visits organized

During the period, a total of 63 one-day training and visit programmes were organized at the institute in which 933 farmers, 04 development personnel, 04 entrepreneurs, 499 students and 34 teachers acquired latest know-how in scientific cane cultivation practices, jaggery making, bio-fertilizer production, tissue culture and sugarcane machines.

## 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. Several residential and off-campus training programme were conducted in which more than 200 participants were groomed as entrepreneurs to pursue agri-business in their available farming systems.

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

| Sl. No. | Detail of the students | Supervisor | Duration of training/dissertation | |
|---|---|---|---|---|
| | | | From | To |
| 1. | Ms. Sapna Neolia,<br>Student of M. Tech. (Biotechnology),<br>Amity University, Noida, UP | Dr. Sangeeta Srivastava | January 3, 2022 | July 2, 2022 |
| 2. | Mr. Mayank Maurya,<br>Student of B. Tech. (Ag. Engg.), SHUATS, Prayagraj | Dr. A.K. Singh | January 14, 2022 | February 13, 2022 |
| 3. | Mr. Kumar Nishkarsh,<br>Student of M.Sc. (Microbiology),<br>Lucknow University, Lucknow | Dr.V.P. Jaiswal | March 3, 2022 | September 2, 2022 |
| 4. | Ms. Deeksha Singh<br>Student of M.Sc. (Microbiology)<br>Lucknow University, Lucknow | Dr. Lalan Sharma | March 3, 2022 | September 2, 2022 |
| 5. | Mr. Anshumali Shalaj<br>Student of M.Sc. (Microbiology)<br>Lucknow University, Lucknow | Dr.V.P. Jaiswal | March 3, 2022 | September 2, 2022 |
| 6. | Ms. Soni Singh<br>Ph.D. student<br>(Genetics & Plant Breeding)<br>ANDUA&T, Ayodhya | Dr. Sangeeta Srivastava | March 4, 2022 | September 3, 2022 |
| 7. | Mr. Saksham<br>Student of M.Sc. (Microbiology),<br>Lucknow University, Lucknow | Dr. Lalan Sharma | March 8, 2022 | June 7, 2022 |
| 8. | Mr. Aabhas Dwivedi<br>Student of M.Sc. (Microbiology)<br>Lucknow University, Lucknow | Dr.V.P. Jaiswal | March 8, 2022 | June 7, 2022 |
| 9. | Mr. Sarthak Singh<br>Student of B. Tech (Biotech.)<br>Ramswaroop Memorial University, Lucknow | Dr. Dinesh Singh | April 6, 2022 | October 5, 2022 |
| 10. | Mr. Ravi Prakash Chaudhary,<br>Ph.D. Scholar (Genetics and Plant Breeding),<br>ANDUA&T, Ayodhya | Dr. Sangeeta Srivastava | March 1, 2022 | May 31, 2022 |
| 11. | Mr. Mohd. Ahmad Hashmi,<br>Student of B. Tech. (Biotech.) Bundelkhand University, Jhansi | Dr. Sangeeta Srivastava | June 1, 2022 | July 15, 2022 |
| 12 | Mr. Tushar Singh,<br>Student of B. Tech. (Biotech.)<br>SHUATS, Prayagraj | Dr. Sanjeev Kumar | June 1, 2022 | July 15, 2022 |
| 13 | Mr. Devashish Chaurasia,<br>Student of B. Tech. (Biotech.)<br>SHUATS, Prayagraj | Dr. Sangeeta Srivastava | June 1, 2022 | July 15, 2022 |

| Sl. No. | Detail of the students | Supervisor | Duration of training/dissertation | |
|---|---|---|---|---|
| | | | From | To |
| 14 | Mr. Ananya Saumitra<br>Student of B.Tech.<br>Shiv Nadar University, Delhi NCR | Dr. Sanjeev Kumar | June 1, 2022 | July 15, 2022 |
| 15 | Mr. Abhinav Pratap Maurya,<br>Student of B. Tech. (Ag. Engg.)<br>MCAET (NDUA&T), Akbarpur, Ambedkarnagar | Dr. A.K. Singh | June 1, 2022 | June 30, 2022 |
| 16. | Mr. Abhishek Verma,<br>Student of B. Tech. (Ag. Engg.)<br>MCAET (NDUA&T), Akbarpur, Ambedkarnagar | Dr. A.K. Singh | June 1, 2022 | June 30, 2022 |
| 17. | Mr. Ashwani Kumar,<br>Student of B. Tech. (Ag. Engg.)<br>MCAET (NDUA&T), Akbarpur, Ambedkarnagar | Dr. A.K. Singh | June 1, 2022 | June 30, 2022 |
| 18. | Mr. Brajesh Patel,<br>Student of B. Tech. (Ag. Engg.)<br>MCAET (NDUA&T), Akbarpur, Ambedkarnagar | Dr. A.K. Singh | June 1, 2022 | June 30, 2022 |
| 18. | Mr. Kishan Singh,<br>Student of B. Tech. (Ag. Engg.)<br>MCAET (NDUA&T), Akbarpur, Ambedkarnagar | Dr. A.K. Singh | June 1, 2022 | June 30, 2022 |
| 20. | Mr. Krishna Giri,<br>Student of B. Tech. (Ag. Engg.)<br>MCAET (NDUA&T), Akbarpur, Ambedkarnagar | Dr. A.K. Singh | June 1, 2022 | June 30, 2022 |
| 21. | Mr. Ram Babu,<br>Student of B. Tech. (Ag. Engg.)<br>MCAET (NDUA&T), Akbarpur, Ambedkarnagar | Dr. A.K. Singh | June 1, 2022 | June 30, 2022 |
| 22. | Mr. Pushpendra Kumar,<br>Student of B. Tech. (Ag. Engg.)<br>MCAET (NDUA&T), Akbarpur, Ambedkarnagar | Dr. A.K. Singh | June 1, 2022 | June 30, 2022 |
| 23 | Mr. Satyam Singh,<br>Student of B. Tech. (Ag. Engg.)<br>MCAET (NDUA&T), Akbarpur, Ambedkarnagar | Dr. A.K. Singh | June 1, 2022 | June 30, 2022 |
| 24 | Mr. Shashi Kant Rawat,<br>Student of B. Tech. (Ag. Engg.)<br>MCAET (NDUA&T), Akbarpur, Ambedkarnagar | Dr. A.K. Singh | June 1, 2022 | June 30, 2022 |
| 25. | Mr. Abhinav Pratap Maurya,<br>Student of B. Tech. (Ag. Engg.)<br>MCAET (NDUA&T), Akbarpur, Ambedkarnagar | Dr. A.K. Singh | June 1, 2022 | June 30, 2022 |
| 26. | Mr. Abhinav Pratap Maurya,<br>Student of B. Tech. (Ag. Engg.)<br>MCAET (NDUA&T), Akbarpur, Ambedkarnagar | Dr. A.K. Singh | June 1, 2022 | June 30, 2022 |
| 27. | Mr. Amnendra Singh Tomer<br>Student of MA (Statistics),<br>Lucknow University, Lucknow | Dr. Rajesh Kumar | June 4, 2022 | July 3, 2022 |
| 28. | Mr. Ashish Kumar Yadav<br>Student of MA (Statistics),<br>Lucknow University, Lucknow | Dr. Rajesh Kumar | June 4, 2022 | July 3, 2022 |
| 29. | Mr. Mayank Gautam Student of B. Tech. ( Ag. Engg.)<br>AKTU, Lucknow | Dr. A.K. Singh | July 6, 2022 | August 5, 2022 |
| 30. | Mr. Manoj Kumar<br>Student of B. Tech. (Ag. Engg.)<br>AKTU, Lucknow | Dr. A.K. Singh | July 11, 2022 | August 10, 2022 |
| 31. | Mr. Shailendra Pratap Verma<br>Student of B. Tech. (Ag. Engg.)<br>AKTU, Lucknow | Dr. A.K. Singh | July 12, 2022 | August 11, 2022 |

| Sl. No. | Detail of the students | Supervisor | Duration of training/dissertation | |
|---|---|---|---|---|
| | | | From | To |
| 32. | Mr. Sudhakar Rawat<br>Student of B. Tech. (Ag. Engg.)<br>AKTU, Lucknow | Dr. A.K. Singh | July 12, 2022 | August 11, 2022 |
| 33. | Mr. Atul Kannojiya,<br>Student of B. Tech. (Ag. Engg), AKTU, Lucknow | Dr. A.K. Singh | July 14, 2022 | August 13, 2022 |
| 34. | Mr. Shubham Kumar<br>Student of MSc (Ag) Plant Pathology<br>CCS University, Meerut | Dr. Dinesh Singh | August 4, 2022 | February 3, 2023 |
| 35. | Mr. Praveen Kumar<br>Student of MSc (Ag) Plant Pathology<br>CCS University, Meerut | Dr. S.K. Goswami | August 5, 2022 | February 4, 2023 |
| 36. | Mr. Shailendra Kumar Maurya<br>Student of MSc (Ag) Plant Pathology<br>CCS University, Meerut | Dr. Dinesh Singh | August 5, 2022 | February 4, 2023 |
| 37. | Mr. Sumit Kumar<br>Student of MSc (Ag) Plant Pathology<br>CCS University, Meerut | Dr. Dinesh Singh | August 5, 2022 | February 4, 2023 |
| 38. | Mr. Avneesh Kumar<br>Student of M.Sc. (Ag) Agril. Entomology,<br>Bundelkhand University, Jhansi | Dr. Arun Baitha | August 18, 2023 | February 17, 2023 |
| 39. | Mr. Vikas Harsh<br>Student of MBA (Rural Management)<br>BBAU, Lucknow | Dr. L.S. Gangwar | September 13, 2022 | October 12, 2022 |
| 40. | Mr. Afroz Ali<br>Student of MBA (Rural Management)<br>BBAU, Lucknow | Dr. L.S. Gangwar | September 13, 2022 | October 12, 2022 |

## Trainings organized at IISR Biological Control Centre, Pravaranagar

1. One-week unit attachment training of 24 B.Sc. (Agri) students on "Sugarcane Research and Management" under RAWE (Rural Agricultural Work Experience) programme of College of Agriculture, Loni affiliated to MPKV, Rahuri at IISR Biological Control Centre, Pravaranagar during September 1-7, 2022. Dr. D.N. Borase acted as the Course Director, while Dr. Y.E. Thorat acted as Co-Coordinator.

2. A hands-on training programme on 'Futuristic approaches in Biological Control of Pests and Diseases' was organized at IISR Biological Control Centre, Pravaranagar in collaboration with the Department of Botany and Research Centre, PVP College, Pravaranagar for 80 UG and PG students of Botany and Seed Technology during April 18-23, 2022. Dr. Y.E. Thorat acted as Course Director and Dr. D.N. Borase and Dr. A.S. Wable acted as Co-Directors.

CHAPTER 15

# Awards

## ICAR Awards

On the occasion of the 94th Foundation Day of ICAR, the first prize of *Ganesh Shankar Vidyarthi Hindi* Award Scheme 2021 was awarded to ICAR-IISR official language magazine *"Ikshu"* in the category among the big ICAR Institutes of "K" and "Kh" region at A.P. Shinde Hall, NASC Complex, New Delhi on July 16, 2022. The award was conferred by Sh. Narendra Singh Tomer, Hon'ble Minister of Agriculture and Farmers Welfare, Govt. of India in presence of Sh. Parshottam Rupala, Hon'ble Minister of Fisheries, Animal Husbandry and Dairy, Govt. of India; Shri Kailash Chaudhari, Hon'ble Minister of State for Agriculture and Farmers Welfare; Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR and Dr. Ramesh Chandra, Hon'ble Member of NITI Aayog; Dr. A.K. Singh, DDG (Ag. Extension), ICAR and other distinguished guests. The award was received by Dr. A.D. Pathak, Director; Dr. A.K. Sah, I/c, *Rajbhasha* and Sh. Abhishek Kumar Singh, Hindi Officer.

## Professional Society Awards

Dr. Rajesh Kumar was awarded *"Sankhyiki Bhushan* Award" the highest award in the field of Agricultural Statistics by ISAS. Prof. M.Y. Samanta, Chief Statistician, Government of India and Secretary, Ministry of Statistics and Programme Implementation, Govt of India presented the award during 73rd Annual Conference of the Indian Society of Agricultural Statistics on November 14-16, 2022 at SKUAS&T, Srinagar.

Dr. Rajesh Kumar was awarded Senior Scientist Award – National Level during Bharatiya Sugar Awards ceremony and Symposium 2022 held on 7th September 2022 at Hyatt Regency Pune Hotel and Residences, Pune, Maharashtra.

Dr. Ashutosh Kumar Mall received Young Scientist Award-2018 from Range Management Society of India, Jhansi.

Dr Rajesh U. Modi received ISAE-JAE(I) Best Reviewer Award 2022 during 56th Annual Convention of Indian Society of Agricultural Engineers, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu on November 09-11, 2022.

## Institute Awards

- Dr. S.K. Yadav received Best Scientist Award by ICAR-IISR, Lucknow on the occasion of 71st Foundation Day of the Institute on 16th Feb. 2022.

- Sh. Brahm Prakash received Best Technical Personnel Award by ICAR-IISR, Lucknow on the occasion of 71st Foundation Day of the Institute on 16th Feb. 2022.

- Dr. Sangeeta Srivastava received Best Woman Scientist award by ICAR-IISR, Lucknow on the occasion of 71st Foundation Day of the Institute on 16th Feb. 2022.
- Dr. S.N. Sushil received Outstanding Institution Building Award by ICAR-IISR, Lucknow on the Foundation Day of the Institute on 16th February, 2022.

- Dr. Sangeeta Srivastava, Dr. S.N. Singh, Dr. Rajesh Kumar, Dr. Ashutosh Kumar Mall, Sh. Brahm Prakash, Dr. Anita Sawnani, Sh. Raj Kumar Yadav, Sh. C.P. Prajapati received Outstanding Institution Building Award by ICAR-IISR, Lucknow on the Foundation Day of the Institute on 16th February, 2022.

## Best Paper Award

- Drs. M.K. Singh, A.K. Singh and R.D. Singh received First Prize for the best oral presentation on their paper entitled 'Mechanization of sugarcane trash management' in the Technical Session–I in the International Conference SUGARCON-2022 on "Sustainability of the Sugar and Integrated Industries: Issues and Initiatives" held at ICAR-IISR, Lucknow during October 16-19, 2022.
- Dr. Rajesh U. Modi received Second Best Oral Paper Award 2022 in the Technical Session-I during the 7th IAPSIT International Sugar Conference and SUGARCON 2022 on "Sustainability of the Sugar and Integrated Industries: Issues and Initiatives" held at ICAR-IISR, Lucknow, India from October 16-19, 2022.
- Dr. Ranjit Singh Gujjar received Second Best Oral Paper Presentation Award during 7th IAPSIT International Sugar Conference and SUGARCON 2022 on "Sustainability of the Sugar and Integrated Industries: Issues and Initiatives" held at ICAR-IISR, Lucknow, India from October 16-19, 2022.
- Dr. M.K. Tripathi received Third Best Oral Paper Award for his paper entitled "Effect of silicon nutrition on sugarcane in subtropical India" presented in the Technical Session-I during 7th IAPSIT International Sugar Conference and SUGARCON 2022 on "Sustainability of the Sugar and Integrated Industries: Issues and Initiatives" held at ICAR-IISR, Lucknow, India from October 16-19, 2022.
- Dr. Rajesh U. Modi received Best Poster Award 2022 in the Technical Session-I during the 7th IAPSIT International Sugar Conference and SUGARCON 2022 on "Sustainability of the Sugar and Integrated Industries: Issues and Initiatives" held at ICAR-IISR, Lucknow, India from October 16-19, 2022.
- Dr. D.N. Borase received Best Poster Award for the paper entitled "Post-harvest quality deterioration in sugarcane under tropical conditions" presented during the 7th IAPSIT International Sugar Conference and SUGARCON 2022 on "Sustainability of the Sugar and Integrated Industries: Issues and Initiatives" held at ICAR-IISR, Lucknow, India from October 16-19, 2022.

- Drs. Y.E. Thorat, D.N. Borase, S.N. Sushil and A.D. Pathak received the Best Oral Presentation Award for the paper entitled 'Entomopathogenic nematodes (EPNs): Isolation, identification and pathogenic potential against white grubs infesting sugarcane' presented in International Conference SUGARCON 2022 organized at ICAR-IISR, Lucknow on October 16-19, 2022.

CHAPTER 16

# Publications

## Research Papers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CHAPTER 17

# Review, Monitoring and Evaluation

## Research Advisory Committee Meeting

The XXVIII meeting of Research Advisory Committee of ICAR-Indian Institute of Sugarcane Research, Lucknow was held on November 23-24, 2022 in hybrid mode under the Chairmanship of Dr. S.K. Datta, Ex. Deputy Director General (CS), ICAR, New Delhi. Dr. N. Vijayan Nair, Ex. Director, ICAR-SBI, Coimbatore; Dr. Indra Mani, Vice-Chancellor, Vasantrao Naik Marathawada Krishi Vidyapeeth, Parbhani; Dr. S.V. Sarode, Ex. Director of Research, Dr. PDKV, Akola; Dr. J.P. Mishra, OSD (PPP) and ADG (IR), ICAR, Krishi Bhawan, New Delhi; Dr. A.K. Vasisht, Ex. ADG (PIM/ESM), ICAR, Krishi Bhawan, New Delhi; Dr. R.K. Singh, ADG (CC), ICAR, Krishi Bhawan, New Delhi; Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow and Dr. Sangeeta Srivastava, Principal Scientist, Division of Crop Improvement, ICAR-IISR, Lucknow and Member Secretary were physically present in the meeting, while Dr. R.L. Tamak, Executive Director & CEO-Sugar, DCM Shriram, New Delhi and Mr. Sudhir Kumar Singh Siddhu, District Barabanki (IMC Member) attended the meeting in virtual mode. All the Heads of Divisions/In-Charges of Sections, In-Charges of RC, Motipur, BCC, Pravaranagar and Sugar beet Breeding Outpost, Mukteswar as well as all the scientists of the Institute also participated in the meeting as special invitees.


Dr. A.D. Pathak, Director, ICAR-IISR gave a brief presentation regarding the research highlights and major activities undertaken by the Institute during 2021-22. The Action Taken Report (ATR) on the recommendations of XXVII RAC meeting held on November 26-27, 2021 was presented by Dr. Sangeeta Srivastava, Member Secretary. After discussion, the RAC


accepted the ATR on the recommendations of XXVII RAC. All the Heads of the Divisions and In-Charge, Sections made presentations on the research activities and achievements of their respective Divisions/Sections during the past one year. The following major recommendations emerged during the meeting:

- Multi-location testing of 100-150 early generation clones should be done at factory locations to identify location specific sugarcane varieties. Use of speed breeding, genomic selection and genome editing tools for specific traits need to be initiated to augment the conventional breeding programme. Research collaborations on these aspects can be made with ICAR-SBI, Coimbatore.
- A collaborative programme on integrated ratoon management with combined efforts of crop production technologies, ratoon management device and physio-biochemical basis of improving ratoon performance need to be formulated and carried out.
- Effect of climate change on insect pests and diseases in the sub-tropical region should be studied in detail by formulating an inter-disciplinary programme. A comparison of previous years' data on incidence of pest and disease surveillance may be utilized to understand the trend.
- A status paper/booklet on red rot management needs to be developed including all the aspects of research such as varietal development, epidemiology, impact management and current scenario of genomics and genome sequencing.
- A holistic approach of using drone technology and AI based detection of diseases and insect pests monitoring and their management to improve accuracy of sugarcane farming should be taken up.

Standardization of the protocols (SOP) should be resorted to for the best functional strategies of using IT tools.

- Ratoon management device and other machinery developed should be sent to ICAR-Sugarcane Breeding Institute, Coimbatore for further evaluation and utilization. Activity-wise documentation of extent of mechanization under different categories (land preparation, seed bed, planting, intercultural operations, harvesting *etc*) should be taken up.
- There is a need of a "Systems approach" to develop the land use plans for sugarcane with the help of scientists of different disciplines and institutions with available resources and constraints and simulate the data to develop a plan in a time span of 4-5 years. Efficiency of sugarcane cultivation in different districts/areas and ecological parameters leading to low yield in some of the districts need to be studied.
- A pilot project of about 5 ha as integrated programme on white grub management should be taken up at BCC, Pravaranagar in collaboration with KVK and MPKV scientists to develop strategies against white grub through demonstrative projects.
- International collaboration with other sugarcane growing countries should be developed to have a global partnership. A success story on sugarcane cultivation can be show-cased in Agriculture Summit of G 20 meeting.
- KVK, Lakhimpur Kheri must adopt a few villages and some of the technologies developed by the Institute should be continuously demonstrated for 5 or more years. The present data may be used as the base line to study the impact of these interventions on socio-economic status.

## Institute Research Council Meeting

The Institute Research Council (IRC) meeting of the ICAR-IISR, Lucknow was held under the chairmanship of Dr. A.D. Pathak, Director of the Institute during August 2-3 and 20 and September 15, 2022 to review and discuss the on-going research projects in the Institute. The IRC discussed the research findings of 70 ongoing-Institute research projects and the technical programme for the next year. Fifty six scientists and four technical officers of the Institute participated in the IRC Meeting.

The following four new research project proposals were submitted and presented by the scientists in the IRC, which were approved after thorough discussion:

- Strategies for the management of *Cyperus rotundus* L. in long-term: the world's most tenacious weed in sugarcane
- Assessing nutrient dynamics as influenced by weeds in sugarcane-grown alluvial soils
- Assessment and standardization of natural farming techniques for sugarcane production system
- Development of IDM module to sustain potential varieties against red rot disease of sugarcane

## Institute Management Committee Meeting

The 50th meeting of the Institute Management Committee (IMC) was held under the chairmanship of Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow on February 25, 2022. Progress of R & D efforts was reviewed and various administrative matters were discussed in the meeting.

## Institute Technology Management Committee Meeting

The first meeting of ITMC during 2022 was held on August 30, 2022 under the chairmanship of Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow. The meeting was attended by Dr. J. Singh, Head, Division of Crop Improvement; Dr. S.K. Shukla, Head, Division of Crop Production; Dr. Sharmila Roy, Head, Division of Crop Protection; Dr. A.K. Singh, Head, Division of Agricultural Engineering; Dr. A.K. Sah, I/c, Extension and Training Unit; Dr. A.K. Sharma, Principal Scientist, AKMU; Dr. A.K. Dubey, Head, KVK, Lucknow; Dr. V.P. Jaiswal, Senior Scientist and I/c, SWAPM Lab; Dr. Dilip Kumar, Principal Scientist, Processing Engineering; Shri. Saroj Kumar Singh, CAO, IISR and Dr. L.S. Gangwar, Principal Scientist & Member Secretary, ITMC, Shri Brahm Prakash, CTO, PME Cell and Dr. Kamini Singh, R.A, ITMU, NAIF Comp-I. The following decisions were taken in the meeting:

- The Institute will determine the price of a technology based on the actual expenditure on its development, refinement and feasibility testing, including labour and material costs. For deciding the higher price of a technology and to negotiate with the firm, the Institute may seek assistance and guidance from the Agri-Innovate Pvt. Limited, New Delhi for bringing higher revenue for technology through licensing fee and suitable royalty percent on sale of products and equipment for transfer of technologies to the entrepreneurs and better services to sugarcane farmers and other end-users.
- The detailed information regarding availability of sugarcane seed, planting conditions, seed rate and seed provider's contact details may be made available on the Institute website.
- As the Institute has received, sufficient fund under AEI, NAIF Comp-II in capital and in general, this may be utilized for the renovation of agricultural engineering lab and procuring an automated moulding machine and a packing machine for jaggery packaging.

The second meeting of ITMC was held on December 09, 2022 under the Chairmanship of the Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow. Dr. A.D. Pathak, Principal Scientist; Dr. S.N. Sushil, Director, ICAR-NBAIR, Bengaluru; Dr. S.K. Shukla, Head, Division of Crop Production; Dr. Shamila Roy, Head, Division of Crop Protection; Dr. A.K. Sharma, Principal Scientist and I/c, AKMU; Dr. A.K. Sah, I/c, Extension and Training Unit; Mr. S.K. Singh, CAO and Dr. L.S. Gangwar, Principal Scientist & Member Secretary, ITMC were other members who attended the meeting. The Committee discussed at length about the price fixation of the technology IISR-WARD which was transferred to SKR Agrotech, Wardha (Maharashtra). The committee decided the price of IISR-WARD to be ₹ 4,200 per unit, including GST, if any.

## Institute Biosafety Committee Meeting

The Institute Biosafety Committee (IBSC) Meeting was held on December 29, 2022 under the chairmanship of the Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow. The meeting was attended by Dr. A.D. Pathak, Ex. Director, ICAR-IISR. Lucknow; Dr. Manish Mishra, Principal Scientist, ICAR-CISH, Lucknow as DBT nominee; Dr. Mahender Singh, Principal Scientist, ICAR-NBFGR, Lucknow as External Expert; Dr. R.S. Gujjar, Senior Scientist, ICAR-IISR as an Internal Expert; Dr. R.M. Singh, Medical Officer, ICAR-IISR and Dr. Sanjeev Kumar, Principal Scientist, ICAR-IISR. Dr. R. Vishwanathan stressed upon the need of taking utmost care while handling equipment, hazardous chemicals, etc. Dr. Sanjeev Kumar, Member Secretary presented the ATR and briefed about different projects being undertaken by Principal Investigators. The members discussed various steps taken by different laboratories of the Institute in the area of biosafety. It was informed that new project staff/trainees be made aware about safety aspects in the laboratory, and encouraged to visit the websites providing information on Regulatory Compliance by IBSC and ICAR Bio-safety Portal. The present disposal system of laboratory waste, buffers, plasticware, agarose gel, *etc.*, was discussed at length.

## 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 13-15, 2022.

**CHAPTER 18**

# Participation of Officials in Conferences/Workshops/ Seminars/ Symposia/Meetings *etc.*

| Name | Seminar/Symposia/Meeting | Venue | Date |
|---|---|---|---|
| Drs. A.D. Pathak, J. Singh, Dr. Rajesh Kumar, Sharmila Roy, S.N. Sushil, M.R. Singh, Arun Baitha, Dinesh Singh, Sanjeev Kumar, M. Swapna, Deeksha Joshi, Lalan Sharma, S. K. Goswami, Shweta Singh, Chandramani Raj and Aalok Shiv | Zonal Breeders and Plant Protection Scientists Meet of All India Coordinated Research Project on Sugarcane through Online Mode | ICAR-IISR, Lucknow | January 24, 2022 |
| Dr. Sangeeta Srivastava | Online Webinar on "*The 3 Ps of Ploidy: Polyploid, Purity and Problematic*" organized by Sysmex Asia Pacific Pte Ltd, Singapore | Online mode | February 15, 2022 |
| Dr. A.D. Pathak and all the staff of the Institute | Foundation Day Function of the Institute | ICAR-IISR, Lucknow | February 16, 2022 |
| Dr A.K. Singh | 36th Annual Workshop of AICRP on Farm Implements and Machinery held Online virtual platform | ICAR-CIAE Bhopal | February 23-24, 2022 |
| Dr. A.D. Pathak, Dr. Sangeeta Srivastava, Sh. S.K. Singh, all the Heads of the Divisions and I/c, Sections | Meeting of Institute Management Committee | ICAR-IISR, Lucknow | February 25, 2022 |
| Dr. Sangeeta Srivastava | National Webinar on "*New Dimensions in Crop Improvement from Allele Mining to Genome Editing*" organized by RLBCAU, Jhansi | Online mode | February 26, 2022 |
| Dr. Sangeeta Srivastava | National Webinar on "*Biofortified Crops for Balanced Nutrition and Immunity Boosting*" organized by ICAR-NIPB, New Delhi | Online mode | February 28, 2022 |
| Dr. A.D. Pathak and Dr. Dilip Kumar | National Conference & Sugar Expo "*MEETHA 2022*" on the topic "Sugar and Health-Myth & Realities" | National Sugar Institute, Kanpur | March 12, 2022 |
| All the staff of Institute | Online Training on "Capacity Building Programme" | ICAR-IISR, Lucknow | March 21-23, 2022 |
| Dr. Lalan Sharma | Conference on Prioritizing crop specific technologies for sustainable profitability: The Uttar Pradesh Chapter (RC-PCSTSP-UPC-2022) | ICAR-IISR, Lucknow | March 25-26, 2022 |
| Dr. A.D. Pathak, all the Scientists and Technical Personnel | Two-days mega event under the campaign *Annadata Devo Bhava* under *Azadi Ka Amrit Mahotsav* | ICAR-IISR, Lucknow | April 23-24, 2022 |

| Name | Seminar/Symposia/Meeting | Venue | Date |
|---|---|---|---|
| Dr. A.D. Pathak and all the Scientists & Technical Personnel | Regional Conference on Prioritizing Crop Specific Technology for Sustainable Profitability | ICAR-IISR, Lucknow | April 29-30, 2022 |
| Dr. A.D. Pathak and all the Scientists | Brain Storming Session on Management of Red Rot and Other Major Diseases of Sugarcane and Inauguration of Soil Testing Laboratory Building Ceremony | ICAR-IISR, Lucknow | May 23, 2022 |
| Dr. M K Singh | One day National Conference on 'Innovative approaches for Sustainable Agriculture' | | June 14, 2022 |
| Dr. Sanjeev Kumar and Dr. Swapna M. | Symposium Commemorating Birth Bicentenary of Gregor Johann Mendel "Tending Mendel's Garden for a Perpetual and Bountiful Harvest" | ICAR-IARI, New Delhi. | July 19-21, 2022 |
| Dr. A.D. Pathak, all the Scientists and Technical Personnel | Stakeholders' Meet on Sugarcane and Sugar Sector @2025 | ICAR-IISR, Lucknow | July 20, 2022 |
| Dr. A.K. Sharma | Meeting of ITMC of ICAR-CISH, Lucknow | ICAR-CISH, Lucknow | June 24, 2022 |
| Dr. A.D. Pathak, all the Scientists of the Institute, Mr. Brahm Prakash, Dr. Anita Sawnani, Dr. D.C. Rajak and Dr. Mukund Kumar | Meeting of Institute Research Council | ICAR-IISR, Lucknow | August 2-3, 20 and Sept. 15, 2022 |
| Dr. Sangeeta Srivastava | 4th edition of Librarian Forum India 2022 at organized by Clarivate South Asia | Taj Mahal Hotel, Lucknow | August 25, 2022. |
| Drs. A.K. Sharma, L.S. Gangwar, R.D. Singh, R Gupta, Sukhbir Singh and Mr. Brahm Prakash | 51st Annual Convention of SISSTA, 2022 | Rahul Convention Center, Tirupati, Andhra Pradesh | August 26-27, 2022 |
| Dr. A.D. Pathak, all the Heads of the Divisions, I/c Sections, Heads, KVKs, Dr. L.S. Gangwar, Dr. A.K. Sharma, Dr. Barsati Lal, Dr. Dilip Kumar, Sh. S.K. Singh, Mr. Brahm Prakash and Dr. Kamini Singh | Meeting of Institute Technology Management Committee | ICAR-IISR, Lucknow | August 30, 2022 |
| Drs. Sharmila Roy, A.K. Sah, M.K. Singh, D.N. Borase, Yogesh E. Thorat and D.C. Rajak | Foundation Stone laying ceremony | ICAR-IISR Biological Control Centre, Pravaranagar | September 29, 2022 |
| Drs. A.D. Pathak, all the Scientists of the Institute | Biennial Workshop of All India Coordinated Research Project on Sugarcane | ICAR-IISR, Lucknow | October 14-15, 2022 |
| Dr. A.D. Pathak, all the Scientists, Mr. Brahm Prakash, Dr. G.K. Singh, Dr. D.C. Rajak, Dr. Om Prakash, Dr. Deepak Rai, Dr. V.N. Singh, Dr. Rakesh K. Singh, Dr. Veenika Singh, Mrs. Mithilesh Tiwari, Dr. Anita Sawnani, Mr. Atul Kumar Sachan, Dr. Ram Kishor, Mr. Y.M. Singh, Mr. A.K. Yadav, Mr. Ashish Singh Yadav, Mr. Rajiv Ranjan, Mr. A.K. Srivastava, Mr. Santosh Kumar | SUGARCON-2022 & 7th IAPSIT INTERNATIONAL SUGAR CONFERENCE under the theme Sustainability of the Sugar and Integrated Industries: Issues and Initiatives | ICAR-IISR, Lucknow | October 16-19, 2022 |

| Name | Seminar/Symposia/Meeting | Venue | Date |
|---|---|---|---|
| Drs. R. Viswanathan, A.D. Pathak, all the Heads of the Divisions, I/c, Sections, Heads, KVKs, Dr. L.S. Gangwar, Dr. A.K. Sharma, Dr. Barsati Lal, Dr. Dilip Kumar, Mr. S.K. Singh and Dr. Kamini Singh | Meeting of Institute Technology Management Committee | ICAR-IISR, Lucknow | December 9, 2022 |
| Dr. Rajesh Kumar | 73rd Annual Conference of the Indian Society of Agricultural Statistics, New Delhi on Statistics and Machine Learning for Big Data Analytics | Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, J&K | November 14-16, 2022 |
| Dr. Rajesh Kumar | National Workshop-cum-Seminar on *Emerging Trends in Statistics for Agricultural Sustainability (ETSAS 2022)* | Department of Statistics, University of Lucknow, Lucknow | October 14-15, 2022 |
| Dr. A.K. Sharma | Webinar "Affordability of Healthy Diets in South Asia: Challenges and recommendations" organized as CGIAR Initiative on Transforming Agricultural Food Systems in South Asia (TAFSSA) | The India Habitat Centre, New Delhi | December 15-16, 2022 |

CHAPTER 19

# Events Organized

## 71st Foundation Day of IISR celebrated

The 71st Foundation Day of the ICAR-IISR, Lucknow was celebrated on February 16, 2022 with great fervour and enthusiasm. Dr. S. Solomon, former VC, CSAUA&T, Kanpur was the chief guest of the function. Dr. Solomon lauded the R &D work of the Institute for making the country self-reliant in sugar production and its export too. He urged the scientists to focus on the development of climate resilient varieties and appropriate varieties for ethanol production, use of nanotechnology, integration of genomics and biotechnology tools, use of ICT- based mobile apps for transfer of technology, use of GIS, artificial intelligence and use of drones for surveillance of insect-pests and diseases and spraying of pesticides.

Dr. A.D. Pathak, Director of the Institute highlighted the major achievements of the Institute during the past one year. He emphasized the rising demand for the newly released IISR variety CoLk 14201 as well as the collaborative efforts in the development of sugarcane machines for tropical India as the major outcomes during the year. On the occasion, the Chief Guest honoured various scientists, officers and other staff for their dedicated and sincere service and outstanding work done in the Institute building activities and increasing visibility of the Institute as the best staff under different categories. A number of publications including two books, 'Seven Decades of Sugarcane Research at ICAR-IISR, Lucknow' and '*Aatmnirbhar Bharat*: Vocal for Local', the Institute's official language magazine *'Ikshu'*, along with three folders published on the symptoms and management of major diseases of sugarcane *viz.*, wilt, YLD and pokkah boeng were released on the occasion. Short plays on *Swachhta* and self-reliant India and various entertaining competitions like *Rangoli*, Tug of war and 'Musical Chair' were also organized.


**Dignitaries on the dias (Left to Right) Sh. Saroj Kumar Singh, Dr. R.K. Singh, Dr. S. Solomon, Dr. A.D. Pathak and Dr. S.N. Sushil on the occasion of IISR 71st Foundation Day**

## Laying of foundation stone of IISR Biological Control Centre, new building at Pravaranagar

Dr. T.R. Sharma, DDG (CS), ICAR, New Delhi laid the foundation stone of the new building of ICAR-IISR, Lucknow Biological Control Center at Pravaranagar (Maharashtra) on September 29, 2022. Dr. R.K. Singh, ADG (CC), ICAR was also present on the occasion. The proposed building and facilities of Biological Control Centre are planned to be constructed in about 1.25 acre land with the total cost of about ₹ 5.0 crore sanctioned by the Govt. of Maharashtra under RKVY scheme. DDG (CS) and ADG (CC) also reviewed the ongoing research projects and experiments and other outreach activities of the Centre for the benefit of sugarcane farmers of the Maharashtra.

**Dr. T.R. Sharma, DDG (CS), ICAR and Dr. R.K. Singh, ADG (CC), ICAR during Foundation Stone Laying Ceremony of IISR Biological Control Centre, Pravaranagar**

A felicitation function was organized in *Kamgar Sanskrutik Bhavan* of Pravaranagar sugar mill on this occasion. The Chief Guest Dr. T.R. Sharma highlighted that in view of the increasing demand for sugar and ethanol in the country, sugarcane farmers need to obtain high production of sugarcane by using modern technology developed and advocated by the ICAR-IISR,

Lucknow. Dr. Sharma also advocated the use of bio-agents for the management of pests and diseases in sugarcane. He appreciated the efforts taken by Pravaranagar sugarfactory for extending all support to the Centre in facilitating research work. A farmers' *goshthi* under chairmanship of Mrs. Shalinitai Vikhe Patil, Ex. President, Zila Parishad, Ahmednagar was also organized. In the *goshthi*, more than 250 farmers and factory personnel participated and interacted with the scientists of the Institute.

## Soil testing laboratory building inaugurated at the Institute

Dr. T.R. Sharma, DDG (CS), ICAR inaugurated the newly constructed building of Soil testing laboratory at ICAR-IISR, Lucknow premises on May 23, 2022. The Soil Testing Laboratory been constructed with the financial aid under RKVY of the Govt. of Uttar Pradesh. On this occasion, Dr. R.K. Singh, ADG (CC), ICAR; Dr. S.C. Dubey, ADG (Plant Protection and Biosecurity), ICAR and Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow were present.

**Dr. T.R. Sharma, DDG (CS), ICAR; Dr. R.K. Singh, ADG (CC); Dr. S.C. Dubey, ADG (PP & B); Dr. A.D. Pathak, Director, ICAR-IISR and other staff of IISR, Lucknow**

## Brainstorming on Status of red rot disease of sugarcane in India and its management organized

Brainstorming on Status of red rot disease of sugarcane in India and its management was organized at ICAR-IISR, Lucknow on May 23, 2022. While chairing the session, Dr. T.R. Sharma, DDG (CS), ICAR highlighted the urgent need of visual and molecular diagnostics of red rot of sugarcane. Dr. Sharma termed resistance breeding, development of artificial intelligence-based sensors, prediction model, gene mapping and gene editing as the need of the hour. He further advocated the use of tissue culture raised healthy planting material for protection from sett-borne disease.

**Dignitaries on the dias (Left to Right), Dr. S.C. Dubey, ADG (PP & B); Dr. A.D. Pathak, Director, ICAR-IISR; Dr. T.R. Sharma, DDG (CS), ICAR; Dr. R.K. Singh, ADG (CC) and Sh. S.K. Singh, CAO, ICAR-IISR, Lucknow**

Dr. S.C. Dubey, ADG (Plant Protection and Biosecurity), ICAR advocated for replacement of most popular variety of sugarcane Co 0238 with Co 98014, Co 0118, Co 15023, CoLk 14201, CoS 13235 etc., in the short term. He also emphasized the need for the sugar industry to come forward with necessary provisions for sett treatment with hot water or MHAT and treatment of setts by Thiophanate Methyl @ 0.1% in large scale under the situations where the variety is not replaced. Dr. R.K. Singh, ADG (CC), ICAR stressed upon the development of red rot resistant varieties of sugarcane, quality seed production and identification of different races of *Colletotricatum falcatum* along with basic research on red rot. Dr Singh also advised IISR to publish a pamphlet on red rot management comprising various management options. Dr. A.D. Pathak, Director, IISR briefed on the huge economic losses caused by red rot and the contribution of the Institute in managing this disease.

A status paper on red rot management in India was presented by Dr. R. Viswanathan, Principal Investigator (Plant Pathology), ICAR-SBI, Coimbatore. During the panel discussion, Dr. N. Vijyan Nair, Ex. Director, ICAR-SBI, Coimbatore; Dr. A. Salem Saumtally, Ex. Director, MSIRI, Mauritius; Dr. O.K. Sinha, Ex. PC, AICRP on Sugarcane, IISR; Dr. Naushad Joomun, MSIRI, Mauritius; officials of the Indian Sugar Mills Association, representatives of Cane and Sugar Commissioners of Uttar Pradesh, Bihar, Punjab and Haryana deliberated upon the extent of damage caused by red rot disease and its management. Dr. R.B. Doule, Chief Cane Advisor, NFCSF, New Delhi cautioned about the ill effect of monoculture and emphasized that no variety should be cultivated in >50% area.

Dr. T.R. Sharma, DDG (CS) also released Coffee Table Book "IISR @ 70: A Memoire". The DDG (CS) also visited the field trials and laboratories of the Institute and appreciated the R &D efforts of the Institute.

## International Conference on Sugar and Integrated Industries (SUGARCON-2022) organized

A four days International Conference-SUGARCON 2022 on "Sustainability of Sugar and Integrated Industries: Issues and Initiatives" was organized at ICAR-IISR, Lucknow in collaboration with the Society for Sugar Research and Promotion and Association of Professionals in Sugar and Integrated Industries during October 16-19, 2022. Speaking as Chief Guest in the inaugural function on 16th October, 2022, Dr. T.R. Sharma, DDG (CS), ICAR New Delhi described sugarcane as a major contributor to the Indian economy and congratulated all the delegates on the World Food Day. He urged the scientists to develop climate – resilient,

**Dr. T.R. Sharma, DDG (CS), ICAR; Dr. S. Solomon, Ex. VC, CSAUA&T, Kanpur and Dr. Rajesh Kumar, VC, DDU Gorakhpur University lighting the lamp.**

nutrient and water efficient varieties, value added products and new products from sugarcane juice, jaggery, molasses, ethanol as essential components of secondary agriculture. Dr. Sharma also advised sugar industry to participate in research in PPP mode by providing financial assistance to sugarcane research institutes. Dr. Sharma expressed the hope of developing new products through genome editing in sugarcane and releasing them after addressing the bio-safety issues. Dr. R.K. Singh, ADG (CC), ICAR expressed concern over coverage of more than 50% of the global cane area by only 10 varieties of sugarcane and said that in India also, more than 70% cane area came under two varieties namely Co 0238 and Co 86023.

Welcoming the guests, Dr. A.D. Pathak, Director, IISR threw light on the history and achievements of the Institute. Dr. Sushil Solomon, Patron of the International Conference and Ex. VC of CSAUA&T, Kanpur elaborated on the theme of the Conference and constraints being faced by sugar industry. On this occasion, researchers, sugar industry personnel and farmers were honoured for their centributions in their respective fields. The souvenir of the conference, the latest issue of Sugar Tech and a book on Sugar Beet Production in India were released by the Chief Guest. Sugar Expo was also organized in the conference in which more than 40 manufacturers, suppliers, service providers displayed sugarcane harvesters, *neem* based urea, liquid phosphorus, organic fertilizers, organic jaggery, vinegar and various other products. Scientist–Farmer Interaction was also held in which queries of sugarcane farmers were addressed. Six technical sessions were organized in three parallel venues. Total 108 oral presentations and 68 posters were presented in the three sessions. More than 300 delegates from India and 30 foreign delegates from Fiji, Thailand, Vietnam, China, Sri Lanka, Myanmar, Egypt, Australia, Iran, Ecuador, Bangladesh, Cuba, Brazil and USA participated in this conference. About 300 farmers from Lakhimpur Kheri, Sitapur and Lucknow districts of Uttar Pradesh participated in the interaction. About 300 students also visited the Sugar Expo.

In the valedictory session on October 19, 2022 under the chairmanship of Sh. S.C. Deshmukh, Advisor, Vasantdada Sugar Institute, Pune, Dr. A.K. Sah,

**Delegates of SUGARCON-2022**

Organizing Secretary presented a brief report of the conference proceedings. Reports on Technical Sessions and the major recommendations that emerged out of the deliberations were presented. Best papers presented in different oral and poster sessions were also awarded. Dr. G.P. Rao, Conference Coordinator proposed formal vote of thanks in the valedictory session.

## Stakeholders' meet on sugarcane and sugar sector organized

A Stakeholders' Meet on *Sugarcane and Sugar Sector @ 2025* was organized by ICAR-IISR, Lucknow on July 20, 2022 with the objective to provide a common platform to various stakeholders to deliberate on all the current issues of concern for the sector and way forward to address the challenges in 2025 and beyond. Inaugurating the meet as the Chief Guest, Shri Sanjay R. Bhoosreddy, Additional Chief Secretary, Department of Sugarcane and Sugar Development, Govt. of Uttar Pradesh said that due to the improved cane production technology of research institutes, hard work of farmers and intervention in the management of sugar mills, farmers income has increased by 1.75 times during the period 2017-2022 and efforts are now intensified to double the farmers' income in real term by 2027 considering the figure in base year 2022. He informed that due to reforms introduced by the state government, the production capacity of 94 operational distilleries in U.P. has enhanced to 183 crore litres bio-ethanol. It would be further increased up to 215 crores litres in the forthcoming cane crushing season 2022-23. He further highlighted that the state government saved ₹ 2,800 crores by generating 700 MW of power through cogeneration in sugar mills. He appreciated the improved sugarcane production technologies developed by the research institutes and congratulated the scientists for their immense contribution.

**Dignitaries on the dias (Left to Right) : Dr. G. Hemaprabha, Director, ICAR-SBI, Coimbatore; Sh. Sanjay Awasthi, President, ASTI; Prof. Narendra Mohan, Director, NSI, Kanpur; Sh. Sanjay R. Bhoosreddy, Additional Chief Secretary, Department of Sugarcane and Sugar Development, Govt. of UP; Shri S.C. Deshmukh, DG, VSI, Pune; Dr. S. Solomon, Ex. VC, CSAUA&T, Kanpur; Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow and Dr. A.K. Sah, Organizing Secretary**

Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow, while welcoming the guests, highlighted the major achievements of the Institute. He informed that research work has been initiated by the Institute in the frontier areas like natural farming, artificial intelligence, nanotechnology and biotechnology. Dr. G. Hemaprabha, Director, ICAR-Sugarcane Breeding Institute, Coimbatore informed that varieties of sugarcane developed by the Institute are prevalent in various countries around the globe. She emphasized the need of fine tuning the breeding strategies for higher biomass production, climate resilience smart varieties through biotechnological approaches. Shri. S.C. Deshmukh, DG, VSI, Pune, in his address, remarked that the sugarcane, considered a political crop, is now being known as an industrial crop. Shri Deshmukh credited the government policies for the transformation of sugarcane and sugar industry. Dr. Sushil Solomon, Ex. VC, CSAUA&T, Kanpur appreciated the coordinated efforts of all the stakeholders to translate the vision documents prepared by IISR, Lucknow into a reality and appreciated the farmers-friendly policies of the Government for the betterment of sugarcane and sugar sector.

Prof. Narendra Mohan, Director, NSI, Kanpur attributed the transformation in the Indian sugar sector to the fixation of minimum selling prices of sugar and the differential pricing policy of ethanol. He expressed satisfaction over increasing profitability of sugar mills through product diversification and less dependency on sugar for revenue generation. He suggested that the sugar sector should be made self-sustained through harnessing the unexploited potential and introduction of new specialty products as per consumers' preference and demand. Shri Sanjay Awasthi, President, STAI credited the success of breaking of infamous sugar cycle to the techniques of research institutes and government policies. He explained the need of transformation into green energy production with global competitiveness in terms of per unit cost. In his plenary presentation, Shri R.K. Gangwar ED, Mawana Sugar, highlighted the yield gains and monetary contribution of variety Co 0238 especially in sub-tropical zone. He emphasized that this variety should be rejuvenated through tissue culture, as farmers still prefer this variety on their farms. On this occasion, Eminent persons of sugar industry; Presidents of women self-help groups of Barabanki, Hardoi, Sitapur and Lakhimpur Kheri and two progressive sugarcane farmers of Sitapur and Bareilly were awarded with certificates and memento. More than 300 scientists, researchers, executives of sugar industry, officers of sugarcane development department, *Urjadata* (sugarcane farmers), members of NGOs/FPOs/SHGs participated in the meeting.

## National Seminar organized on the occasion of the foundation day of UPCAR

The Institute shared its resources with UP Council of Agriculture Research, Lucknow in organizing its 33rd Foundation Day at the Institute premises. A National Seminar on Innovative Approaches for Sustainable Agriculture was organized to mark the occasion. Delivering a lecture in virtual mode as the Chief Guest, Shri Yogi Adityanath, Hon'ble Chief Minister, Uttar Pradesh, called upon to adopt cow-based natural farming. The Chief Minister highlighted that UP state provides food grains to 30% of the country's total population along with 17% of the country's population living in the state, despite the fact the state shares only 12 per cent of the country's cultivable land area. Shri Yogi also appreciated the efforts being made by the four agricultural universities and 90 KVKs in Uttar Pradesh for crop diversification. Shri Surya Pratap Shahi, Hon'ble Minister of Agriculture, Agricultural Education and Research, Uttar Pradesh, the Special Guest, congratulated the farmers for the record production of food grains in the state by adopting natural farming which was earlier practiced since the Vedic period in India. Shri Shahi asked agricultural scientists and farmers to increase the production of pulses and oilseed crops in Uttar Pradesh and make the state self-sufficient in their production. Mr. Baldev Singh Aulakh, Hon'ble Minister of State for Agriculture, Agricultural Education and Research, Uttar Pradesh highlighted the works and achievements of the Uttar Pradesh Council of Agricultural Research. Dr. A.K. Singh, DDG (Agric. Extension), ICAR, New Delhi expressed the need for strategic planning, for tackling the major challenges with respect to lack of resources like labour, water, energy in the state, decomposition of resources like soil, water and environment, increase in cost of production, reduction in profits and the dangers of climate change *etc.* Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow said that smart agriculture is the need of the hour for sustainable agricultural production. On this occasion, Padma Shri Bharat Bhushan Tyagi, Padma Shri Ram Saran Verma and 20 other progressive farmers from across the state were also felicitated.

Capt. Vikas Gupta, President, UPCAR; Dr. Devesh Chaturvedi, Additional Chief Secretary, Agriculture, Agriculture Education and Research Department, Uttar Pradesh; Dr. Sanjay Singh, Director General, UPCAR, Lucknow; Dr. N.P. Singh, Vice-Chancellor, Banda University of Agriculture & Technology, Banda and Dr. Rajesh Singh, Vice-Chancellor, Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur, along with more than 200 eminent scientists from across the country were also present. An exhibition was organized on this occasion.

## Regional Seminar on Prioritization of Crop-Specific Technologies for Sustainable Profitability organized

The Society for Advancement of Wheat and Barley Research and the Centre for Research and Development jointly organized a two-day Regional Seminar on Prioritization of Crop-Specific Technologies for Sustainable Profitability – Uttar Pradesh Chapter on 29-30 April, 2022 at the IISR, Lucknow. Dr. H.S. Gupta, Chairman, Agriculture Commission, Assam and Ex. DG, Borlaug Institute for South Asia was the Chief Guest on the occasion. Emphasizing the need for the farmers of the state to increase the production of pulses and oilseed crops, Dr. Gupta urged the farmers to increase the cropping intensity, crop diversification by cultivating sugarcane, potato, mustard, pulses and vegetables by following intercropping, quality seed production, rapid dissemination of agricultural technology, effective marketing and value addition. He also advised to increase income by more than double by adopting other agricultural business-like animal husbandry, goat rearing, poultry and fisheries.

**Shri Surya Pratap Shahi, Hon'ble Agriculture Minister, Govt. of UP; Sh. B.S. Aulakh, Minister of State for Agriculture; Dr. Sanjay Singh, DG, UPCAR, Lucknow and Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow lighting the lamp**

**Dignitaries on the dias (Left to Right): Dr. O.N. Singh, VC, BAU, Ranchi; Dr. G.P. Singh, Director, ICAR-IIWBR, Karnal; Dr. H.S. Gupta, Chairman, Agriculture Commission, Assam; Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow**

Dr. A.D. Pathak, Director, IISR, briefed about the activities of the Institute and said that the productivity of sugarcane in the country has increased due to the research efforts of the institute, from 30 t/ha in 1952 to 80 t/ha in 2022. Uttar Pradesh has become the largest producer of sugarcane, sugar and bio-ethanol in the country. Dr. Pathak mentioned that Indian agriculture has seen several innovations and improved technological interventions such as good agricultural practices, effective water and nutrient management practices, disease and pest management modules, better food practices and value addition strategies. Advances in agricultural technology through these innovations have been commendable, however, the awareness and accessibility to farmers in different regions of the country is still required.

Expressing concern over the low productivity of wheat in Eastern Uttar Pradesh, Dr. G.P. Singh, Director, ICAR-IIWBR, Karnal stressed the need to increase the productivity to bring it at par with the average yield of Western Uttar Pradesh. He also expressed the possibility of India exporting more wheat in the present global conditions. Dr. O.N. Singh, Vice-Chancellor, Birsa Agricultural University, Ranchi, expressed happiness over the farmers of Eastern Uttar Pradesh getting higher returns from cultivation of *Kala Namak* variety of paddy as compared to cultivation of Basmati rice. He stressed upon on the conservation of traditional varieties. Dr. Baijnath Singh, Ex. Director, ICAR-CRRI, Cuttack and President, NIDEF advised the farmers to be aware of climate change and urged the farmers to adopt climate tolerant varieties. Dr Singh stressed the need for more coordination between the Agriculture Department, State Agricultural Universities, research institutes of Indian Council of Agricultural Research and Krishi Vigyan Kendras to increase the income of farmers in Uttar Pradesh. On this occasion, the scientists were also felicitated with distinguished awards.

More than 200 scientists, educationists, policy makers, crop experts, extension workers, agri-entrepreneurs, agri-business professionals from Indian Council of Agricultural Research/ Central Agricultural Universities/ Krishi Vigyan Kendras/ NGOs, and the representatives of corporates, farmers, students participated in the seminar.

## *Annadata Devo Bhava* Campaign programme organized

A mega event was organized by the ICAR-IISR, Lucknow on April 23-24, 2022. "*Annadata Devo Bhava: Abhyan*" under "*Azadi Ka Amrit Mahotsav*" campaign. In this mega programme, an interactive meeting on natural and organic farming was organized on April 23, 2022. Padma Shri Bharat Bhushan Tyagi a progressive farmer was the chief guest. He emphasized on changing the mindset to make natural farming practical and popular. Shri Tyagi described natural farming as environment friendly and safe to human health and farmers. Dr. Ram Avadh Ram, Principal Scientist, CISH, Lucknow delivered a lecture on 'Natural Farming and Organic Farming of Horticultural Crops'. Mr. Mahendra Pal Gangwar, Mr. Gopal Upadhyay and Mr. Neeraj Mishra shared their experiences on natural farming and its beneficial aspects for environmental protection and human welfare.

**Dr. A.K. Singh, DDG (Ag. Extension), ICAR and Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow lightening the lamp at the programme**

## Interactive meeting on bio-ethanol, cogeneration and jaggery production organized

Under the mega campaign "*Annadata Devo Bhava*" as part of the "*Azadi Ka Amrit Mahotsav*", an interactive meeting on bio-ethanol, cogeneration and jaggery production was organized at ICAR-IISR, Lucknow involving scientists, farmers and other stakeholders on April 24, 2022. Addressing the sugarcane growers as the '*Urjadata*' for producing bio-ethanol from molasses and cogeneration from bagasse, the Chief Guest on the occasion, Dr. A.K. Singh, DDG (Agri. Extension), ICAR and I/c, Agriculture Commissioner, Govt. of India


**Dr. A.K. Singh, DDG (Ag. Extension), ICAR & I/c, Agriculture Commissioner; Dr. Sanjay Singh, DG, UPCAR; Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow on the dias**

congratulated them for reducing the import of petrol and termed sugarcane as a multi-purpose crop. Dr. Singh asked the farmers to form FPOs for enhancing their income. Five extension folders on the improved technologies were also released by the Chief Guest. Dr. Sanjay Singh, DG, UPCAR briefed about the government schemes of agricultural development in UP. Dr. A.D. Pathak, Director, IISR welcomed all the distinguished guests and called upon the farmers to maximize their income by intercropping and value added jaggery. Briefing the audience about the theme of the meeting, Dr. A.K. Sah, Principal Scientist and I/c, Extension and training informed that the main objective of this event was to popularize use of sugarcane for bioethanol, co-generation and jaggery production. Shri Raja Srivastava, Joint Vice President, DCM Shriram Ltd., New Delhi informed that sugarcane is not being only used for sugar production but it is also being used for bioethanol production from molasses, cogeneration from bagasse and jaggery production from cane juice. Apart from sugarcane, the plant-residues of wheat, paddy, maize and pulses are also being used for bioethanol production. Dr. Dilip Kumar, Principal Scientist urged the farmers to enhance their income by jaggery production. Dr. P.K. Singh, Principal Scientist (Pl. Breeding), IISR requested the farmers for conservation and protection of traditional varieties and explained about the farmers' rights under PPV &FR Act, 2001. Speaking on Biological Diversity Act 2002 and National Biodiversity Authority, Dr. L.S. Gangwar, Principal Scientist & I/c, ITMU, IISR urged the farmers to conserve the biodiversity. Organic jaggery entrepreneur of Farrukhabad, Shri Himanshu Gangwar shared the success story of natural farming of sugarcane and organic jaggery production with the fellow farmers. More than 250 farmers from Hardoi, Sitapur, Barabanki, Pilibhit and Lakhimpur Kheri; agricultural scientists and officers of sugar industry participated in the programme.

## Farmers' Day organized

Krishi Vigyan Kendra, ICAR-IISR, Lucknow celebrated December 23, 2022 as "Farmers' Day" to commemorate the birth anniversary of the fifth Prime Minister of India, late Chaudhary Charan Singh. The portrait of late Chaudhary Charan Singh was garlanded. 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. Ninety five participants including 83 farmers participated in the Farmers' Day.

## National Science Day celebrated

National Science Day was celebrated on February 28, 2022 on the theme "Integrated Approach in Science and Technology for Sustainable Future" with enthusiasm and fervour. Several competitions such as Open Mic, General Knowledge and Extempore Speech was organized for the students which was highly encouraging for the youths and other 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, a three-day Health Awareness Programme was organized during June 20-22, 2022 at ICAR-IISR, Lucknow to commemorate International Yoga Day. On the first day of the programme on June 20, 2022, a meditation and yoga session was organized in the Institute. A detailed yoga session was organized in front of the administrative building of the Institute. Scientists, officers, employees and students of the Institute enthusiastically participated in this yoga programme. More than 20 different *asans* of yoga demonstrated by Yoga Instructor were performed by all the participants effortlessly. All the participants of the yoga programme took a pledge to do yoga regularly. A Health Check-up Camp was organized on June 22, 2022 in the Institute in which a team of specialist doctors examined the health of all the staff of the Institute. A drawing competition was also organized on June 22, 2022 in the library building of the Institute for school children in the age group of 6-12 years and 13-17 years on the topic "Role of Yoga in Personality Development". Winners of the competition were given prizes. Dr. A.K. Sah, I/c, Extension and Training was the Nodal Officer of the three-days programme. 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 for creating awareness the about importance of yoga in everyday life.

**International Yoga Day celebrations at ICAR-IISR, Lucknow**

## Vigilance Awareness Week-2022 observed

The Vigilance Awareness Week-2022 was observed on the CVC declared theme. Corruption free India for a developed Nation, during October 31-November 6, 2022. The week commenced with the taking of the "Integrity Pledge" by the staff in the Institute on October 31, 2022 Special posters were prepared and displayed in all the notice boards in all the Divisions. Banners to make the staff, visiting stakeholders and other public aware of importance of vigilance awareness were prepared and displayed at the Institute premises.

A lecture on the theme was delivered by Shri Saroj Kumar Singh, Chief Administrative Officer, IISR, Lucknow on the various rules and regulations to curb the corruption. A lecture on "Corruption and Vigilance" was delivered by Shri Ravi Bhadra, Finance & Accounts Officer, ICAR-IISR, Lucknow on November 3, 2022. He highlighted various root causes of corruption and the regulatory bodies to reduce corruption. A lecture on "Latest Concern in Vigilance" was delivered by Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow on November 4, 2022. Dr. Pathak emphasized the need for developing a system of preventive vigilance in the Institute, and taking stock of the situation periodically.

**Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow at the Vigilance Awareness Week-2022**

## National Unity Day celebrated

National Unity Day was celebrated on October 31, 2022. The run for unity was organized in five categories and a total of 65 participants took part in the competition organized during National Unity Day.

**Participants of various competitions organized on the occasion of National Unity Day**

## MoU signed with Vasantrao Naik Marathwada Agricultural University, Parbhani

An MoU was signed between ICAR-IISR, Lucknow and Vasantrao Naik Marathwada Agricultural University, Parbhani at ICAR-IISR, Lucknow on November 23, 2022. The MoU was signed by Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow and Dr. Indra Mani, Vice Chancellor, Vasantrao Naik Marathwada Agricultural University, Parbhani; Dr. Dutt Prasad Vaskar, Director Research, of the University and Dr. Uday Khodke, Associate Dean, College of Agricultural Engineering and Technology. Dr. A.K. Singh, Head, Division of Agricultural Engineering and Dr. L.S. Gangwar, Principal Scientist and In-charge, PME Cell of IISR, Lucknow were also present on the occasion. The MoU was signed with the aim to conduct trainings, long-term research programmes for sugarcane farmers, researchers and students on various subjects.

**Dr. Indra Mani, VC, VNMAU, Parbhani and Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow with the signed MoU document**

## MoU signed with CSKHP Agriculture University

ICAR-IISR, Lucknow signed an MoU with CSK HP Agriculture University (HPAU), Palampur to facilitate academic cooperation in research, particularly on seed production. This meeting was organized under the chairmanship of Dr. H.K. Chaudhary, Vice-

**Dr. H.K. Chaudhary, VC, HPKVV, Palampur and Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow with the signed MoU in the presence of Dr. T.R. Sharma, DDG (CS), ICAR**

Chancellor, HP Agriculture University and in the presence of Dr. T.R. Sharma, DDG (Crop Science), ICAR, New Delhi. Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow signed MoU on behalf of IISR, Lucknow. HPAU also signed MoU with ICAR-NBAIR, Bengaluru and ICAR-IISS, Mau.

## MoU signed between IISR, Lucknow and Jannayak Chandrashekhar University, Ballia

An MoU was signed between IISR, Lucknow and Jannayak Chandra Shekhar University, Ballia for cooperation and expansion in academics and research. ICAR-IISR, Lucknow is an institute of international repute for technology and innovation related research while Jannayak Chandrashekhar Vishwavidyalaya, Ballia has achieved many heights in a short span of time since its inception in December 2016. Through this agreement, both the institutions will be able to collaborate in academics and research in a number of common areas such as science and technology, agriculture, skill development and value education. The scientists, teachers, researchers and students working in both the institutes will get an opportunity to work at each other's place and exchange knowledge.

The agreement was signed by the Director of IISR, Lucknow, Dr. A.D. Pathak and Vice-Chancellor of Jananayak Chandrashekhar University, Ballia, Prof. Kalpalata Pandey. Welcoming the agreement, Dr. A.D. Pathak, Director of the Institute elaborated on the scope for collaboration between the two institutions. IISR has always been in the forefront in conducting state-of-the-art research and has been doing excellent research by collaborating with national and international level institutions. Vice Chancellor of Jananayak Chandrashekhar University, Ballia, Prof. Kalpalata Pandey mentioned that the University has been granted I.G.R.S. and it will be a matter of great pleasure to have collaborations with the prestigious scientific community.

**Dr. Kalplata Pandey, VC, Jananayak Chandrashekhar University, Ballia and Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow with the signed MoU document**

## *"Kisan Bhagidari- Prathmikta Hamari"* Campaign programme under *"Azadi Ka Amrit Mahotsava"* organized

Under the aegis of Krishi Vigyan Kendra, ICAR-IISR, Lucknow, *"Kisan Bhagidari-Prathmikta Hamari"* campaign programme was organized under *Azadi Ka Amrit Mahotsava* on April 26, 2022 at the Institute. While addressing the farmers online, Dr. Trilochan Mohapatra, DG, ICAR informed that 50-55 KVKs located on the banks of holy river Ganga have been selected in the first phase for promoting natural farming. Training on natural farming will be imparted to the farmers by these KVKs. Simultaneously, the Traditional Agricultural Development Scheme will remain operational on the farmers' fields. Addressing the farmers of the country through live broadcasting, Hon'ble Minister of Agriculture and Farmers Welfare, Govt. of India, Shri Narendra Singh Tomar said that if the farmers are prosperous, villages will be prosperous. If villages will be prosperous, districts will prosperous. The prosperity of the districts will lead to prosperity of the state and the prosperity of the states will lead to prosperity of the nation. He also informed that all the farmers of the country have been covered under the crop insurance scheme. The minister urged all the KVKs to organize awareness campaigns to ensure large scale implementation of crop insurance scheme. He also emphasized on soil testing and soil health cards for effective implementation of natural farming. The Hon'ble Minister also emphasized on implementing drone technology in agriculture on selected crops. The Minister also interacted with the progressive farmers of various parts of the country and, specifically with Shri Girja Shankar Maurya, a progressive farmer of Lucknow.

Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow invited the farmers to have trainings at KVK, IISR, Lucknow for adopting natural farming and organic farming. Dr. Sanjay Singh, DG, UPCAR highlighted the importance of connecting all the KVKs of Uttar Pradesh and stressed the need to integrate the FPOs among themselves so that the farmers can easily produce as well as sell their produce. Dr. O.P. Mishra, District Agriculture Officer, Lucknow and Dr. A.K. Mishra, Deputy Director (Agriculture), Lucknow were also present on this occasion as keynote speakers. Dr. Sushil Kumar Shukla, Principal Scientist, ICAR-CISH, Lucknow and Dr. S.R. Singh, Principal Scientist, ICAR-IISR, Lucknow delivered lectures to the farmers on natural farming. At the end of the programme, Dr. Akhilesh Kumar Dubey, Head, KVK, IISR, Lucknow thanked all the farmers and visitors present in the programme. Four hundred sixty-eight farmers from Lucknow district participated in the event.

## 94th Foundation Day of ICAR organized

To mark the 94th Foundation Day of ICAR, a programme was organized by KVK, ICAR-IISR, Lucknow on July 16, 2022, as a part of the live telecast of the programme organized by the ICAR, New Delhi. All the Krishi Vigyan Kendras, Institutes and Agricultural Universities of the country participated online in this programme. Dr. A.K. Singh, DDG (Ag. Extension), ICAR welcomed all the guests, scientists and farmers. Dr. Trilochan Mohapatra, Secretary, DARE and DG, ICAR, New Delhi spoke about the achievements made by the Council over the years. Appreciating the work done by the Council, Shri Kailash Chowdhary, Hon'ble Union Minister of State for Agriculture, Govt. of India said that due to the hard work of the farmers and the untiring efforts of the scientists, there has been a lot of increase in agricultural production and many products are being exported now. He also talked about the schemes being run by the Government of India to give impetus to agriculture. Mr. Parshottam Rupala, Hon'ble Union Minister for Fisheries, Animal Husbandry and Dairying, Government of India, in his address emphasized on the need to work on malnutrition and said that fisheries and dairy sector is very important for this. He gave special emphasis on the innovations in the field of agriculture at the village level. He also told about the cultivation of coarse grains and their importance. The chief guest of the programme, Shri Narendra Singh Tomar, Hon'ble Union Minister of Agriculture and Farmers Welfare, Government of India, interacted with the farmers of Krishi Vigyan Kendras located in different districts of the country through video conferencing. He asked about the methods adopted by the farmers to double their income. He also congratulated them for their excellent work. He told that all the KVKs of the country have done a commendable job by giving the success stories of doubling the income of 75,000 farmers. He also thanked all the associated persons with this task and congratulated on this achievement. The Minister urged to celebrate the foundation day as the resolution day. The Minister also honoured the farmers, Krishi Vigyan Kendras, institutes and scientists for their excellent work. In this sequence, *Ikshu* magazine published by ICAR-IISR, Lucknow was honoured with Ganesh Shankar Vidyarthi Puraskar. A total of 70 farmers and farmer women of the district participated in this programme. The programme was presided over by Dr. S.K. Shukla, Principal Scientist of the Institute. At the beginning of the programme, Chairman of KVK. Dr. A.K. Dubey welcomed all the guests and farmers and in his address told about the schemes run by KVK. He also inspired the farmers to do natural farming and also told the success story of the farmers associated with natural farming.

## *Har Ghar Tiranga* Campaign organized

On the occasion of the 75th anniversary of India's independence, a special programme *'Har Ghar Tiranga'* was celebrated with great enthusiasm under the *Azadi Ka Amrit Mahotsav* programme. The major objective of the programme was to hoist the tricolor at every house on the call of the Honorable Prime Minister to express their respect and love for the country through the national flag and to reflect their commitment to the nation. The Institute organized *Har Ghar Tiranga Padyatra* on 12th August 2022, in which the scientists, officers, employees, farmers, students and teachers of the Institute participated. In this *padyatra*, the participants marched from the administrative building of the institute to the Ikshupuri residential complex of the institute with patriotic songs and slogans. On this occasion, Dr. A.D. Pathak, Director of the Institute, appealed to everyone to hoist the tricolor at their respective places and advised them to do their duties sincerely by awakening the spirit of patriotism. The senior officers of the Institute also planted trees in the Institute campus. On this occasion, a *Nukkad Natak* was also organized by the employees of the Institute to give the message of respecting the national flag. The staff and their children also participated in national flag making craft competition, slogan competition on *Azadi ka Amrit Mahotsav*, face painting and taking selfie by hoisting tricolor at their home. The best entries were awarded by the Director on the Independence Day. On this occasion, 75 farmers were given national flag and one sapling each of mango and guava for plantation. Citations were also presented to them for their remarkable work in the felicitation ceremony during *Kisan Sammelan* organized by Krishi Vigyan Kendra, Lucknow.

**Dr. A.D. Pathak, Director, ICAR-ISR, Lucknow leading the *Har Ghar Tiranga* Campaign with the IISR Staff**

## Interactive meet with delegation from NSI, Belagavi organized

A thirteen member delegation led by an officer of S. Nijalingappa Sugar Institute, Belagavi visited the Institute on April 19-20, 2022. The delegation comprised of Vice President, Governing Council, Member of S. Nijalingappa Sugar Institute, Belagavi;

Board Members of Cooperative Sugar Mills, Cane growers and officials of the Government of Karnataka. On April 19, 2022, an interactive session with Director and Heads/Incharges of Divisions/Units was organized to have insights into mutual areas of interest for the betterment of sugar and sugarcane sector in the state of Karnataka. Dr. A.D. Pathak, Director formally welcomed the delegates and presented detailed account of Institute's R & D achievements. All the Heads of the Divisions and Incharge, Sections participated in the Session. The cane supply and marketing related issues raised by visiting delegates were thoroughly discussed and deliberated upon. Dr. L.S. Gangwar, Principal Scientist and Incharge, PME Cell presented vote of thanks.

**Dr. A.D. Pathak, Director, ICAR-IISR, Lucknow with the delegation from Karnataka visiting IISR, Lucknow**

The delegation visited Engineering Workshop on April 20, 2022. Dr. Sukhbir Singh, Principal Scientist (Agril. Engineering) explained about the cane machines prototypes developed by the Institute. The delegates also visited IFS model in IISR, KVK, Lucknow and Bio control Laboratory.

## *Swachhata Pakhwada* organized

*Swachhata Pakhwada* was observed at the Institute during December 16-31, 2022. On December 16, 2022, banners were displayed at all the gates of the Institute. *Swachhata* pledge was taken by all the staff members of the Institute. Activities planned for the whole *Pakhwada* were explained to all the staff members. Trees of guava were also planted by the Director, Heads of the Divisions, Incharge Sections and staff of the Institute.

***Swachchhta* Pledge being taken by Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow and the IISR Staff**

On December 17, 2022, digitalization of office records were discussed in detail with all concerned officers. All the IISR Annual Reports have been digitalized. Several old photographs which were available in negative form have been digitalized and kept in CD/DVD. The cleanliness drive of the office premises was initiated. Old and obsolete furniture and other junk material which was stored for a pretty long period was auctioned.

On December 18, 2022, cleanliness and sanitation drive in the village adopted under the *Mera Gaon Mera Gaurav* Programme was undertaken at Sonikpur, Haidergarh, Barabanki. About 150 farmers and sugar mill officials participated in the programme and reviewed the progress made under ongoing *Swachhta* activities including implementation of *Swachhta* Action Plan.

**Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow planting the guava tree at the Institute campus**

On December 19, 2022, cleanliness and sanitation drive within ICAR-IISR, Lucknow campus including *Ikshupuri* residential colony was undertaken. Disposal status of biodegradable and non-biodegradable waste was reviewed and on the spot solutions were provided to the residents of *Ikshupuri* residential colony.

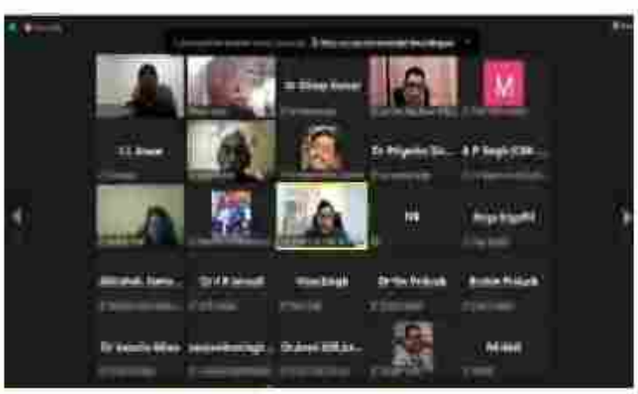
On December 20, 2022, status of waste management and other activities including utilization of organic wastes was reviewed. Residents were made aware about composting of waste materials. Clean and green technologies and organic farming practices were advocated for the kitchen gardens of *Ikshupuri* residential colony.

On December 21, 2022, awareness on recycling of waste water was created and water harvesting for kitchen gardens of residents in *Ikshupuri* residential colony was created. Awareness was created for cleanliness and roof top gardening in nearby areas.

On December 22, 2022, awareness camps and street plays were conducted in Junior High Scool, Ntkur, Sarojini Nagar, Lucknow. Drawing and elocutions competitions were organised for the school children on 22nd December 2022. The theme of competition was "*Swachha Bharat, Swastha Bharat*", where more than 25 students from the age of 5 years to 14 years participated enthusiastically. Certificates and prizes were given to all the winners and participants on the same day. In nearby villages, agri-techniques for waste to wealth were explained.

On December 23, 2022, *Kisan Diwas* (Farmers' Day) was celebrated at the Institute. The programme started with the garlanding of the photo of Late Chaudhary Charan Singh, Ex. Prime Minister of India. The contributions made by Shri Chaudhary Charan Singh in the field of agriculture and rural development was recalled by Dr. R. Viswanathan, Director, IISR and other speakers. A number of progressive sugarcane farmers were honoured on this occasion for exemplary initiatives on *Swachhta*.

On December 24, 2022, *Swachhta* Campaign was organized in a village in Lakhimpur Kheri with the help of farm women. On December 25, 2022, cleaning of markets, parks and other public places was done. On December 26, 2022, a digital talk was organised in the Institute to spread awareness on cleanliness. The talk was given by Mr. Sanjay Singh, Lead Consultant and Founder Director, Dimensions Education Pvt. Ltd., New Delhi on "Excellence though cleanliness". At the outset, Dr. Aalok Shiv, Scientist, Division of Crop Improvement gave the brief introduction of the Chief Guest. Dr. A.K. Sah, Nodal Officer of Swachhata Pakhwada and Principal Scientist briefed about the various activities undertaken by the Institute during *Swachchhta Pakhwada*. Mr. Sanjay Singh sensitized the listeners about covid plastic waste, its category, its socio-economic impact, status of research in India and abroad, government role and policies and finally how to curb this problem. This talk was organized online mode through zoom platform in which more than 60 scientists/officers/students/teachers from the Institute, participated. Dr. R. Viswanathan, Director of the Institute attended the programme as Chairman.



**Participants of digital talk on cleanliness**

On December 27, 2022, awareness on waste management and other activities including utilization of organic wastes were created. The evil effect of polythene on the environment was explained to public and they were requested not to use single use plastic. On December 28, 2022, awareness was created on recycling of waste water, water harvesting for agriculture/horticulture applications/kitchen gardens in *Ikshupuri* residential colony. Visit of community waste disposal sites/compost pits, cleaning and creating awareness on treatment and safe disposal of bio-degradable/non-degradable wastes.

On December 29, 2022, a team of the Institute visited nearby community waste disposal sites/compost pits and created awareness on treatment and safe disposal of bio-degradable/non-degradable wastes.

On December 30, 2022, Mrs. Riya Kejriwal, IAS, Hon'ble Chief Development Officer, Lucknow was the Chief Guest in the programme organised in the Institute premises on December 30, 2022. On her arrival, she planted a tree in the campus and visited the premise to observe the cleanliness in the campus. She was informed that awareness about *swachchhta* was created among 2,500-3,000 persons through various programmes during this fortnight. Mrs. Kejriwal urged the people to follow 3 R (Reduce, Reuse and Recycle) for urban waste management and thanked the Institute for organizing various competitions for children/students to create awareness about *Swachchhta*.

**Mrs Riya Kejriwal, IAS, CDO, Lucknow and Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow at the Institute**

On December 31, 2022, a Press Conference was organized at the Institute premises where various activities of *Swachchh Bharat Pakhwara* undertaken by the Institute were highlighted.

## Promotion of Official Language *(Hindi)*

Number of activities were organized to promote the use of official language *Hindi* in day to day

functioning which are as follows :

## (i) Hindi Workshops

Four Hindi Workshops were organized on 21-23 March, 22 June, 26 September and 30 December 2022.

On 26 September 2022, Mr. Saurabh Mishra and his entire team of three people gave lectures on "Cyber-Crimes".

## (ii) Hindi Fortnight

Hindi *Pakhwada* was organized at the Institute during September 14-30, 2022. Dr. A.K. Sah was the convener of Hindi Fortnight. During this fortnight, several competitions *viz.*, Hindi typing in Unicode, noting/drafting, essay writing competition, *antakshari* competition, debate competition, quiz based on general knowledge of Hindi and sugarcane were organized in which more than 200 personnel attended.

Padmashree Dr. Vidya Bindu Singh, Former Joint Director, Hindi Institute, Lucknow, delivered a lecture on the topic "Global Scenario of Hindi" during September 14-30, 2022. The Hindi fortnight programme was organized at ICAR-IISR, Lucknow. Dr. Singh told that having a native language is very important for the development of any country. Dr. Singh called upon the scientists to write science books originally in Hindi. He also told that Hindi has enriched its dictionary by adopting thousands of words from regional and foreign languages. Describing Hindi as an employment-oriented language, Dr. Singh highlighted the need for the promotion and dissemination of Hindi in global trade. Dr. J. Singh, Head, Division of Crop Improvement narrated the message of Hon'ble Agriculture and Farmers Welfare Minister, Govt of India, Shri Narendra Singh Tomar on the occasion of Hindi Day.


**Padamshree Dr. Vidya Bindu Singh, Former Joint Director, Hindi Sansthan, Lucknow on the occasion of launch of *Hindi Pakhwada***

On October 06, 2022, the winning participants of various competitions organized during Hindi *Pakhwada* were awarded in a function organized in the auditorium of the Institute. In the prize distribution ceremony, certificates and prize money to 93 personnel of the Institute for first, second, third and consolation prizes in various competitions were given.

A *Kavi Sammelan* was organized on 24th September 2022. Eminent poets of the state *viz.*, Mr. Ram Kishore Tiwari, Mr. Pramod Pankaj, Mrs. Rupa Pandey 'Satrupa', Mr. Bihari Lal Ambar, Mrs. Vyushna Shukla, Mr. Anant Mishra, Mr. Abhishek Sahaj, Mr. Ashok 'Jhanjhati' and Dr. Sudhir Shukla, Convener recited their poems/songs. *Kavi Sammelan* was attended by 350 listeners who thoroughly enjoyed the poetries/songs composed by the poets.

## (iii) Meeting of *NARAKAS* (Office-3)

- A meeting of the District Official Language Implementation Committee was organized online by the Institute on June 08, 2022, in which the office heads of Narakas Office-3 and the Department of Official Language, Government of India Mr. Nirmal Kumar Dubey participated as the representative of the Govt. In this meeting, 10 institutions doing excellent work in Hindi were awarded.

**Dr. R. Viswanathan, Director, ICAR-IISR, Lucknow chairing the Meeting of District Official Language Implementation Committee**

**Participants of District Official Language Implementation Committee Meeting**

- The Second meeting of the District Official Language Implementation Committee was organized online on December 26, 2022, in which the office heads of *Narakas* Office-3 participated. Ten institutions doing excellent work is Hindi were felicitated.

CHAPTER 20

# Distinguished Visitors

| Sl. No. | Name and address of the visitor | Date of visit |
|---|---|---|
| 1. | Sh. Durga Shanker Mishra, IAS, (Chief Secretary) to Govt. of Uttar Pradesh, Lucknow | January 15, 2022 |
| 2. | Shri Devesh Chaturvedi, IAS, Additional Chief Secretary (Agriculture), Government of Uttar Pradesh, Lucknow | January 15 and June 20, 2022 |
| 3. | Dr. Neelima Garg, Director, ICAR-CISH, Lucknow | January 17, 2022 |
| 4. | Prof. Kalplata Pandey, Vice Chancellor, Jananayak Chandrashekhar University, Ballia | February 12, 2022 |
| 5. | Dr. U.S. Gautam, Director, ICAR-ATARI, Kanpur | March 26, 2022 |
| 6. | Padma Shri. Mr. Bharat Bhushan Tyagi, Bulandshahar | April 23, 2022 |
| 7. | Dr. A.K Singh, DDG (Agri. Extension), ICAR, New Delhi | April 24, 2022 |
| 8. | Dr. Sanjay Singh, DG, UPCAR, Lucknow | April 24 and June 20, 2022 |
| 9. | Dr. A.K. Singh, DDG (Ag. Extension), ICAR, New Delhi | April 24 and June 20, 2022 |
| 10. | Shri Raja Srivastava, Joint Vice President, DCM Shriram Ltd., New Delhi | April 24, 2022 |
| 11. | Dr. O.P. Mishra, District Agriculture Officer, Lucknow | April 26, 2022 |
| 12. | Dr. H.S. Gupta, Chairman, Agriculture Commission, Assam and Ex-DG, Borlaug Institute for South Asia, New Delhi | April 29, 2022 |
| 13. | Dr. O.N. Singh, Vice-Chancellor, Birsa Agricultural University, Ranchi | April 29, 2022 |
| 14. | Dr. Gyanendra Pratap Singh, Director, ICAR-IIWBR, Karnal | April 29, 2022 |
| 15. | Dr. Sujay Rakshit, Director, ICAR-IIMR, Ludhiana | April 29, 2022 |
| 16. | Dr. Baijnath Singh, Ex-Director, ICAR-Central Rice Research Institute, Cuttack | April 29, 2022 |
| 17. | Dr. T.R. Sharma, DDG (Crop Science), ICAR, New Delhi | May 23, September 29 and October 16, 2022 |
| 18. | Dr. R.K. Singh, ADG (CC), ICAR, New Delhi | May 23, September 29, October 16 and November 23-24, 2022 |
| 19. | Dr. S.C. Dubey, ADG (Plant Protection and Biosecurity), ICAR, New Delhi | May 23, 2022 |
| 20. | Dr. R.B. Doule, Chief Cane Advisor, NFCSF, New Delhi | May 23, 2022 |
| 21. | Dr. N. Vijyan Nair, Ex. Director, ICAR-SBI, Coimbatore | May 23 and November 23-24, 2022 |
| 22. | Dr. O.K. Sinha, Former PC, AICRP on Sugarcane, IISR, Lucknow | May 23, 2022 |
| 23. | Shri Ajeet Pal Singh, Minister of State for Electronics and Information Technology, Government of Uttar Pradesh | June 17, 2022 |
| 24. | Ms. Riya Kejriwal, IAS, CDO, Lucknow | June 17 and December 30, 2022 |

| Sl. No. | Name and address of the visitor | Date of visit |
|---|---|---|
| 25. | Mr. Surya Pratap Shahi, Hon'ble Minister of Agriculture, Agricultural Education and Research, Govt. of Uttar Pradesh, Lucknow | June 20, 2022 |
| 26. | Mr. Baldev Singh Aulakh, Hon'ble Minister of State for Agriculture, Agricultural Education and Research, Govt. of Uttar Pradesh, Lucknow | June 20, 2022 |
| 27. | Padma Shri, Mr. Ram Saran Verma, Barabanki | June 20, 2022 |
| 28. | Dr. Rajesh Singh, Vice-Chancellor, DDU Gorakhpur University, Gorakhpur | June 20 and October 16, 2022 |
| 29. | Dr. N.P. Singh, Vice-Chancellor, BUAT, Banda | June 20, 2022 |
| 30. | Dr. Y.S. Nerker, Ex. Vice Chancellor, MPKV, Rahuri | June 26, 2022 |
| 31. | Dr. Surendra Singh, Ex. Project Coordinator, FIM, ICAR-CIAE, Bhopal | June 26, 2022 |
| 32. | Shri Sanjay R. Bhoosreddy, Additional Chief Secretary, Department of Sugarcane and Sugar Development, Government of Uttar Pradesh | July 20, 2022 |
| 33. | Dr. Sushil Solomon, Ex. Vice Chancellor, CSAUA&T, Kanpur and Former Director, ICAR-IISR, Lucknow | July 20 and October 16-19, 2022 |
| 34. | Prof. Narendra Mohan, Director, NSI, Kanpur | July 20 and October 16, 2022 |
| 35. | Shri Sanjay Awasthi, President, STAI, New Delhi | July 20, 2022 |
| 36. | Shri R.K Gangwar, ED, Mawana Sugar | July 20, 2022 |
| 37. | Dr. Randhir Singh, ADG (Agril. Extension), ICAR, New Delhi | August 3, 2022 |
| 38. | Dr. G. Hemaprabha, Director, ICAR-SBI, Coimbatore | July 20, 2022 and October 16, 2022 |
| 39. | Sh. S.C. Deshmukh, IAS (Retd.), Director General/Adviser, VSI, Pune | July 20 and October 16, 2022 |
| 40. | Dr. S.K. Datta, Ex. DDG (CS), ICAR, New Delhi | November 23-24, 2022 |
| 41. | Dr. Indra Mani, Vice-Chancellor, Vasantrao Naik Marathawada Krishi Vidyapeeth, Parbhani | November 23-24, 2022 |
| 42. | Dr. S.V. Sarode, Ex. Director of Research, Dr. PDKV, Akola | November 23-24, 2022 |
| 43. | Dr. J.P. Mishra, OSD (PPP) and ADG (IR), ICAR, Krishi Bhawan, New Delhi | November 23-24, 2022 |
| 44. | Dr. A.K. Vasisht, Ex. ADG (PIM/ESM), ICAR, Krishi Bhawan, New Delhi | November 23-24, 2022 |

CHAPTER 21

# Personnel

(As on December 31, 2022)

| | | |
|---|---|---|
| **Crop Improvement** | | |
| Dr. Rasappa Viswanathan | Director | r.viswanathan@icar.gov.in |
| Dr. Jyotsnendra Singh | Principal Scientist and Head | jyotsnendra.singh@icar.gov.in |
| Dr. Sangeeta Srivastava | Principal Scientist (Genetics & Cytogenetics) | sangeeta.srivastava@icar.gov.in |
| Dr. P.K. Singh (On deputation) | Principal Scientist (Plant Breeding) | praveen.singh@icar.gov.in |
| Dr. Sanjeev Kumar | Principal Scientist (Plant Breeding) | sanjeev.kumar6@icar.gov.in |
| Dr. M. Swapna | Principal Scientist (Genetics) | swapna.m@icar.gov.in |
| Dr. Sanjeev Kumar | Principal Scientist (Agril. Biotechnology) | sanjeev.kumar7@icar.gov.in |
| Dr. Ashutosh Kumar Mall | Principal Scientist (Plant Breeding) | ashutoshmall@icar.gov.in |
| Dr. Ranjit Singh Gujjar | Senior Scientist (Agril. Biotechnology) | ranjit.gujjar@icar.gov.in |
| Mr. Aalok Shiv | Scientist (Genetics & Plant Breeding) | aalok.shiv@icar.gov.in |
| Mr. Nenavath Krishna Kumar Rathod | Scientist (Genetics & Plant Breeding) | krishna.nenavath@icar.gov.in |
| Mr. Raghwendra Kumar | Assistant Chief Technical Officer | raghwendra.kumar@icar.gov.in |
| Dr. Ram Kishor | Assistant Chief Technical Officer | ram.kishor@icar.gov.in |
| Mr. Anil Kumar Bansraj Maurya | Technical Officer | anilkumar.maurya@icar.gov.in |
| **Crop Production** | | |
| Dr. S.K. Shukla | Principal Scientist & Head | sudhir.shukla@icar.gov.in |
| Dr. V.P. Singh | Principal Scientist (Agronomy) | vinay.singh2@icar.gov.in |
| Dr. T.K. Srivastava | Principal Scientist (Agronomy) | tapendra.srivastava@icar.gov.in |
| Dr. A.K. Singh (On deputation) | Principal Scientist (Agronomy) | akhilesh.singh2@icar.gov.in |
| Dr. K.K. Singh | Principal Scientist (Agronomy) | kranti.singh@icar.gov.in |
| Dr. Chandra Gupta | Principal Scientist (Agronomy) | chandra.gupta1@icar.gov.in |
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| Dr. V.K. Singh | Principal Scientist (Agronomy) | vinay.singh2@icar.gov.in |
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## Appointments

| Name of Official | Designation | Date of joining |
|---|---|---|
| Dr. R. Viswanathan | Director | December 9, 2022 |
| Mr. Manoj Kumar Pathak | SSS | August 2, 2022 |
| Ms. Shweta Srivastava | SSS | August 2, 2022 |

## Promotions

| Name | Promoted to the post of | w.e.f. |
|---|---|---|
| **Technical** | | |
| Sh. S.K. Kushwaha | Chief Technical Officer | January 1, 2021 |
| Sh. K.N. Singh | Chief Technical Officer | April 24, 2021 |
| Mr. C.P. Singh | Chief Technical Officer (One increment) | February 3, 2021 |
| Dr. G.K. Singh | Chief Technical Officer (One increment) | July 19, 2020 |
| Mrs. Promila Lal | Chief Technical Officer | February 24, 2018 |
| Mr. Raghwendra Kumar | Assistant Chief Technical Officer | July 1, 2017 |
| Dr. A.D. Deepak Mishra | Assistant Chief Technical Officer | January 19, 2020 |
| Mr. V.K. Saxena | Assistant Chief Technical Officer | February 24, 2012 |
| Mr. Ashish Singh Yadav | Technical Officer | March 1, 2021 |
| Mr. Ram Lakhan | Technical Officer | October 26, 2017 |
| Mr. Kalpnath | Technical Officer | June 26, 2022 |
| Mr. Umesh Chandra Pandey | Senior Technical Assistant | November 29, 2021 |
| Mr. S.P. Prajapati | Senior Technical Assistant | July 16, 2022 |
| Mr. A.K. Vishwakarma | Senior Technical Assistant | September 3, 2022 |
| Mr. M.P. Tripathi | Senior Technical Assistant | October 20, 2021 |
| Mrs. Pallavi | Technical Assistant | November 13, 2021 |

| Name | Promoted to the post of | w.e.f. |
|---|---|---|
| Mr. Dhirendra Kumar | Technical Assistant | December 2, 2021 |
| Mr. Upendra Kumar | Technical Assistant | March 27, 2022 |
| Mrs. Santosh Kumari Gautam | Sr. Technician | March 15, 2022 |
| **Administration** | | |
| Mr. Saroj Kumar Singh | Chief Administrative Officer | March 26, 2022 |
| Mr. Raj Kumar Yadav | Administrative Officer | May 20, 2022 |
| Mr. V.P. Tiwari | Administrative Officer | May 20, 2022 |
| Mr. Ganesh Singh | Assistant Administrative Officer | July 30, 2022 |
| Mr. R.V. Dwivedi | Assistant Administrative Officer | July 30, 2022 |
| Mr. Sanjay Mishra | Assistant | July 12, 2022 |

## Transfers

| Name and designation | From | To | Date of leaving |
|---|---|---|---|
| Mr. A.P. Singh. Asstt. Chief Technical Officer | ICAR-IIPR, Kanpur | ICAR-IISR, Lucknow | March 23, 2022 |
| Mrs. Shruti Srivastava, Assistant | ICAR-IIPR, Kanpur | ICAR-IISR, Lucknow | March 28, 2022 |
| Mr. Alok Kumar Singh. Sr. Technician | ICAR-IARI RS, Pusa | ICAR-IISR, Lucknow | April 1, 2022 |
| Dr. Mona Nagargade, Scientist | ICAR-IISR, Lucknow | ICAR-IARI, New Delhi | April 5, 2022 |
| Mr. Avinash Aman, LDC | ICAR-CIRCOT, Mumbai | ICAR-IISR, Lucknow | April 21, 2022 |
| Mr. A.K. Sharma, Administrative Officer | ICAR-IISR, Lucknow | ICAR-PDFSR, Meerut | April 23, 2022 |
| Mr. Sanjay Lal Srivastava, Technical Assistant | ICAR-RCER, Patna | ICAR-IISR, Lucknow | August 8, 2022 |
| Dr. S.N. Sushil, Principal Scientist | ICAR-IISR, Lucknow | ICAR-NBAIR, Bengaluru | September 9, 2022 |
| Dr. Chandan Kumar Gupta, Scientist | ICAR-IISR, Lucknow | ICAR-IARI, New Delhi | December 16, 2022 |

## Superannuations

| Name of Official | Designation | Date of retirement |
|---|---|---|
| Dr. S.N. Singh | Principal Scientist | January 31, 2022 |
| Dr. Brij Kishor | Technical Officer | January 31, 2022 |
| Dr. B.B. Joshi | Chief Technical Officer | March 31, 2022 |
| Sh. Dasha Ram | Senior Technician | March 31, 2022 |
| Sh. Chhatra Pal | Skilled Support Staff | June 30, 2022 |

| Name of Official | Designation | Date of retirement |
|---|---|---|
| Shri Radhey Mohan | Skilled Support Staff | July 31, 2022 |
| Mr. C.P. Prajapati | Technical Officer | July 31, 2022 |
| Mr. Sanjay Mishra | Assistant | August 31, 2022 |
| Dr. R.S. Dohare | Principal Scientist | November 30, 2022 |
| Mr. Kapil Deo Pandey | Senior Technician | December 31, 2022 |

**Obituary**

| Name of Official | Designation | Date of death |
|---|---|---|
| Late Sh. Vijay Kumar | Skilled Support Staff | July 20, 2022 |

CHAPTER 22

# Meteorological Data

Important weather parameters during January 2022 to December 2022 at ICAR-Indian Institute of Sugarcane Research, Lucknow are given below:

| Month | Temperature (°C) | | Relative humidity (%) | | Rainfall (mm) | Rainy days (No.) | Bright sunshine hours (hrs./day) | Evaporation (mm/day) | Wind speed (km/hr) |
|---|---|---|---|---|---|---|---|---|---|
| | Maximum | Minimum | at 7 : 18 am | at 2 : 18 pm | | | | | |
| January 2022 | 19.3 | 8.4 | 92.8 | 61.6 | 24.4 | 4 | 3.7 | 1.3 | 2.4 |
| February 2022 | 24.4 | 9.4 | 92.0 | 41.8 | 8.2 | 1 | 7.3 | 2.3 | 3.2 |
| March 2022 | 34.0 | 16.2 | 82.3 | 26.3 | 0.0 | 0.0 | 8.7 | 5.0 | 3.6 |
| April 2022 | 41.0 | 21.2 | 64.6 | 17.2 | 0.0 | 0.0 | 9.1 | 7.8 | 3.5 |
| May 2022 | 38.3 | 25.5 | 67.6 | 41.1 | 36.6 | 4 | 8.2 | 6.1 | 2.9 |
| June 2022 | 40.9 | 28.2 | 68.7 | 35.1 | 33.2 | 2 | 7.7 | 7.8 | 4.8 |
| July 2022 | 35.6 | 28.1 | 80.1 | 61.7 | 252.6 | 8 | 6.6 | 4.7 | 2.6 |
| August 2022 | 34.3 | 26.9 | 88.3 | 66.8 | 152.8 | 12 | 3.5 | 3.1 | 3.3 |
| September 2022 | 33.5 | 25.8 | 91.6 | 69.3 | 367.2 | 8 | 5.8 | 3.5 | 2.7 |
| October 2022 | 31.6 | 20.2 | 95.4 | 57.1 | 192.2 | 5 | 6.7 | 2.3 | 1.6 |
| November 2022 | 29.3 | 13.0 | 91.7 | 41.1 | 0.0 | 0.0 | 7.0 | 2.1 | 1.7 |
| December 2022 | 24.7 | 8.4 | 93.4 | 44.1 | 0.0 | 0.0 | 6.4 | 1.5 | 2.0 |


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